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Efficient use of interest rate swaps to manage interest rate risk

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1 Executive summary

1. In this report I have, consistent with the views of the AER and Lally, derived estimates of the efficient use of interest rate swaps based on the starting premises that:

   a. the benchmark efficient debt management strategy is one that attempts to minimise the variation between the actual cost of debt and the allowed cost of debt; and

   b. the benchmark efficient entity's past debt management strategy was consistent with the objective set out in "a" above; and

   c. the assessment of what debt management strategy achieves this must be in the context of the regulatory regime that applied in the past; namely where the cost of debt allowance was set to reflect the prevailing cost of debt at the beginning of the regulatory period.

2. So far the debate within the above parameters has been whether a strategy of not hedging the base rate minimises interest rate risk exposure more than an assumed strategy of resetting the hedging for 100% of the base rate exposure.

3. In this report, unlike the AER and Lally I have not restricted myself to a binary set of debt management strategies; being strategies where either none or all of the business's base interest rate costs were reset using swaps at the beginning of each regulatory period. Rather, I have examined the possibility that hedging somewhere between the extremes of 0% and 100% will minimise interest rate risk.

4. Consistent with empirical analysis in Lally (2015) I have used the standard deviation of the difference between the 'on the day' allowance and the cost of debt as the measure of how closely a debt management strategy limits the potential mismatch between the actual cost of debt and the allowed cost of debt.

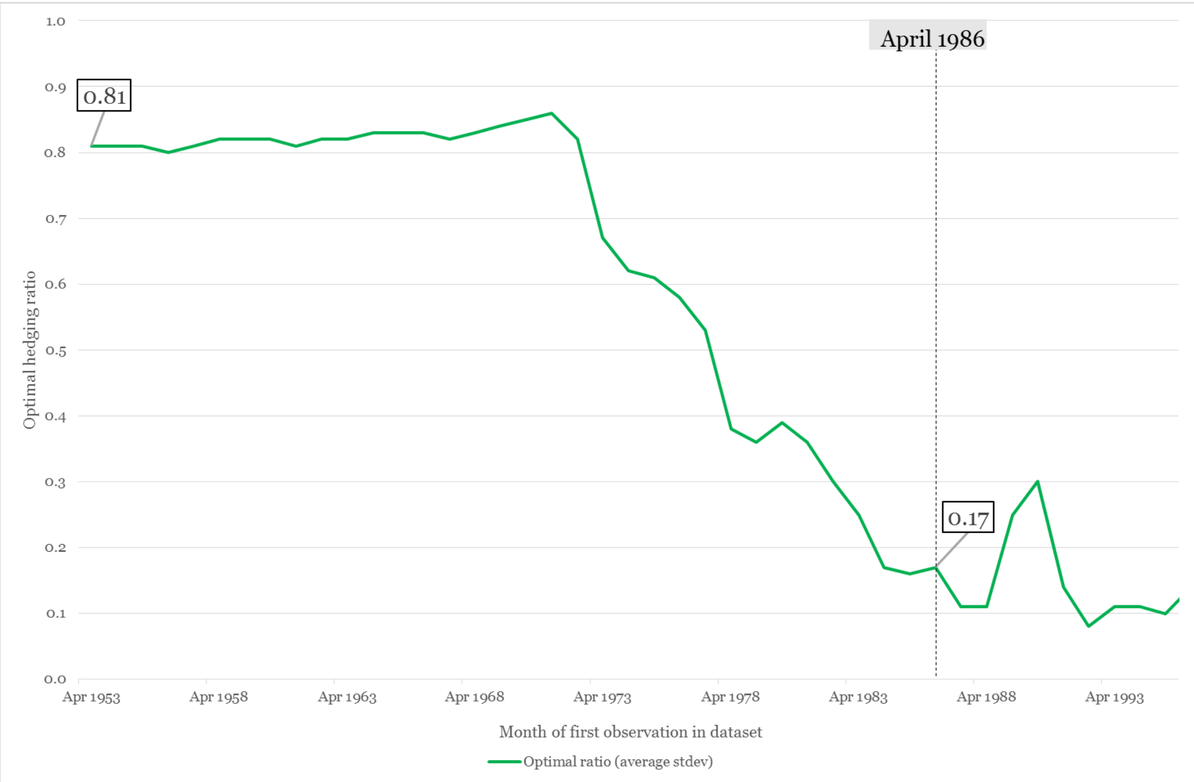
5. I follow the analysis presented by Lally (2015). This approach is purely empirical in that it starts with a time series for the cost of debt and calculates the regulatory allowance associated with an averaging period in any (and all) month(s) of that time series and compares it to the cost of debt over the subsequent five years associated with a staggered debt issuance and a given percentage use of interest rate swaps. The percentage use of interest rate swaps that minimises the standard deviation of the difference between regulatory allowance and cost is the strategy that minimises interest rate risk.

6. I find that, using precisely Lally's dataset and methodology, the percentage use of interest rate swaps that minimise interest rate risk is 81%. That is, risk is minimised leaving 19% of the cost of debt as a pure trailing average and hedging only 81% of the base rate exposure to reset at the beginning of each regulatory period. Lally

does not report this result because his focus was (inappropriately given the context) on comparing the risk of a 100% hedging strategy to a 0% hedging strategy rather than determining the most effective strategy.

7. However, I build on Lally's analysis by correcting a critical error in the form of his inclusion of US data from pre 1986 (a period over which high and volatile inflation invalidates his methodology). Figure 1 shows the hedging ratios that minimise interest rate risk for different starting observations. When the starting observation is changed from Lally's full dataset beginning in April 1953 to one that starts in April 1986, the hedging ratio that minimises interest rate risk falls from 81% to 17%. Furthermore, the hedging ratio that minimises interest rate risk appears to always be between 0% and 100%, which confirms that simply comparing 0% and 100% hedging strategies would not identify the hedging strategy with the lowest risk.

Figure 1: Hedging ratios which minimise interest rate risk for different starting observations

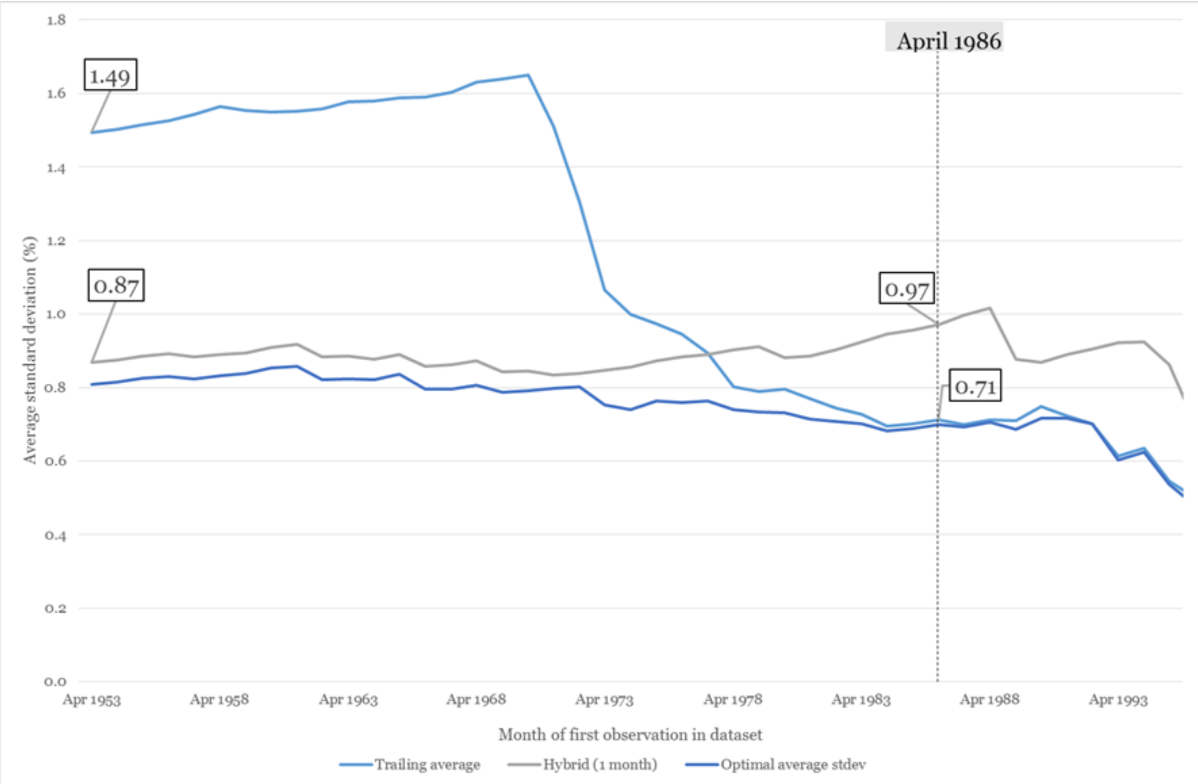


Source: CEG analysis

8. When the standard deviations that result from using the hedging ratio that minimises interest rate risk is compared against those from the 0% and 100% hedging strategies, it can be seen in Figure 2 that the average standard deviation of the above hedging ratio is a lower bound of the trailing average (0% hedging) and 1-month "hybrid" (100% hedging) approaches. Furthermore, if the dataset begins in

April 1983 and onwards, the trailing average approach produces average standard deviations that are very close to (nearly indistinguishable from) minimal risk. By contrast, the standard deviation associated with the 100% use of interest rate swaps is demonstrably higher than the standard deviation associated with the partial use of swaps.

Figure 2: Standard deviation associated with different hedging ratios for different starting observations



Source: CEG analysis

9. I also make other changes to Lally's methodology by including Australian data (which has been constructed by applying my own and Chairmont's methodology for deriving a BBB yield time series), and by making a number of other methodological changes to Lally's analysis (including reporting the uncentred standard deviation and adopting a more exhaustive analysis of the number of potential regulatory cycles).

10. When I do this, I find that, the optimal hedging ratio based only on the US data series rises from 17% up to as high as 33%. This is broadly consistent with the estimates that are derived from the Australian dataset which range from 26% to 38%.

11. Based on the analysis in this report, I consider that the use of interest rate swaps that would have minimised interest rate risk for the benchmark efficient entity under the 'on the day' regulatory regime would have involved hedging around 1/3 of base interest rate exposure at the beginning of the regulatory period. The remaining 2/3 of the debt portfolio would not be affected by the use of interest rate swaps and would be best modelled based on a trailing average of past debt costs.

2 Introduction

12. My name is Tom Hird. I have a Ph.D. in Economics and 20 years' experience as a professional economist. My curriculum vitae is provided separately. This report has been prepared for Australian Gas Networks, CitiPower, Powercor, APA Group, and United Energy to assess the reasonableness of the AER's approach to transitioning the methodology for setting the cost of debt allowance to a trailing average. Specifically, whether it is reasonable to assume that the benchmark efficient entity would have, in the past, used interest rate swaps such that at the beginning of the next regulatory period 100% of its base interest rate exposure can be assumed to be floating rate exposure.

13. The remaining structure of this report is as follows:

- Section 3 provides relevant background, including on the AER's views and a critique of those views;
- Section 4 introduces Lally's (2015) analysis on the comparative risks of hedging and not hedging and uses his methodology and data to derive the optimal use of interest rate swaps given an objective of minimising interest rate risk;
- Section 5 sets out recommended amendments to Lally's methodology and data (including the use of Australian data). I then re-estimate that level of interest rate swaps which meets the objective of minimising interest rate risk;
- Appendix A sets out the reason why negative correlation between debt risk premium (DRP) and swap rates creates a natural hedge – the effect of which is that that level of interest rate swaps which minimises interest rate risk will be less than 100%;
- Appendix B sets out the empirical literature on the existence of negative correlation between debt risk premium (DRP) and swap rates;
- Appendix C sets out the existence of a negative correlation between debt risk premium (DRP) and swap rates in Lally, CEG and Chairmont data
- Appendix D sets out the existence of a negative correlation between debt risk premium (DRP) and swap rates from other datasets
- Appendix E sets out the methodology used for detrending interest rate series (which is examined as a sensitivity to the core results);
- Appendix F provides a graphical representation of the standard deviations derived following Lally's methodology of estimating a standard deviation for each regulatory cycle but estimating 60 regulatory cycles (rather than 4);
- Appendix G carries out Lally's methodology using a different dataset, whereby only the period from March 1970 to March 1986 is excluded, thus confirming that Lally's observations arise from the high and unstable inflation that

occurred in the US in the 70s and 80s with no influence from the 50s and 60s; and

- Appendix H sets out the "combined dataset" approach that I use for measuring standard deviations.

14. I acknowledge that I have read, understood and complied with the Federal Court of Australia's *Practice Note CM 7, Expert Witnesses in Proceedings in the Federal Court of Australia*. I confirm that I have made all inquiries that I believe are desirable and appropriate and that no matters of significance that I regard as relevant have, to my knowledge been withheld.

15. I have been assisted in the preparation of this report by Johnathan Wongsosaputro and Yanjun Liu from CEG's Sydney office. However, the opinions set out in this report are my own.

Thomas Nicholas Hird

29 June 2015

3 Background, including AER position and critique

16. This report examines the issue of what use of interest rate swaps by a regulated business could be expected to minimise interest rate risk; where interest rate risk is defined as the mismatch between the actual cost of debt and cost of debt allowance set by the regulator. The context for this assessment is one where the regulator set the cost of debt allowance based on the prevailing corporate interest rates in a short window immediately before the beginning of each regulatory period.

17. Previously, I have estimated that the use of Australian data with no application of interest rate swaps (0% hedging) would have resulted in actual debt costs being closer to the regulatory allowance under an 'on the day' approach to setting that allowance than hedging 100% of base interest rates using interest rate swaps.[1]

18. The AER engaged Lally[2] to provide an analysis that was, in large part a response to my analysis. The analysis in this report can be viewed as an extension of both my own and Lally's analysis. In Lally's report he examines, using a different dataset and methodology, the same issue and concludes that a 100% hedging strategy had lower interest rate risk than a 0% hedging strategy. The AER has relied on this analysis to justify its conclusion that a regulated business would have most efficiently managed interest rate risk by hedging 100% of its base interest rate costs using interest rate swaps.

19. This conclusion, that 100% hedging strategy minimises interest rate risk, may be correct where the relevant benchmark efficient entity is actually assumed to have entered into hedging contracts using swaps to reset 100% of its base rate of interest every 5 years.

20. However, where this assumption is not made, the question is no longer whether 0% or 100% hedging better minimises interest rate risk (the question Lally sought to answer). The relevant question is: what level of hedging minimises interest rate risk?

21. This report addresses that question in detail. I have concluded as specified in this report that contrary to Lally's findings, substantially less than 100% hedging minimises interest rate risk.

[1] CEG, Efficient debt financing costs, a report for Networks NSW, January 2015, section 4.5.

[2] Lally (2015), Review of Submissions on the Cost of Debt, April 2015.

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3.1 AER position

3.1.1 Summary

22. The AER's position is that an assessment of the appropriate transition provisions to put in place when adopting a trailing average debt management strategy requires an assessment of how the benchmark efficient entity would have responded to past regulatory practice in setting the cost of debt allowance. That is, the starting point for an assessment of the prospective efficient financing costs of the benchmark efficient entity will reflect a debt and hedging portfolio that was entered into in order to adapt to past regulatory practice.

23. With this context established, my understanding of the AER's view is that, under the past regulatory practice of setting compensation for the cost of debt based on the 'on the day' approach, the benchmark efficient entity: [3]

- would have attempted to hedge its actual cost of debt as close as possible to the regulatory allowance in order to manage 'interest rate risk';
- was unable to hedge the DRP;
- could use interest rate swaps to hedge the base rate of interest; and
- would have, consistent with the first dot point, used interest rate swaps such that 100% of the base rate of interest was reset equal to the 5 year swap rate at the beginning of each regulatory period.

24. The AER also expresses the view that:

- the above rationale was consistent with the rationale provided by privately owned businesses for their use of interest rate swaps; and
- this interest rate swap strategy would lower costs relative to not using interest rate swaps, because 5 year interest rate swaps tended, on average, to have lower interest rates than 10 year interest rate swaps.

3.1.2 AER statements

25. In its most recent decision for JGN the AER has argued:[4]

> *Our assessment that the above strategy* [staggered debt portfolio with interest rate swaps] *was an efficient financing practice of a benchmark*

[3] See, for example: AER, Jemena Gas Networks (NSW) Ltd Access Arrangement 2015-20, June 2015, pp. 3-171, 3-177; AER, Better Regulation Explanatory Statement: Rate of Return Guideline, December 2013, Section 7, pp. 98-125.

[4] AER, Jemena Gas Networks (NSW) Ltd Access Arrangement 2015-20, June 2015, pp. 3-178, 3-179.

> *efficient entity under the on-the-day approach is supported by expert advice from both an academic perspective (Dr Lally) and a financial market practitioner perspective (Chairmont).*
>
> *A staggered debt portfolio with interest rate swaps is also the financing strategy that most privately owned service providers generally adopt under the on-the-day approach. This tendency is reflected in:*
>
> - *corporate treasurers' statements to our 2009 weighted average cost of capital (WACC) review*
> - *the data on debt financing strategies of the privately owned service providers we collected during the 2009 WACC review,*
> - *submissions from privately owned service providers to the Australian Energy Market Commission (AEMC) during the 2012 network regulation rule change process*
> - *submissions to our development of the 2013 rate of return guideline.*
>
> …
>
> ***For the above reasons, we consider a staggered debt portfolio with interest rate swaps was an efficient financing practice of a benchmark efficient entity under the on-the-day approach. [Emphasis added]***

26. The AER's view that interest rate swaps should be used as hedges comes down to a belief that hedging 100% of the base rate of the debt portfolio using interest rate swaps:
    - results in the actual cost of debt being more closely matched to the 'on the day' regulatory allowance than does a trailing average without swaps; and
    - reduces the (expected) cost of debt because it shortens the base interest rate exposure from 10 to 5 years.

3.1.3 Lally's analysis

27. At the heart of the AER's views on why it believes that the hybrid (by which it means 100% interest rate swap hedging strategy) debt management strategy was more efficient is the following quote from Dr. Lally:[5]

> *Adopting the strategy of a staggered debt portfolio with interest rate swaps, compared with a staggered debt portfolio without interest rate swaps, would have led to the same degree of refinancing risk. However,*

5 Lally, M. Transitional arrangement for the cost of debt. November 2014, pp 25-30

> *compared to the later strategy, adopting a staggered debt portfolio with interest rate swaps would have resulted in:*
>
> - *Lower interest rate risk – as interest rate risk would only have been borne on the debt risk premium component of the return on debt, rather than bearing interest rate risk on the total return on debt, and*
> - *Lower actual return on debt – as hedging using interest rate swaps has the impact of reducing the effective term of the debt. As longer term debt is typically more expensive than otherwise equivalent shorter term debt, due to the greater risks faced by the holders of long term debt, reducing the effective term would be expected to reduce the lower (sic) actual return on debt, on average.*

3.2 Is past regulatory practice relevant to an assessment of efficient financing costs?

28. It is unclear whether past regulatory practice is relevant to an assessment of current/future efficient financing costs. The debate in the reports written by Lally and myself to date, including this one, canvass both prospects: on the one hand that it is not relevant, and on the other, that it is. Rule 87(3)[6] states:

> *The allowed rate of return objective is that the rate of return for a service provider is to be commensurate with the efficient financing costs of a benchmark efficient entity with a similar degree of risk as that which applies to the service provider in respect of the provision of reference services (the allowed rate of return objective).*

29. The AER's draft decision for JGN proceeds on the basis that it is appropriate to define the efficient financing costs of a benchmark efficient entity on the assumption that the entity is regulated and that its financing strategies are a function of the nature of the regulatory framework under which the entity has been operating in the past. For example, at page 3-115 of the JGN draft decision the AER states:

> *Based on the above, we consider a staggered debt portfolio with interest rate swaps was an efficient financing practice of the benchmark efficient entity* ***under the on-the-day approach***. (Emphasis added.)

30. There is, inevitably, an element of circularity in this construction – with the efficient debt management strategy depending on the regulatory policy rather than the regulatory policy depending on the efficient debt management strategy.

[6] The equivalent clause under the NER is 6.5.2(c)

31. I have made this 'circularity' point previously. For example, in my February 2013 report for Ausgrid, I stated:[7]

> *A 10 year trailing average approach would largely mimic the debt management strategy employed by infrastructure businesses (regulated and unregulated) around the world.*
>
> *In this regard, it is worth noting that it is also quite common for infrastructure businesses subject to "lighter-handed" forms of regulation to adopt the same strategy. This is important because regulated business financing activity may well be distorted by the particular way in which the relevant regulator compensates for the cost of debt. Examining similar infrastructure businesses that are only lightly regulated, such as Toll Roads and Airports, provides an insight into the way in which infrastructure businesses manage their debt absent incentives created by the regulatory regime.*

32. In short, if it is appropriate for efficient debt management practices of infrastructure owners in more competitive markets to inform the definition of a benchmark efficient debt management strategy, then this would suggest that the trailing average debt management strategy should define the "efficient financing costs of a benchmark efficient entity".[8]

33. The AER has determined that the most efficient debt management strategy in the long run is the trailing average debt management strategy. If past regulatory practice is not relevant to informing efficient financing costs (i.e., if causation runs in the opposite direction) then the most efficient debt management strategy in the long run is also the most efficient debt management strategy in the short run.

34. I have previously indicated that it may be possible to assess the cost of debt of an efficient benchmark entity under Rule 87(3) on a number of bases depending on the assumptions made: one basis may be without reference to past regulatory practice, resulting in the trailing average being the method which reflects a minimisation of interest rate risk; another basis may be to assume an efficient benchmark entity would take into account regulatory practice and adopt a strategy of wholly hedging a base rate; another basis may be, as this report seeks to demonstrate, that minimising interest rate risk should be determined by reference to the extent to which an efficient benchmark entity should hedge. Each of these alternatives may be credible depending on the context and assumptions made. For example, in the context of an assumption of an entity hedging 100% of its base rate, that assumption would be relevant to the determination of the cost of debt.

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7 CEG, Efficiency of staggered debt issuance, February 2013, pp. 30 to 31, paragraphs 97 and 98.

8 CEG, Efficiency of staggered debt issuance, February 2013, pp. 29 to 32.

3.3 Why a 100% hedging ratio will not necessarily minimise interest rate risk

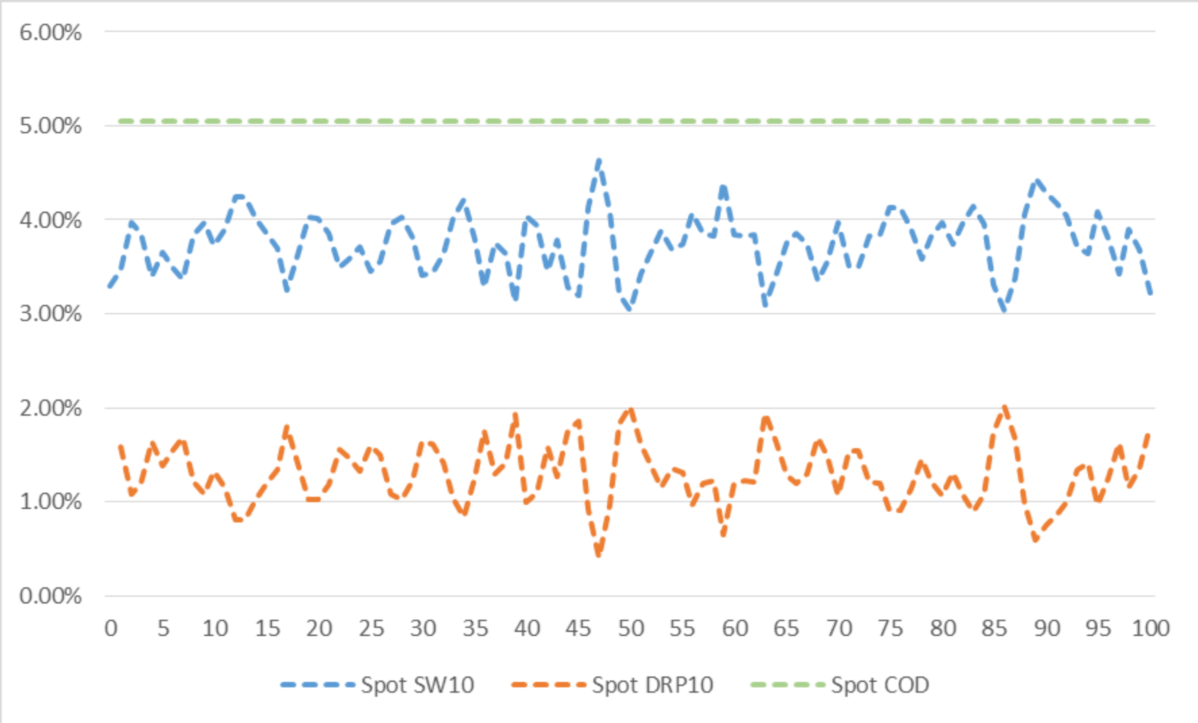
35. On a purely theoretical level there is no basis to assume that using interest rate swaps to hedge 100% of the debt portfolio would best align actual costs to an 'on the day' allowance for the cost of debt (i.e., would minimise interest rate risk). The AER's position pre-supposes that the prevailing DRP is independent of the base level of prevailing interest rates.

36. In reality, it is well established in the finance literature since at least Longstaff and Schwartz (1995) that credit spreads are inversely related to the base level of interest rates.[9] In the presence of negative correlation, leaving *at least some* of the base rate of interest unhedged will be the most efficient strategy for hedging the cost of debt allowance – which is comprised of both the base rate of interest and the DRP.

37. I devote Appendix A to an intuitive conceptual elaboration of this result. What follows provides a simple illustration taken from Appendix A. Imagine that the prevailing DRP (measured relative to swap rates) always moved in an exactly offsetting way to movements in swap rates – such that the cost of debt was constant. Such a scenario is depicted in Figure 3, which shows a variable swap rate series and a DRP series with an exactly offsetting pattern – such that the prevailing cost of debt (COD) is constant.

9 Longstaff, and Schwartz, A simple approach to valuing risky fixed and floating rate debt, *Journal of Finance*, July 1995. They find that "Using Moody's corporate bond yield data, we find that credit spreads are negatively related to interest rates and that durations of risky bonds depend on the correlation with interest rates: (p. 789).

Figure 3: Variable base rate of interest with perfect offsetting variation in DRP



Source: CEG analysis

38. Under the on the day approach, the cost of debt allowance is set equal to the prevailing cost of debt at the beginning of a five year regulatory cycle (which is why the data is broken into 5 year blocks on the horizontal axis). The allowed cost of debt in each five year period is represented in Figure 4 by the grey line – which is constant by construction. Superimposed on this is the trailing average cost of debt (with 0% use of swap rates) which is also constant by construction (given that it is simply a trailing average of the constant prevailing cost of debt).

Figure 4: Trailing average and 100% swap strategy with perfect offsetting variation in swap rates and DRP

Source: CEG analysis

39. In contrast, the cost of debt associated with a 100% swap strategy is not constant but, rather, has much the same variability as the swap rate at the beginning of the regulatory period (which is locked in under the 100% swap strategy). It does not have exactly the same volatility as the prevailing swap rate because the trailing average DRP, which is a component of the costs for both strategies, has low, but non-zero, variability.

40. It can be seen that, despite the 100% swap strategy 'locking in' the prevailing swap rate used by the regulator, it provides a worse hedge to the total regulatory allowance because the swap contracts undo (or double up) the natural hedge that already existed. Specifically, variability in the swap rates was dampened (in this example perfectly dampened) by offsetting variability in the DRP (a negative correlation). By entering into 100% swap contracts, the business made the actual cost of debt more volatile than the regulatory allowance because it failed to take into account the existence of a natural hedge.

41. Of course, the real world relationship between swap rates and DRP is not as simple as in the above stylised analysis. However, as previously noted CEG performed analysis with Australian data in a report for network NSW and found that a 0%

hedging strategy provided a closer fit to the regulatory allowance (lower interest rate risk) than a 100% hedging strategy.[10] This report extends that analysis to attempt to identify the percentage use of interest rate swaps that minimises interest rate risk.

3.4 AER rejection of CEG analysis in favour of Lally's analysis

42. The AER rejected the validity of this conclusion on the basis that CEG had only compared the difference between the allowance and the cost of debt in the first month of the regulatory period – not over the entire regulatory period.[11]

43. The AER proceeded to argue that the relevant question was not whether a 100% swap strategy was a perfect hedge but whether it efficiently managed interest rate risk and to rely on alternative empirical analysis by Lally that measured the difference between cost and allowance over the entire regulatory period.

> *We consider that the correct question should be whether engaging in interest rate swaps efficiently managed interest rate risk under the on-the-day regulatory regime (not whether it provided a perfect hedge). While acknowledging that the hedging strategy applies only to the base rate component of the return on debt, Lally and Chairmont demonstrated that hedging under the on-the-day regulatory regime was efficient to manage interest rate risk. The NSW network service providers or their consultants did not provide evidence to the contrary apart from stating it would not have been efficient for these businesses to hedge at the 2009 revenue determination (we address this issue below). They did not carry out analysis to demonstrate that the risk arising from hedging (though imperfect) is higher than that resulting from not hedging at all.* [Sic] [12]
>
> *Furthermore, Lally undertook analysis on this issue, using data from April 1953 to January 2015. Lally concluded:*
>
>> *In summary, when a regulator uses an on-the-day policy with a one month window for setting the allowed rate, the use of interest rate swaps reduces the mismatch between the on-the-day allowance and the incurred costs of debt.*

10 CEG, Efficient debt financing costs, a report for Networks NSW, January 2015, section 4.5.

11 AER, Final Decision Ausgrid Determination, April 2015, p. 3-503 to 3-504.

12 I note that, as discussed above, CEG did provide the type of analysis that the AER claims above was not provided so it is difficult to understand the emphasised claim in the above quote. Indeed, Lally's empirical analysis is a direct response to CEG's analysis and is of the same basic type. The AER may conclude that the analysis was inappropriate in some fashion, however, it is not reasonable to conclude that it did not exist.

Lally's analysis draws upon US data, and in particular the US treasury constant maturity series for five and ten year bonds and the DRP series for BBB bonds. While Lally used data from the US on this occasion, we note that his evidence only added to the evidence set out in the draft decision based on Australian data. For more information, refer to: Lally, M., Review of submissions on the cost of debt, April 2015, pp.72–74.

44. The AER relies on Lally's empirical analysis elsewhere in its decision, such as in the following passage:

While UBS provided an analysis of costs and risks for using swaps, it did not provide a similar analysis for not using interest rate swaps. Without analysing the two scenarios in parallel, it is not possible to conclude that it would have been inefficient for the NSW network service providers to use interest rate swaps. This observation also applies to Frontier, CEG and HoustonKemp who all concluded, based on UBS' analysis, that it would have been inefficient for these businesses to use interest rate swaps.

- *Lally (2015) examined whether, under the on-the-day approach, there would be more or less risk to a business from not engaging in interest rate swap contracts versus doing so for the period April 1953 to January 2015. He concluded that compared to not using interest rate swaps, the use of interest rate swaps reduces the mismatch between the on-the-day allowance and the incurred costs of debt under the on-the-day regulatory regimes. Lally (2014) also demonstrated that the benefit of hedging is higher than the costs incurred. We agree with Lally in this regard.*[13]

45. Lally's analysis differs from CEG's analysis in only three important respects:

- Lally measures the standard deviation of the difference between costs and allowance over the entire 5 year regulatory period rather than in the first month of the regulatory period;
- Lally uses a data set from the US while CEG used a data set from Australia;
- Lally used a longer dataset (beginning in 1953) while CEG used a shorter dataset (beginning in 1994).

46. Neither the AER nor Lally considered which of these changes caused Lally to reach the opposite conclusion to CEG. We have performed this analysis and find that Lally's result – that using 100% swaps provides a better hedge to the regulatory allowance than using 0% swaps – is purely dependent on the third factor. Indeed, Lally's conclusion is purely dependent on the inclusion of the high and volatile inflation period of the 1970s. For the reasons described in section 4.3.1, the

[13] AER, Final Decision Ausgrid Determination, April 2015, p. 3-511.

inclusion of this period in the analysis is wholly inappropriate and invalidates Lally's conclusions.

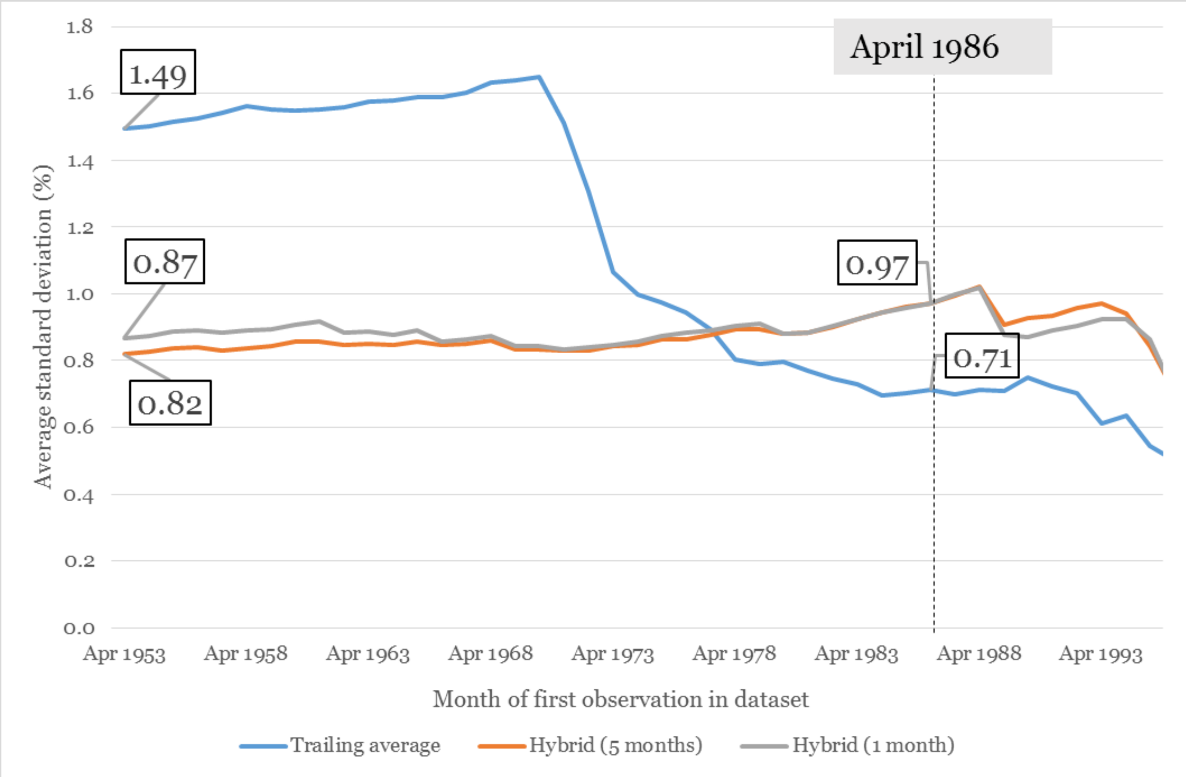
47. Lally does not report the impact of choosing alternative starting dates for the *data series* used in his analysis. Instead, Lally only investigates the effect of choosing different starting dates for *individual sets of regulatory cycles*, such that the five separate sets of regulatory cycles that he investigates are only one year apart. Specifically, Lally considers five sets of regulatory cycles with starting dates in March 1963, March 1964, March 1965, March 1966, and March 1967. The five standard deviations from these five sets of regulatory cycles are averaged to obtain a single average standard deviation. However, it is Lally's selection of April 1953 as the start date for the *data series* that, in effect, defines the associated 5 regulatory cycles examined by Lally – with the first regulatory cycle (March 1963) beginning 10 years after April 1953; when sufficient data is available to calculate a trailing average. Lally also examines regulatory cycles beginning in March of each of the next 4 years (1964 to 1967). Naturally, a regulatory period that begins in March 1968 is already captured by the regulatory cycle that begins in March 1963 so it would be 'double counting' to examine a regulatory cycle beginning in March 1968 (and beyond). (As we will note later, Lally could have examined regulatory cycles beginning in each month of the year (not just March) which would have increased his observations by a factor of 12.) [14]

48. Changing the starting date for the *data series* to a later, more recent date, would involve shifting the starting dates of *each set of regulatory cycles* forward by the same amount of time. For example, shifting the starting date for the *data series* forward by one year to April 1954 would involve obtaining the average of five standard deviations from sets of regulatory cycles that begin in March 1964, March 1965, March 1966, March 1967, and March 1968. As another example, shifting the start of the *data series* to April 1986 would entail obtaining the average of five standard deviations obtained from sets of regulatory cycles beginning in March of 1996, 1997, 1998, 1999, and 2000.

49. It is, in fact, a simple matter to obtain additional average standard deviation estimates for different start dates of the *data series* using the same data and calculations that Lally used to generate the results that he does report. Changing nothing else in Lally's methodology except the start date of the data used results in the pattern shown in Figure 5 below.

14 Unless otherwise stated, I use the phrase "starting date" to refer to the starting date for the *data series*, as opposed to the starting date for an individual regulatory cycle.

Figure 5: Lally results with different start dates



Source: CEG analysis

50. The very first points (on the far left hand side) of each series in the above chart are the figures Lally reported in his Table 4 and which the AER relies on to conclude that a 0% hedging strategy has a lower risk (0.82 to 0.87 standard deviation) than a 100% hedging strategy (1.49% standard deviation). However, as we move along the right of the horizontal axis the start date for the analysis changes. Once the 1970's are excluded from the analysis the standard deviation of the 0% swap strategy is lower than the standard deviation of the 100% swap strategy.

51. As indicated above, I consider that the period of high and unstable inflation in the 1970s (and early 1980s) must not be included and the dataset should begin in the "Post Volcker"[15] inflation targeting period of US monetary policy. This is why the April 1986 start date is highlighted because this is the year from which I believe that the analysis should ideally begin (discussed further in section 4.3.1). In summary, there are two very important reasons for the exclusion of the high and unstable inflation period:

15 Paul Volcker was the US Federal Reserve Chairman at the time the "Fed" implemented a high interest rate policy with the intention of targeting inflation. For a discussion of this event see Sumo, Federal Reserve, Region Focus, *From Stagflation to the Great Moderation, How former Federal Reserve Chairman Paul Volcker tamed inflation and changed monetary policymaking as we know it*, Summer 2006.

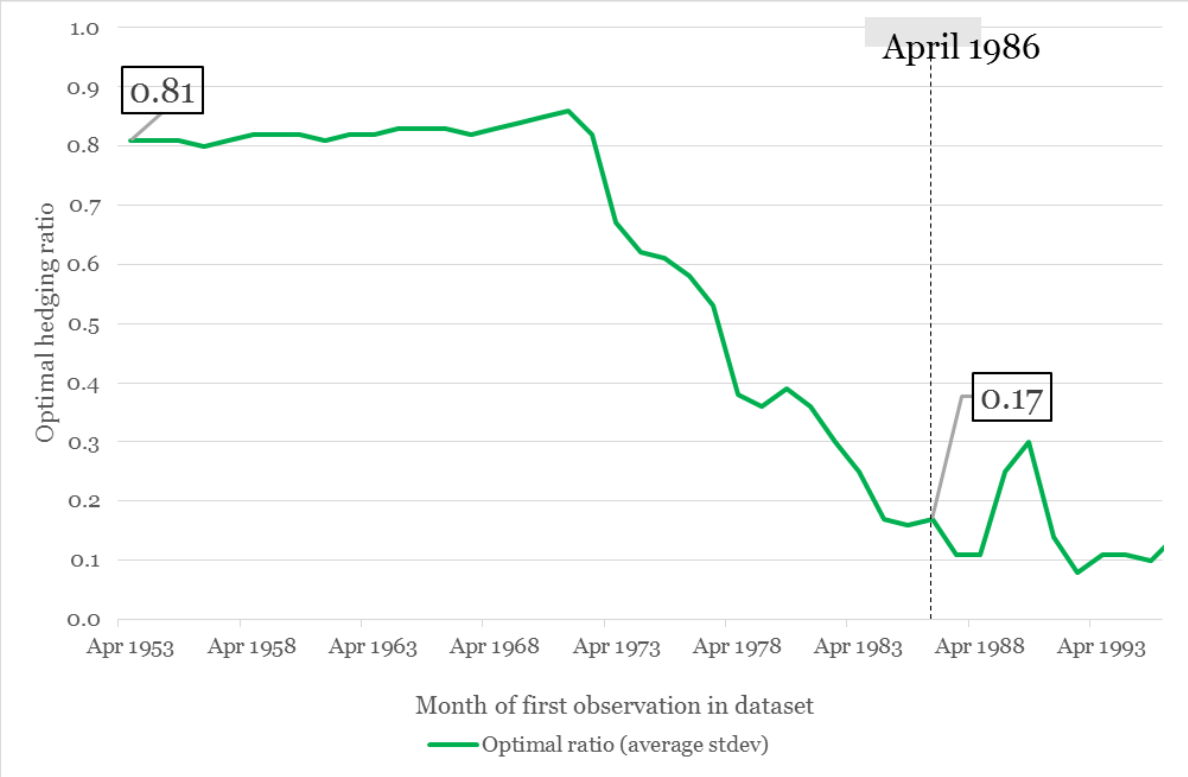
- It does not reflect the market conditions under which the benchmark efficient entity is assumed to be undertaking its hedging strategy (which is a post inflation targeting period with low and stable inflation); and
- In any event, the assumptions underpinning Lally's analysis are invalid in a period where ex-post inflation is materially different to expected inflation (which was the case in the 1970s and early 1980s).

52. However, even if Lally's full dataset is used, a 100% interest rate swap hedging strategy is not the strategy that minimises the standard deviation measured using Lally's methodology. Rather, the hedging ratio that minimises standard deviation is 81%. That is, using Lally's methodology without any changes, using interest rate swaps to reset 81% of a business's base rate exposure at the beginning of each regulatory period delivers a lower standard deviation than either a 0% or a 100% hedging strategy.

53. This is relevant because the logic of both Lally and the AER's position is that the benchmark efficient debt management strategy is the one that minimised interest rate risk. However, Lally does not report results that address this question; he only reports data that addresses the separate question of whether a 100% strategy was lower risk than a 0% strategy. When, unconstrained by prior assumptions about the strategy undertaken, the question considered is what hedging strategy will minimise interest rate risk. The answer is less than 100% hedging.

54. This is shown in Figure 6 for different initial starting months of Lally's US dataset. The very first point on the left hand side of the chart indicates that the hedging ratio which minimises interest rate risk for Lally's full dataset starting in April 1953 is 81%. However, had the analysis excluded the high and unstable inflationary environments in the 1970s and early 1980s, and considered only the data from 1986 onwards, the optimal hedging ratio would have been a substantially lower (17%). The relevant hedging ratio is below 50% if the dataset begins in 1978 or later. In any case, it is clear from Figure 6 that Lally's analysis does not support an assumption that 100% hedging minimises risk – over all possible start dates standard deviation is minimised using less than 100% interest rate swap hedging.

Figure 6: Optimal hedging ratios for different starting observations



Source: CEG analysis

55. In section 5.2 I demonstrate that using Australian data gives rise to very similar results. Specifically, the hedging ratio that minimises interest rate risk is closer to zero than 100%. I also make a number of modifications to Lally's methodology that make it more robust but do not materially change the results (there is a slight decrease/increase in the relevant hedging ratio for the full/post Volcker US data set).

3.5 AER's claimed threshold for a natural hedge to exist

56. For the reasons set out in section 3.3 above, whenever there is a negative relationship between DRP and swap rates then there exists a natural hedge for movements in base interest rates. In the presence of a natural hedge, the relevant artificial hedge (i.e., swap contract) will be less than 100%. Otherwise the business will be 'over hedged' with the natural plus artificial hedge adding to more than 100% and causing the cost of debt to move more strongly with base interest rates than the regulatory allowance.

57. The AER has acknowledged that there exists a negative relationship between changes in DRP and swap rates but did not accept that this implied a natural hedge existed.[16]

> *We are not satisfied that the material presented by the NSW service providers or ActewAGL clearly establishes that there is a natural hedge between the risk free rate and debt risk premium. Further, if there is a correlation between these two variables, it must be sufficiently negative and stable for there to be a natural hedge between the risk free rate and the debt risk premium (**e.g. a correlation coefficient close to 1*** [sic: a perfectly negative correlation would have a coefficient of -1 instead of 1]*). Lally agreed with this view. Lally stated:*
>
> > *However, negative correlation would not be sufficient to support the conclusion that swapping was inefficient. It would have to be sufficiently negative to cause the risk from not swapping to be less than the risk from swapping, and HoustonKemp present no evidence on this matter.*
>
> [Emphasis added.]

58. The AER does not explain why it believes that there is a requirement that the correlation be 'sufficiently negative and stable for there to be a natural hedge (e.g. a correlation coefficient close to 1)'. A negative correlation means that, on average, the variables move in the opposite direction to each other. This is all that is required for there to be a natural hedge. It is correct that the magnitude of the natural hedge may be larger or smaller depending on how negative the correlation is and depending on how large the relative variability of the DRP and swap rates is. However, these factors go to the magnitude of the natural hedge – not the existence of the natural hedge.

59. Once a negative relationship between DRP and swap rates is accepted it follows that a natural hedge exists and that less than 100% hedging is efficient. The magnitude of this effect can be established through precisely the type of analysis provided in the previous section (using Lally's empirical framework). We examine this in more detail in section 5.2.

60. Contrary to the assertion by the AER, Lally does not agree that a correlation coefficient of close to negative 1 is required for a natural hedge to exist. Lally's statement is restricted to a binary comparison of 0% and 100% hedging – with Lally then correctly arguing that a negative correlation does not automatically make 0% hedging less risky than 100% hedging. Lally does not make a definitive statement that a negative correlation would in itself be insufficient to conclude that less than 100% hedging is optimal. For the reasons set out above, Lally is quite correct not to fall into the error that the AER has (and which the AER incorrectly ascribes to him).

[16] AER, Final Decision Ausgrid Determination, April 2015, p. 3-502.

61. That there is a negative relationship between DRP and risk free rates is incontrovertible. We survey the evidence from the empirical literature and a range of other sources from a range of different countries in Appendix B, Appendix C and Appendix D respectively. All of the evidence points to a strong negative correlation. In any event, the evidence presented in the previous section and in 5.2 below clearly demonstrates that the strength of this negative correlation implies an optimal hedging ratio that is not only below 100% but closer to 0% than 100%.

3.6 Summary of empirical literature

62. The empirical literature surveyed in Appendix B investigates the relationship between the DRP and base interest rates, consisting of a long line of papers that each found a negative association between the DRP and interest rates. These papers formulated regression models using DRP as the dependent variable and risk-free rates as one of the independent variables. Consequently, if the regression coefficient is negative then less than 100% swap hedging is efficient, and the more negative the coefficient the smaller the percentage of swap hedging that is efficient.

63. A summary of the coefficients on the risk-free rate explanatory variable as estimated in various empirical studies is shown in Table 1, along with the explanatory variables used in each respective model. These results show that a change in the risk-free rate is typically associated with a negative change in the debt risk premium, and that such an observation holds across almost all credit ratings, maturities, and leverage values. Table 1 is also replicated in Table 9 of Appendix B.

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Table 1: Summary of empirical estimates in literature

	Coefficient of the risk-free rate	Category	Explanatory variables
Longstaff and Schwartz (1995)	-0.184	Baa utilities	• Change in Treasury bond yield • Return on stock index
Duffee (1998)	-0.424	Baa non-callable bonds with long maturities (15 to 30 years)	• Change in 3-month Treasury bill yield • Change in slope of the Treasury term structure (difference between 30-year and 3-month Treasury bill yield)
Collin-Dugresene et al (2001)	-0.211	Bonds with >55% leverage and remaining term to maturity exceeding 12 years	• Change in firm leverage ratio • Change in yield on 10-year Treasury • Squared change in yield on 10-year Treasury • Change in 10-year minus 2-year Treasury yields • Change in implied volatility of S&P 500 • Return on S&P 500 • Change in slope of Volatility Smirk
Huang and Kong (2003)	-22.4 (bp)	BBB-A bonds with maturities exceeding 15 years	• Changes in yield of Merrill Lynch Treasury Master Index • Changes in yield of Merrill Lynch 15+ years Treasury Index minus yield of Merrill Lynch 1-3-year Treasury Index • Changes in historical volatility of Merrill Lynch Treasury Master Index yields
Landschoot (2008)	-0.40	US BBB bonds	• Default risk factors (interest rate and stock market variables) • Liquidity risk factors • Credit cycle • Taxation
Lepone and Wong (2009)	-16.44 (bp)	BBB Australian Corporate bonds	• Changes in the 10 year government bond yield • Changes in the squared value of the 10 year government bond yield • Changes in the yield of 10 year government bonds minus the yield of 3 year government bonds • Changes in the volatility implied by options on 3 year government bond futures • Changes in the leverage ratio of banks and financial institutions • Returns on SPI 200™ Index Futures • Changes in the volatility implied by options on SPI 200™ Index futures • Changes in the dollar value of outstanding corporate bonds • Changes in the total net fund flow to bond mutual funds, standardised by net assets
QTC (2012)	-0.4 (correlation coefficient)		• The correlation between the DRP from the Bloomberg 7-year BBB Fair Value Curve and the 7 year risk-free rate from 2001 onwards

64. The published literature provides strong support for the existence of the negative relationship between risk free rates and the DRP, which in turn suggests that the optimal hedging ratio should be less than 100%.

65. However, while the published results clearly indicate that a hedging ratio of less than 100% minimises interest rate risk, they do not help us to clearly identify that particular ratio which minimises interest rate risk. This is done in section 4.4 and 5.2.

3.7 Other evidence of negative correlation

66. Lally, Chairmont and CEG have all presented time series data of DRP and risk free rates to the AER. These datasets are described in Appendix C. However, in all of them the correlation coefficients between DRP and the 10-year swap or Treasury rate are negative. The slope coefficients for all three datasets range between -0.15 to -0.71, which is broadly in line with empirical literature estimates in Table 1.

Table 2: Correlation coefficients for datasets submitted to the AER

Dataset	Correlation
CEG AU (not including pre 1998 DRP)	-0.45
CEG AU (assumed constant DRP pre 1998)	-0.51
Chairmont (1991 to 2001 DRP assumed to move with CGS/swap rate spread)	-0.41
FRED US – 1986 onwards	-0.56

Source: CBASpectrum, RBA, Bloomberg, Chairmont, Federal Reserve Bank of St Louis, CEG analysis

67. In addition to these time series datasets (two of which have been identified by the AER's consultants) we have used Bloomberg and the Federal Reserve Bank of St Louis "FRED" to examine a range of other datasets. The correlations between DRP and their corresponding 10-year local currency swap rates are described in Appendix D and are summarised in Table 3 and Table 4 below. They show a universally, and with one exception, strongly, negative correlation.

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Table 3: Correlations obtained from Bloomberg data

Bloomberg Ticker	Correlation	Bloomberg Ticker	Correlation
USD		**EUR**	
C00910Y Index	-0.554	C46810Y Index	-0.003
C03910Y Index	-0.518	**CAD**	
C52710Y Index	-0.426	C29710Y Index	-0.571
C56710Y Index	-0.709	C29910Y Index	-0.528
C01110Y Index	-0.437	**JPY**	
GBP		C45410Y Index	-0.513
C40510Y Index	-0.597		
Interquartile range	**-0.46 to -0.57**		

Source: Bloomberg, CEG analysis

Table 4: Correlations obtained from the Federal Reserve Bank of St Louis data

Series	Correlation
Moody's Baa Corporate Bond Yield©	-0.577
BofA Merrill Lynch US Corporate 7-10 Year Effective Yield©	-0.383
BofA Merrill Lynch US Corporate 10-15 Year Effective Yield©	-0.559
BofA Merrill Lynch US Corporate BBB Effective Yield©	-0.282
Range	**-0.28 to -0.58**

Source: Federal Reserve Bank of St Louis, CEG analysis

3.8 Swap hedging as a cost minimisation strategy

68. In footnote 10 of a recent report for the AER, Lally states:[17]

> *Jemena (2013, page 22) estimated the total cost at 0.09% based upon quotes from its banks. Chairmont (2013, page 19) provides the even lower estimate of 0.05%. By contrast, the average differential between the five and ten year swap rates has been 0.28% from 1.1.1988 to 31.8.2014, 0.25% from 1.1.2000 to 31.8.2014, and 0.46% from 1.1.2010 to 31.8.2014 (using Bloomberg data). So, net of the transactions costs of the swaps, the swap transactions would have yielded expected benefits of at least 0.15% as well as reducing risk. Using the 2008-2013 period, Jemena (2013, page 27) estimated the net gain at about 0.25%. It should also be noted that even hedging arrangements of this type consummated in the 10-40 business day window matching the risk-free rate averaging period allowed by the AER would be imperfect because the firms would have been paying the*

[17] Lally, Transitional arrangements for the cost of debt, 24 November 2014, p. 27.

> *five-year risk free rate (after swapping the ten-year rate for the five-year rate) prevailing at the beginning of the regulatory cycle whilst the AER would have been allowing the ten-year rate observed at the same time.*

69. In the first part of this passage, Lally is arguing that the average difference between the 10 and 5 year swap rates is higher than (some estimates of) the transaction costs of the swap strategy and, therefore, it is reasonable to believe that hedging using interest rate swaps will, on average, lower debt financing costs.

70. In response I note that Lally's estimates of transaction costs of swaps are on the low side relative to publicly available estimates. For example, the QCA has stated: [18]

> *Interest-rate swap contract transactions costs are typically around 15-20 basis points per annum…*

71. In a similar vein, the Australian Financial Markets Association (AFMA) submitted to the AER that "due to recent international regulatory developments it considers that interest rate swaps are likely to increase the cost of debt rather than reduce the cost of debt".[19] Moreover, these estimates of transaction costs do not include costs associated with moving the market price for swaps when attempting to undertake very large volumes over the relatively short averaging period adopted by the AER.

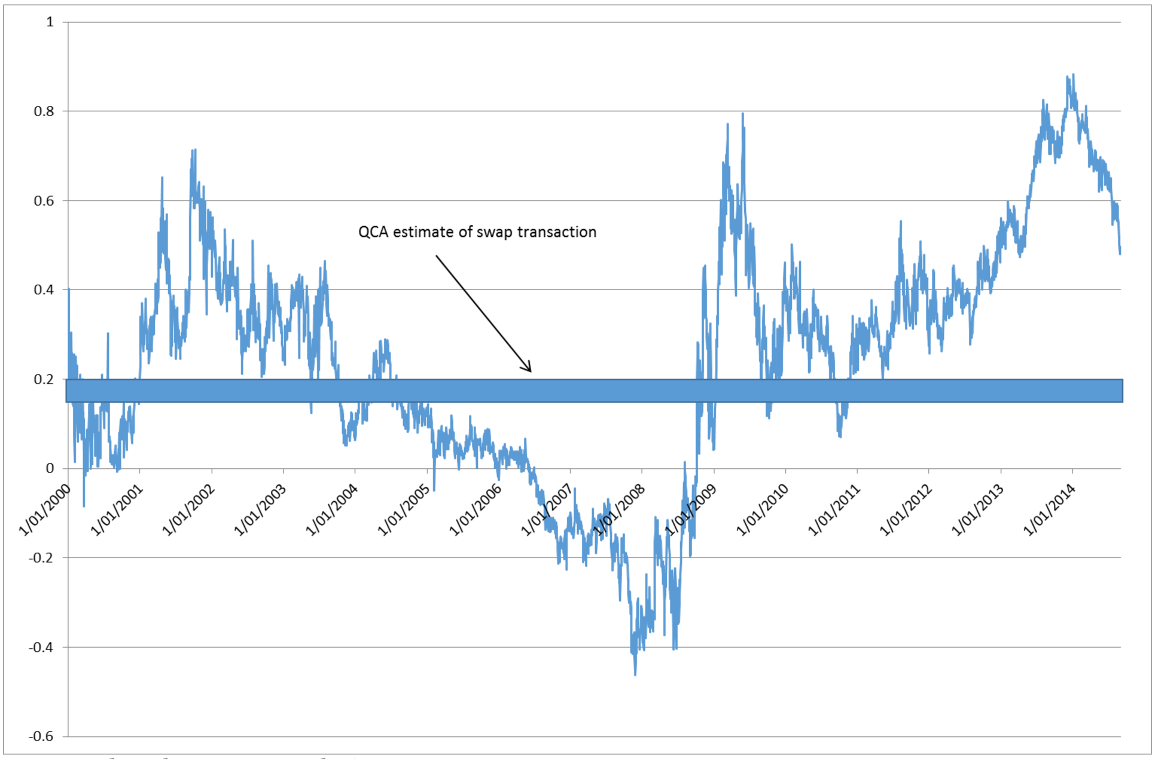
72. However, the last sentence of the above quote from Lally is highly relevant to an assessment of the efficacy of the interest rate swap strategy in *managing interest rate risk*.

73. Lally notes that under this strategy the business will pay the five year swap rate plus transaction costs and be compensated based on the 10 year swap rate (with no compensation for transaction costs). Figure 7 demonstrates that the difference between the 5 and 10 year swap rates is very volatile. Over the period analysed by Lally the 10 year swap rate has been as high as 88bp above the 5 year swap rate (January 2014) and as low as 46bp below the 5 year swap rate (November 2007).

18 QCA, Position paper: Long-term framework for SEQ water retailers – weighted average cost of capital (WACC), August 2014, p. 29.

19 AER, Explanatory Statement to the Rate of Return guideline, December 2013, p. 122.

Figure 7: Time series of 10 less 5 year swap rate



Source: Bloomberg, CEG analysis

74. This volatility in the difference between these swap rates reduces the value of the hedge associated with using interest rate swaps. That is, even putting aside the negative correlation with the DRP, the fact that the relativities between the 5 year swap rate plus transaction costs and the 10 year swap rate are unstable reduces the utility of using interest rate swaps to hedge even the base rate of interest.

75. Furthermore, the time series in Figure 7 shows that the 5-year swap rate can at times be higher than the 10-year swap rate. This is observed for an extended length of time from mid-2007 to mid-2009. There was, in effect, a negative spread between the 5-year and 10-year swap rates for an extended period of time from mid-2007 to mid-2009. A number of businesses were subject to regulatory resets during that interval. If those businesses had hedged for a regulatory period using vanilla interest rate swaps, then they would have locked in 5-year base rates of interest which surpassed the prevailing 10-year rates. Should this observation take place at the beginning of a regulatory period, then carrying out swap hedging becomes very expensive. This demonstrates that it is incorrect to assume that hedging can always be assumed to lower the cost of debt.

76. Of course, a business could speculate that the 5 year swap rate plus swap transaction costs will be below the 10 year swap rate. However, that is precisely what such a strategy would be; speculation. The word "speculate" is used here in the same manner that Lally and Chairmont use it below:

> *An efficient company will remain focused on its business(es) rather than taking on risks or costs in areas not necessary for the business strategy. For industrial companies this includes* ***avoiding speculation in financial markets*** *or taking risks which are not necessary. Any risk which is required to be taken must have the expectation of being adequately rewarded.*
>
> *It can be critical to business survival to follow this principle. When a company* ***speculates*** *on financial events or business areas in which it does not specialise, it typically is not set up to manage the risks appropriately. There is a history of failed organisations, e.g. Pasminco and Sons of Gwalia that either did not understand that the corporate treasury function was to manage interest rate or foreign exchange exposures, or took speculative positions that brought the company down.*[20]
>
> *It is also interesting to see from para 6.3 of Annexure BT-2 to Thiow's Statement that TransGrid engages in speculation (switching between nominal and inflation-linked debt, and between short-term debt and long-term debt depending upon market conditions), and engaging in such speculation would preclude the use of swaps for hedging in the manner under discussion here. Thus, an additional reason for TransGrid not using* ***swaps is its desire to speculate, but this is not efficient behavior*** *and therefore would not warrant a regulator granting the firm a different allowed cost of debt.*[21]

77. Both Lally and Chairmont argue that a utility business will efficiently focus on hedging its costs to the regulatory allowance. I agree with this view. In order to be consistent with this, to the extent that an interest rate swap strategy is to be judged efficient it must be on the basis that it successfully manages interest rate risk – not that it takes on risk in order to give rise to potential speculative gain.

3.9 Actual business practice

78. I understand that there is a wide range of business practices in terms of the use of interest rate swaps. For example, the NSW businesses have clearly stated that they did not use interest rate swaps to hedge the base rate at all and UBS[22] has provided analysis to the effect that this was an efficient strategy. The AER is correct that

20 Chairmont, Cost of Debt: Transitional Analysis, April 2015, p. 17-18.

21 Lally (2015), Review of Submissions on the Cost of Debt, April 2015, p. 46

22 UBS, Response to the Networks NSW request for financeability analysis following the AER Draft Decision of November 2014, 16 January 2015.

some (but not all) privately owned regulated energy businesses have used interest rate swaps.

79. Indeed, when I examine all of the references provided by the AER to support the above statement I find that four privately owned regulated businesses state that they adopt this strategy: AusNet, Envestra, Jemena and the Cheung Kong Infrastructure companies'.[23] Indeed, there are another 6 privately owned businesses that the AER has relied on to estimate the benchmark asset beta in its Guideline process. There is no reason to believe that the four firms which the AER describes as having used interest rate swaps define the benchmark efficient entity.[24]

80. However, even for these firms, the statements only make clear that some use of interest rate swaps is employed. They do not state that 100% of the base rate of debt is hedged using interest rate swaps. (Moreover, even in the presence of such statements, disentangling the properties of interest rate swaps between hedging the cost of debt and hedging the cost of equity allowances is problematic.)[25] For example, Mr Sim Buck Khim, Head of Jemena Treasury Department, stated[26]:

> *We also undertake hedging. Hedging is like an insurance policy against certain risks. For example we have currency hedges when we issue bonds in currencies other than Australian dollars. Similarly we also hedge against interest rates moving away from that forecast. In hedging interest rates, one of the factors that we consider for that* ***part of our asset base*** *that is regulated is when the AER sets our revenue reset because our* ***regulated revenues*** *cashflows are derived from* ***the interest rate used in the regulatory reset.***

23 Citipower, Powercor and SAPN which also comprise the listed Spark Infrastructure.

24 Indeed, I note that the actual gearing of many of these firms is materially higher than the benchmark assumption of 60% gearing. In the most recent five year period examined by Henry, the gearing for each of these companies is above 60% (Envestra has a gearing of 71%, Spark Infrastructure has a gearing of 67% and SPAusNet has a gearing of 63%). By comparison, the other two businesses in the same sample have a gearing of 60% (APA Group) and 51% (HDF). Moreover, the other three businesses (which have been delisted and therefore only appear in more dated samples) have a gearing of 40% (Alinta), 30% (AGL) and 66% (GasNet). See Henry, Estimating β: An update, April 2014, p. 21, Table 4.

25 Indeed, using interest rate swaps to hedge the cost of equity allowance is arguably more sensible given the AER's historical (and current) practice amounts to effectively adding a more or less fixed risk premium to the prevailing risk free rate. This meant that, in relation to the cost of equity, the inverse relationship between the risk premium the AER allowed and the base rate of interest did not exist. Thus, there was no natural hedge provided by these two elements and, consequently, hedging the base rate component would not undo any natural hedge.

26 Statement of Sim Buck Khim, Head of Jemena Treasury Department, Paragraph 5.25 to 5.26. The Joint Industry Associations (JIA), Submission on the explanatory statement: WACC review, February 2009, JIA Appendix E; https://www.aer.gov.au/node/11822.

> *One point to note with interest rate hedging, ... Although we can hedge movements in the bank bill swap rate, we cannot effectively hedge changes in the premium payable above the bank bill rate…* [Emphasis added]

81. This statement is not inconsistent with an interest rate hedging strategy that involves hedging less than 100% of the cost of debt allowance. The aspects of this statement that have been emphasised are also consistent with an interpretation of interest rate swap hedging being, at least in part, a hedge of the regulatory cost of equity allowance. That is, Mr Sim Buck Khim does not constrain his discussion to the component of the regulatory asset base or regulatory revenues that is associated with the debt financing component of the RAB in order to minimise interest rate risk.

4 Lally's (2015) analysis on the comparative risks of hedging and not hedging

82. Section 3 firmly establishes that there is a negative correlation between DRP and the corresponding base interest rates. I now analyse the effect that this negative correlation has on determining the hedging strategy which will minimise interest rate risk.

83. As already noted, in a recent report for the AER, Lally[27] has developed a framework for analysing the comparative risks of debt management strategies involving hedging and not hedging. In that report, Lally supports the AER's view that a 100% interest rate swap hedging strategy was efficient under the 'on the day' approach.

84. I devote this section to an analysis of Lally's framework, along with a critique of the approach in his 2015 paper.

4.1 Context of Lally's analysis

85. CEG originally provided analysis[28], using Australian data, that suggested that the trailing average debt management strategy was a better hedge to the prevailing cost of BBB debt (the 'on the day' rate previously used by the AER to set compensation for the cost of debt) than a strategy that involves using interest rate swaps to reset 100% of the base rates of interest every five years. Specifically, CEG found that the standard deviation of the difference between the prevailing cost of debt and a business's actual cost of debt was lower for the 0% swap debt management strategy than the 100% swap debt management strategy.

86. Lally criticised this analysis on two grounds.

    - The first ground was that CEG only compared the cost of each debt management strategy to the prevailing cost of debt at the same point in time. However, Lally notes that a regulatory period extends five years into the future from the point in time that the cost of debt allowance is set. In effect, the CEG analysis only analysed the relative quality of the hedge at the beginning of the (hypothetical) regulatory period; not over the whole period.
    - The second criticism was that the Australian time series was relatively short – which required the analysis to be undertaken with only 20 years of data.

27 Lally (2015), Review of Submissions on the Cost of Debt, April 2015.

28 CEG, Efficient debt financing costs: A report for Network NSW, 19 January 2015, section 4.5 on p. 22.

87. Lally sought to remedy both of these criticisms by using US data, for which there is a longer time series of the cost of BBB corporate debt, and by altering the CEG methodology to examine the quality of the hedge over the five years following the measurement of a given prevailing rate (in a hypothetical regulatory averaging period). Lally used US data from 1953 to 2014 for this purpose – all of which was taken from the Federal Reserve Bank of St Louis database ("FRED"). Lally did not attempt to correct the first claimed error and perform the analysis on the available Australian data.

88. When Lally made both of these changes, his results reversed those presented by CEG. In my opinion, Lally's methodology contains various flaws that invalidate his results. As will be shown in Sections 4.3 to 5.3, when these flaws are corrected, the results concur with CEG's conclusion that the trailing average debt management strategy provides a better hedge to the on-the-day rate compared to the hybrid swaps approach. This is observed for both US and Australian data, the latter of which had not been investigated by Lally.

4.2 Lally's methodology

89. In Appendix 2 of his report, Lally provides a detailed description of his methodology for comparing the risks of hedging and not hedging.[29]

4.2.1 Lally's dataset

90. Lally's dataset was obtained from the FRED database, which is available on the website of the US Federal Reserve Bank of St Louis.[30] Lally used the following monthly series in his analysis:

    i. Moody's seasoned Baa Corporate Bond Yield Relative to Yield on 10-Year Treasury Constant Maturity;[31]

    ii. 10-Year Treasury Constant Maturity Rate;[32] and

    iii. 5-Year Treasury Constant Maturity Rate.[33]

91. All three of these series are available from April 1953 onwards, and Lally's full dataset extends to January 2015.[34]

[29] Lally (2015), Review of Submissions on the Cost of Debt, April 2015.

[30] Lally (2015), Review of Submissions on the Cost of Debt, April 2015; see description on page 72.

[31] Available at: http://research.stlouisfed.org/fred2/series/BAA10YM

[32] Available at: http://research.stlouisfed.org/fred2/series/GS10

[33] Available at: http://research.stlouisfed.org/fred2/series/GS5

4.2.2 Lally's notation

92. Lally uses the following mathematical notation in Appendix 2 of his report (pages 71-73):

$DRP_{10}^{OTD(1)}$:	Prevailing 10-year DRP over a one-month window
DRP_{10}^{TA}:	Ten-year trailing average of the 10-year DRP
R_{f10}^{TA}:	Ten-year trailing average of the 10-year risk-free rate
$R_{f10}^{OTD(1)}$:	Prevailing 10-year risk-free rate
$R_{f5}^{OTD(1)}$:	Prevailing 5-year risk-free rate
$R_{f5}^{OTD(5)}$:	Prevailing 5-year risk-free rate, averaged over the regulatory reset month, the two months before, and the two months after

93. I make use of the same notation in the remainder of this document.

4.2.3 Key equations

94. On page 71 of his report, Lally identifies the regulatory allowed cost of debt under an on-the-day regime as the "sum of the prevailing ten-year risk-free rates and DRPs averaged over a short window shortly before the beginning of the regulatory cycle". If a one-month window is assumed, the average DRP is equal to the prevailing DRP. This is shown in Equation (13) of his report:

Equation (13)

$$k(All) = R_{f10}^{OTD(1)} + DRP_{10}^{OTD(1)}$$

Source: Lally (2015), pg 71, Equation (13)

95. The cost of debt incurred by a business that uses the trailing average approach would be "the sum of the ten-year trailing averages of the ten-year risk-free rate and the DRP":

$$k(Paid) = R_{f10}^{TA} + DRP_{10}^{TA}$$

Source: Lally (2015), pg 71

34 Lally (2015), Review of Submissions on the Cost of Debt, April 2015; see middle of page 72.

96. Lally thus defines the risk associated with the trailing average approach as the standard deviation of the difference between the regulatory allowed rate and the incurred cost:

Equation (14)

$$SD(All - Paid) = SD\left(R_{f10}^{OTD(1)} + DRP_{10}^{OTD(1)} - R_{f10}^{TA} - DRP_{10}^{TA}\right)$$

Source: Lally (2015), pg 71, Equation (14)

97. On the other hand, the hybrid (100% interest rate swap hedging strategy) approach generates a cost of debt equal to "the sum of the prevailing five-year risk-free rate (averaged over the regulatory reset month, the two months before, and the two months after) and the ten-year trailing average of the ten-year DRP":

$$k(Paid) = R_{f5}^{OTD(5)} + DRP_{10}^{TA}$$

Source: Lally (2015), pg 71

98. Similarly, Lally defines the risk incurred from engaging in these swaps as the standard deviation of the difference between the regulatory allowance and the incurred cost:

Equation (15)

$$SD(All - Paid) = SD\left(R_{f10}^{OTD(1)} + DRP_{10}^{OTD(1)} - R_{f5}^{OTD(5)} - DRP_{10}^{TA}\right)$$

Source: Lally (2015), pg 72, Equation (15)

99. Lally also investigates an alternative specification in which swaps are undertaken in the same month as the regulatory reset, which generates the following standard deviation:

Equation (16)

$$SD(All - Paid) = SD\left(R_{f10}^{OTD(1)} + DRP_{10}^{OTD(1)} - R_{f5}^{OTD(1)} - DRP_{10}^{TA}\right)$$

Source: Lally (2015), pg 72, Equation (16)

100. Lally notes, however, that the above equations implicitly assume that the "five and ten year swap rates are identical to the corresponding risk-free rates". He

acknowledges that this "is not the case", but elects not to use swap rate data because of its shorter time series.[35]

101. When estimating the regulatory allowed rate, *k(All)*, in Equation (13) of his report, Lally assumes that it is locked in at the beginning of each five-year regulatory cycle, and only resets every five years.[36]

102. In contrast, the incurred cost of debt, *k(Paid)*, is calculated every month, although the five-year risk-free rates in the two hybrid approaches are also locked in at the beginning of each regulatory cycle and only reset every five years.

103. Since all of the standard deviation equations contain at least one ten-year trailing average component, Lally sets the initial regulatory reset month in March 1963, and repeats the analysis for four other initial regulatory reset months in March 1964, March 1965, March 1966, and March 1967, before taking the average of the five standard deviations.

104. This means that Lally calculates the five standard deviations with reference to five sets of observations for five different initial regulatory reset months. For example, when the initial regulatory reset month is March 1963, the standard deviation is calculated assuming that the regulatory allowed rate and five-year swap rate are reset in March 1963, March 1968, …, March 2013. For the March 1964 initial regulatory reset month, the standard deviation is calculated assuming that resets take place in March 1964, March 1969, …, March 2014. The same applies to the sets of observations with initial regulatory reset months in March 1965, March 1966, and March 1967. The five standard deviations obtained from these five sets of observations are then averaged.

4.2.4 Key assumptions and results

105. Lally's methodology as described above implicitly makes use of the following assumptions:

    i. The benchmark efficient entity would issue 10% of its total debt requirements each year and spread evenly over the year, with each newly issued debt having a time to maturity of 10 years (implicitly there is a stable RAB that is neither growing or shrinking);

    ii. The benchmark efficient entity would have to pay interest on the 10-year debt based on the sum of the 10-year interest rates as proxied by the 10-year risk-free rate;

35 Lally (2015), Review of Submissions on the Cost of Debt, April 2015, page 73 to 74.

36 Lally (2015), Review of Submissions on the Cost of Debt, April 2015, page 72.

iii. The benchmark efficient entity can only use interest rate swaps to hedge the base (risk free) level of interest rates;

iv. The benchmark efficient entity can hedge the level of base interest rates for the five-year regulatory period – a process that involves converting all fixed rates of interest to become floating rate at the beginning of the regulatory period and then engaging in an interest rate swap transaction to convert the floating rates of interest into 5-year fixed rates. (This resets the risk-free rate component of interest rates every 5 years while leaving the DRP as a trailing average.)[37];

v. The hypothetical entity can only select either a trailing average (0% hedging) or hybrid swap (100% hedging) debt management strategy. Once the hypothetical entity has selected one of the two debt management strategies, it will not switch to the other strategy so long as the "on the day" regulatory regime remains indefinitely; and

vi. The debt management strategy that minimises interest rate risk is the strategy that minimises the standard deviation of the difference between the allowed and incurred costs of debt, which is proxied by the average standard deviation from five different possible starting months of the initial regulatory cycle.

106. Lally presents his results in Table 4 of his report:

Table 5: Lally (2015) Table 4, standard deviation of costs from regulatory allowance

Firm Policy	Std Dev
Enter swaps over 1 month	0.87%
Enter swaps over 5 months	0.82%
Do not use swaps	1.49%

Source: Table 4 in Lally (2015)

107. I have exactly replicated Lally's analysis to the number of decimal places that he provides.[38]

[37] It should be noted that Lally's analysis does not assume that the five year swap rate (which is the rate paid by the business) is a perfect hedge for the 10 year swap rate (which is implicitly built into the 'on the day' rate allowed by the regulator). That is, deviations between the 5 and 10 year swap rate will, other things equal, contribute to the measured standard deviations.

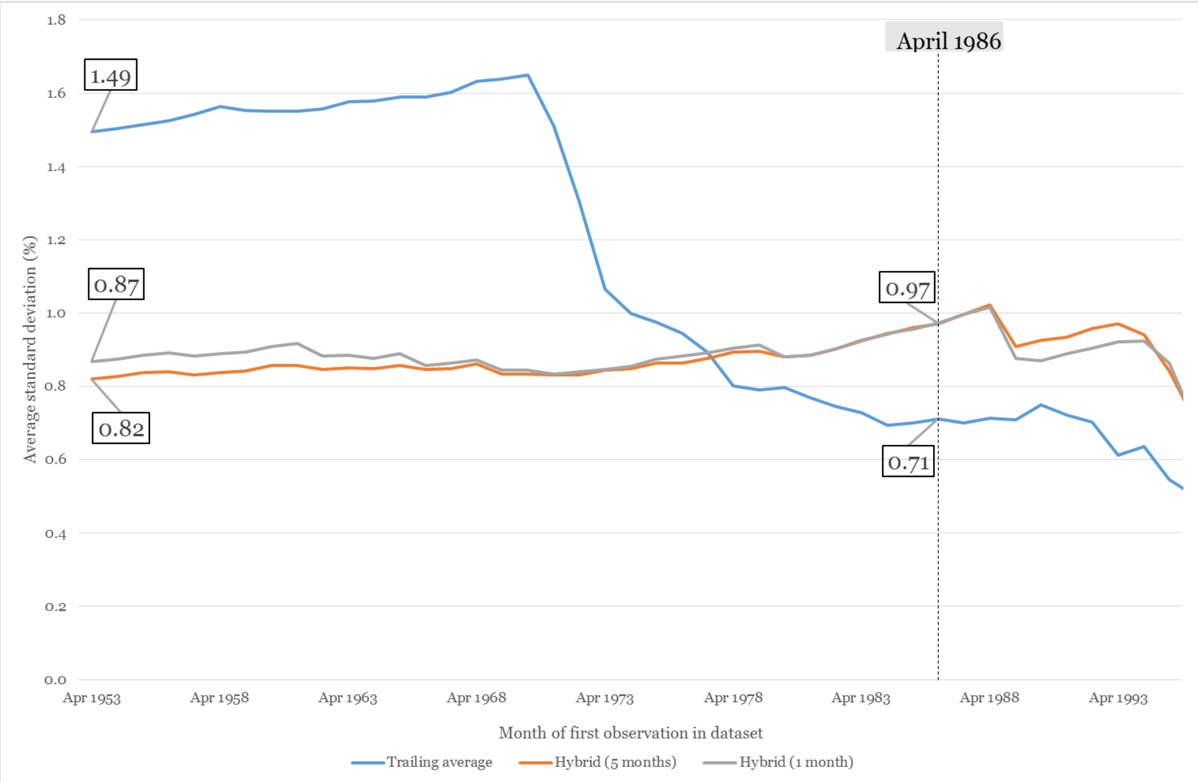
[38] See row 3 of Table 6.

4.3 Lally's results with different start dates

108. As argued in Section 3.4, Lally does not report the impact of choosing alternative start dates for his analysis.[39] However, it is a simple matter to do so from the same data and calculations that Lally used to generate the results he does report. I have done this and graphed the results in Figure 5, which I replicate in Figure 8 below for convenience.

109. The horizontal axis in Figure 8 is interpreted as the month of the first observation in the dataset, with the vertical axis being the average standard deviations that Lally's methodology would have produced had his dataset begun on that particular month.

Figure 8: Lally results with different start dates



Source: CEG analysis

110. The very first points (on the far left hand side) of each series in the above chart are the figures Lally reported in his Table 4 and which we reproduce above in Table 5 – corresponding to a start date of data of April 1953, at which the average standard deviation is calculated as the average of five standard deviations from five sets of

39 Lally investigates the effect of choosing different *regulatory cycles* in his analysis, but does not report the impact of different *start dates*.

regulatory cycles beginning in March 1963, March 1964, March 1965, March 1966, and March 1967.

111. Each point to the right of this reports the results of Lally's analysis starting one year later. For example, the point that corresponds to April 1954 is calculated as the average of five standard deviations from regulatory cycles beginning in March of 1964, 1965, 1966, 1967, and 1968.[40]

112. The chart in Figure 8 has to be interpreted carefully. The standard deviations in the chart are not calculated from a single five-year regulatory cycle. As explained in paragraph 104 of Section 4.2.3, Lally's approach involves assuming that the regulatory cycle resets every five years for each of these five sets of regulatory cycles. Thus, the standard deviation for the set of regulatory cycles beginning in March 1964 is calculated based on the differences between the regulatory allowed rate and the incurred cost for all months from March 1964 until January 2015, assuming that the regulatory cycle resets in March 1964, March 1969, ..., March 2009, and March 2014. The standard deviation for the cycles beginning in March 1965 is calculated based on the differences for observations from March 1965 and January 2015, assuming that the resets occur in March 1965, March 1970, ... March 2005, and March 2010. The five standard deviations obtained from the five sets of regulatory cycles are then averaged and used as the estimated level of risk associated with each debt management strategy.

113. It can therefore be seen from the above description that each point in Figure 8 is influenced by all of the observations in the dataset that come after the month indicated on the horizontal axis. That is, the average standard deviations that correspond to the 1950s and 1960s are calculated based on datasets that include the period of high and unstable inflation in the 70s and 80s. These standard deviations will thus have to be excluded from the analysis as well even though inflation in the 1950s and 1960s was not as high and unstable that of the 70s and 80s. In Appendix G, I repeat Lally's procedure using a dataset that consists of two separate periods from April 1953 to February 1970, and then from April 1986 to January 2015. This analysis confirms that the relatively high average standard deviation observed for the 0% swap strategy for datasets that correspond to starting months in the 1950s and 1960s as shown in Figure 8 can mostly be attributed to inflation in the 70s and 80s, with no influence from the 50s and 60s.

40 I note that the initial regulatory cycles do not necessarily have to begin in March. In fact, a more comprehensive analysis would calculate the standard deviations for 5*12 = 60 regulatory cycles to take intra-year variations into account, which I carry out in Section 5.1.1. However, following Lally's methodology, the analysis in this Section only evaluates the regulatory cycles beginning in March.

I further note that each standard deviation is calculated with reference to a set of observations assuming that the regulatory cycle resets every 5 years starting with the first month of the initial regulatory cycle.

114. The last point on the right hand side of Figure 8 corresponds to a 1995 start date for the data – which is the last year in which it is possible to perform the Lally analysis with all estimates covering at least one whole regulatory period. This point calculates the average standard deviations from regulatory cycles beginning in March 2005, 2006, 2007, 2008, and 2009.[41]

115. It can be seen that as the 1970s and early 1980s fall out of the data the standard deviation for the 0% swap strategy declines precipitously and falls materially below the standard deviation of the 100% swap hedging strategies.

116. For the reasons set out in Section 4.3.1, I regard the inclusion of the 1970s and early 1980s in the dataset as a material error. In summary, this is because this period was a high and unstable inflation environment in the US that:

- Did not reflect the market conditions under which the benchmark efficient entity is assumed to be undertaking its hedging strategy (which is a post inflation targeting period with low and stable inflation); and
- The assumptions underpinning Lally's analysis are false in a period where ex-post inflation is materially different to expected inflation (which was the case in the 1970s and early 1980s).

4.3.1 Why Lally's use of data from the 1970s and the first half of the 1980s is invalid

117. I consider that Lally's reported results are fundamentally flawed because they include the high and unstable inflationary environment of the 1970s and the first half of the 1980s. There are two reasons why the analysis should not include this period.

118. The first is that it was a radically different financial environment to that which existed in the 2000s under which the benchmark efficient entity (BEE) must be presumed to be determining its efficient debt management strategy. By the 2000s, consistent with the adoption of inflation targeting by central banks in the US and Australia, inflation had stabilised at low levels with limited volatility.

119. If it is the case that the 100% swap debt management strategy performs better in the 1970s/80s and the trailing average debt management strategy performs better from the 1990s onward then, unless it is reasonable to believe that a resurgence of 1970s style inflation was as likely as not to reoccur post 1990, the trailing average debt management strategy should be presumed to be more likely to minimise interest

[41] Lally's method requires 10 years of data (in order to inform the trailing average DRP and total cost of debt elements of costs) before any standard deviations can be generated. A further 5 years is required for Lally to set the start date of his shortest regulatory cycle. This means if the data starts in April 1996, the shortest of Lally's five regulatory cycles begins in March 2010 and ends in March 2015. Given that Lally's data ends in January 2015 this is less than one full regulatory cycle.

rate risk for a BEE operating in the low and stable inflation environment which describes the period of the 1990s onward. This is true even if, when analysed together, the 100% interest rate swap hedging strategy performs better over the whole period.

120. As I shall discuss below, it is the case that the 100% interest rate swap hedging strategy performs worse at managing interest rate risk than the trailing average from the 1990s onward and it is only its performance during the 1970s and early 1980s that makes it *appear* to be better performing overall.

121. This brings me to the second, even more important, reason why the 1970s and the first half of the 1980s should be excluded. The application of the Lally test is invalid in the 1970s and first half of the 1980s. This is because in high and unstable inflationary environments the prevailing nominal cost of debt estimated in the initial averaging period (and used as an input into the AER's PTRM model) will not be a good proxy for the actual nominal compensation provided by the regulatory process.

122. Under the 'on the day' approach, the PTRM has two critical inputs into it: a) the nominal cost of debt in the initial averaging period (R^{Prev}); and b) the expected inflation rate in the initial averaging period (π^{Exp}). These combine to deliver a real cost of corporate debt which is then escalated by actual inflation outcomes over the regulatory period (π^{Act}). Consequently, the nominal compensation for the cost of debt can be written as follows:

Nominal compensation = R^{Prev} - $\pi^{Exp} + \pi^{Act}$

123. However, without acknowledging this issue, Lally's analysis proceeds as if π^{Exp}=π^{Act}; such that the nominal compensation provided by the regulatory regime will be equal to the prevailing nominal cost of debt measured in the averaging period at the beginning of the regulatory period. This assumption is reasonable if the data used is taken from a low and stable inflation environment. It is not reasonable if the data is taken from a variable inflation environment where expected inflation was generally materially different to actual inflation.

124. Lally, himself, in separate advice to the AER in the rate of return guideline process argued that nominal government bond yields in the last century were artificially low because investors failed to anticipate inflation (π^{Exp} was systematically less than π^{Act}) and that this caused equities to outperform nominal bonds leading to a higher

estimated MRP.[42] In essence, Lally argued that the realised MRP has overstated the expected MRP for certain periods in the past.[43]

125. I do not endorse Lally's view that there was a systematic underestimation of inflation. However, I do endorse the view that during the 70s and early 80s, inflation was not accurately estimated. That is, it was both underestimated and overestimated at different times. However, what is important in the context of this report is that we both agree it was inaccurately estimated. We only disagree on whether there was a systematic bias in the direction of the inaccuracy. Irrespective of who is correct, the fact that there was an inaccuracy in inflation expectations means that this data period must be excluded from Lally's analysis. This is because, as explained above, Lally's analysis assumes that inflation is accurately anticipated at the beginning of the regulatory period.

126. Notwithstanding that Lally hs raised this issue in the context of estimating the MRP, in the current context Lally does not consider the importance of the under-estimation of inflation during the 1970s for his analysis in Appendix 2.

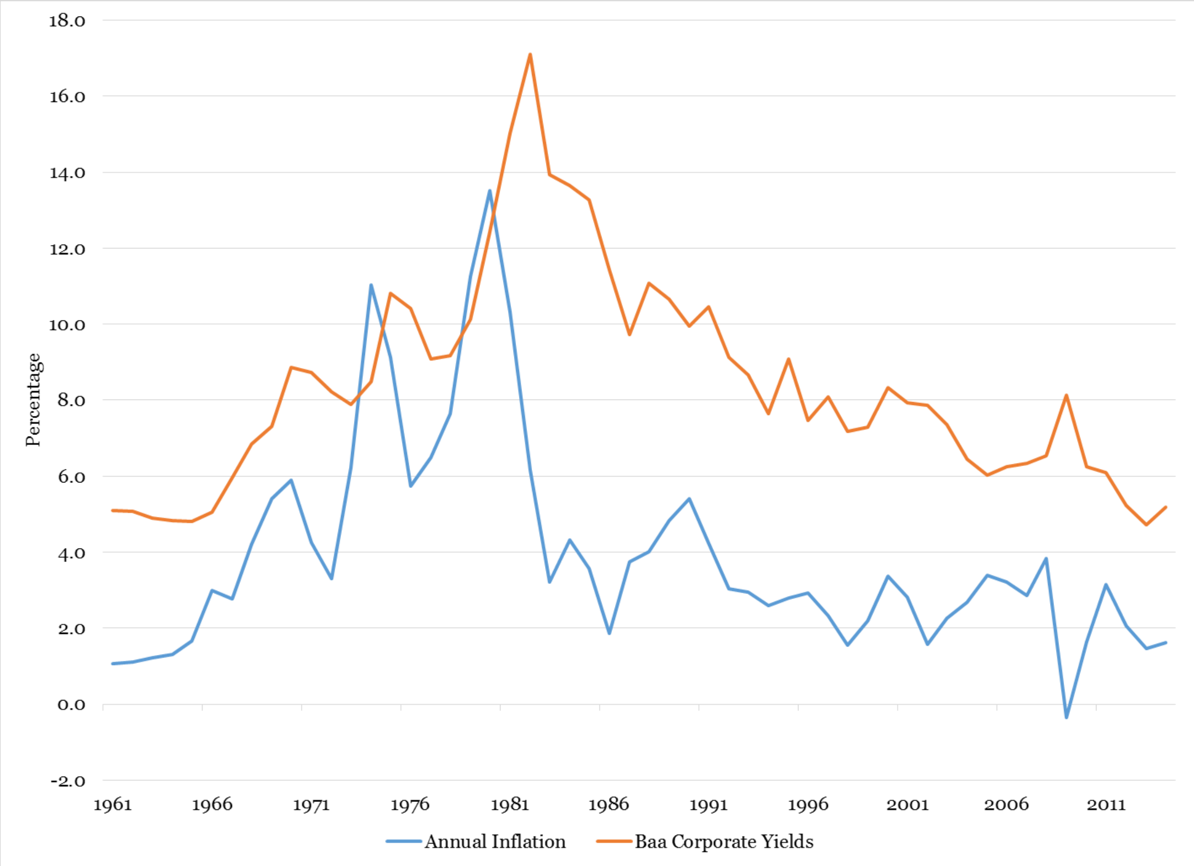
4.3.2 What period of data should be excluded

127. Figure 9 below shows the US Corporate Baa yields used by Lally relative to US inflation in the year immediately prior to the date at which the Baa yield is measured. It can be seen that inflation is high and variable over the 1970s and early 1980s.

42 For example, see Lally, Review Of The AER's Methodology For The Risk Free Rate And The Market Risk Premium, 4 March 2013, p. 29.

43 NERA (2013) provides evidence from two long-running US surveys of inflation forecasts that there was a tendency to under-estimate inflation up until the appointment of Paul Volcker as Chairman of the Federal Reserve in 1979 and then overestimated over the first half of the 1980s before actual inflation and inflation expectations stabilized under the inflation targeting regime introduced by Volcker. See NERA, The Market, Size and Value Premiums, a report prepared for the Energy Networks Association, June 2013, pp. 21-22.

Figure 9: US annual inflation rates and Baa Corporate bond yields: 1961 to present



Source: FRED database

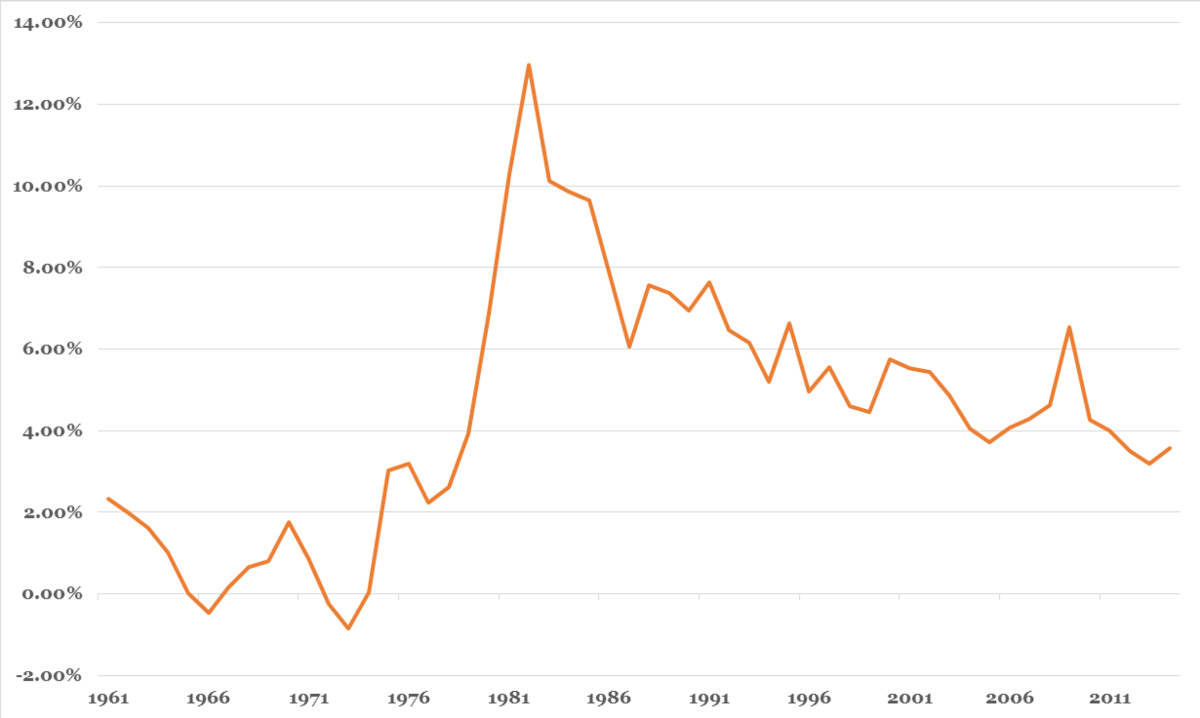
128. Over this period, it is simply not reasonable to assess the risk properties of a debt hedging strategy 'as if' actual and expected inflation were the same. Visual inspection of the above graph shows that yields responded with a lag to movements in inflation – both up and down strongly suggesting that the actual inflation outcomes were not expected.

129. This is illustrated in Figure 10 below which shows the real (*ex post*) return on a 10 year bond issued at the Baa corporate yield[44] used by Lally (calculated as yield less the subsequent average inflation rate over the next 10 years[45]).

44 It is not clear that this is always a 10 year yield; despite the fact that the series is expressed relative to the 10 year Treasury yield.

45 Using the Fisher equation and, where less than 10 years inflation is available (i.e., from 2004 onwards) using what inflation outcomes are available.

Figure 10: US real return on Baa corporate bond yields



Source: FRED database

130. This chart suggests that investors materially underestimated prospective inflation from the early 1960s to the late 1970s (often receiving negative real returns on bonds) and then materially overestimated inflation until the late 1980s (when real yields fell down to around 7% or less).

131. I consider that, when using US data, the earliest date at which it could be reasonable to assume that expected and actual inflation are aligned is from 1986 onwards – when inflation had been below 6% for 3 consecutive years (1983 to 1985) and *ex post* real Baa bond yields stabilised around 7% or lower. In the 4 years prior to 1986 real *ex post* real bond yields averaged 10.25% and were between 9.3% and 12.5% (compared to the level of 6.4% reached in January 2009 at the height of the GFC).

132. The high level of *ex post* Baa corporate real bond yields suggests that, prior to 1986, investors were anticipating much higher inflation than actually occurred. Therefore, Lally's implicit assumption that the regulatory process would deliver nominal compensation equal to the nominal cost of debt is incorrect. The regulatory process would deliver materially lower nominal compensation – based on actual inflation being materially lower than expected inflation.

133. For example take the peak in BAA yields of in excess of 16% in the early 1980s. This peak was hard on the heels of peak inflation of just under 14% - suggesting the 16% yield peak was driven by peak expected inflation. For the purpose of this example, imagine that investors' expected inflation was 10% and that the regulator correctly

estimated this and put both 16% nominal cost of debt and 10% inflation expectations into the PTRM (or equivalent version of the AER's regulatory model). However, actual inflation after that point averaged around 4%. In this circumstance, nominal compensation provided to the business would be around 10% - which is the nominal cost of debt at the time the regulatory decision is made (16%) less expected inflation at the same time (10%) plus actual inflation over the regulatory period (4%).

134. However, Lally's analysis is incorrectly set up to assume that, in this circumstance, actual nominal compensation equals the nominal input into the PTRM. This assumption is only strictly/approximately valid where expected and actual inflation are the same/similar. This clearly was not the case in the 1970s and early 1980s.

4.4 The required use of swaps to minimise risk

135. As was argued in Section 4.3, Lally's presentation of his empirical work does not identify the use of swaps that minimises risk, it simply compares one extreme (100% hedge) strategy with another extreme (0% hedge) strategy. Lally's dataset and methodology is capable of answering this question. All that is required is to repeat his analysis to estimate the standard deviation for a range of different strategies (e.g., 0% use of swaps, 1% use of swaps, 2% use of swaps … up to 100% use of swaps).

4.4.1 Lally's analysis compares two extremes – does not identify the use of swaps that will minimise interest rate risk

136. Lally's original analysis purports to show that a 100% swap strategy provided a better hedge to the "on the day" allowance than a 0% hedge strategy. Correcting the error identified in section 4.3.1 reverses this conclusion. However, even putting that error (and other methodological problems) aside, Lally has also not addressed the correct question.

137. Lally and the AER believe that the efficient debt management strategy under the "on the day regime" is one that minimises interest rate risk relative to the "on the day" allowance. The AER proposes to set future compensation based on the assumption that the benchmark efficient entity undertook such a debt management strategy in the past. It therefore must seek to identify the most efficient debt management strategy – the one that minimises interest rate risk relative to the "on the day" allowance.

138. However, this is not what Lally's empirical work seeks to do. It simply seeks to test whether a 100% hedge strategy is has lower interest rate risk than a 0% hedge strategy. The correct question that Lally and the AER must address is not whether one extreme is better than the other; the correct question is what percentage use of interest rate swaps was most efficient.

139. Even if we accept all of the other elements of Lally's (and the AER's) conceptual framework this restriction to a binary comparison is an error. If the objective against which efficiency is to be assessed is the minimisation of the variance of actual costs from the regulatory allowance, the question is not whether one extreme (in terms of the use of interest rate swaps) has more/less interest rate risk than the other. The question should be what use of interest rate swaps minimises interest rate risk.

140. In my view, if this question had been the one posed by Lally or the AER then their conclusions would have been radically different. In particular, Lally's analysis in Appendix 2 would have tested what percentage use of swaps would have minimised the standard deviation of the difference between costs and allowance; not whether 0% use of swaps had a higher or lower standard deviation than 100% use of swaps.

141. I have done this in section 5.2, making a number of relatively minor modifications to Lally's methodology to make it more robust. Without making any modification to Lally's methodology and using his full dataset, I estimate that the optimal hedging ratio would have been 81% (see below). However, in section 5.2, I make modifications to Lally's methodology, the effect of which is that the optimal hedging ratio falls to 74-78% when using the full data set. Moreover, as described in the preceding section, I consider Lally has erred by including in his dataset the high and volatile inflation environment of the 1970s and early 1980s. When I exclude this period the hedging ratio which minimises interest rate risk falls to 17% without any other modifications to Lally's methodology or to 23-38% with the modifications that I perform in section 5.2.

4.4.2 Identifying the hedging ratio which minimises interest rate risk

142. As stated in Section 4.2, Appendix 2 of Lally (2015) defines the cost of debt under the trailing average approach as the sum of the ten-year trailing averages of the ten-year risk-free rate and the DRP:

$$k(Paid) = R_{f10}^{TA} + DRP_{10}^{TA}$$

143. Meanwhile, the cost of debt under a 100% swaps strategy is the sum of the prevailing five-year risk-free rate and the ten-year trailing average of the ten-year DRP:

$$k(Paid) = R_{f5}^{OTD} + DRP_{10}^{TA}$$

144. The cost of debt incurred under a particular hedging ratio, x, is thus a weighted average of the costs of debt under the two approaches above:

$$k(x\%\ swaps) = xR_{f10}^{TA} + (1 - x)R_{f5}^{OTD} + DRP_{10}^{TA}$$

145. Equation (13) in Lally (2015) also defines the regulatory allowed rate as the sum of the prevailing ten-year risk-free rates and DRP over an assumed one-month window:

$$k(All) = R_{f10}^{OTD(1)} + DRP_{10}^{OTD(1)}$$

146. In turn, Equations (14) and (15) in Lally (2015) define the risk incurred from a particular debt strategy as the standard deviation of the difference between the regulatory allowed rate and the corresponding cost of debt under the selected debt strategy. Under a particular hedging ratio, x, this would be:

$$SD_x(All - x\%\ swaps) = SD\left(R_{f10}^{OTD(1)} + DRP_{10}^{OTD(1)} - xR_{f10}^{TA} - (1-x)R_{f5}^{OTD} - DRP_{10}^{TA}\right)$$

147. For Lally's full dataset beginning in April 1953, the average standard deviation for hedging ratio x would then be:

$$Average\ SD = \frac{SD_{x,1963} + SD_{x,1964} + SD_{x,1965} + SD_{x,1966} + SD_{x,1967}}{5}$$

148. The relevant hedging ratio for the full dataset would thus be the ratio "x" that produces the smallest average standard deviation as calculated from the equation above. Of course, the above formula can also be applied to different starting months by adjusting the subscripts accordingly.

149. I have computed this optimal value of x using the following steps, which I apply on Lally's FRED dataset.

i. Compute the average standard deviations for 101 debt management strategies, ranging from 0% to 100% hedging in 1% increments. These 101 average standard deviations are computed as the averages of the 101*5 standard deviations corresponding to the 5 unique regulatory cycles examined by Lally. In turn, each of the 101*5 standard deviations are calculated from the mismatches between the allowed and actual costs of debt series for different hedging ratios;

ii. Determine the optimal hedging ratio as the one that has the lowest average standard deviation out of the 101 obtained in step (i).

iii. Repeat the process but adopting a start date that is one year later – such that a time series is developed of the hedging strategy which minimises interest rate risk beginning with Lally's full dataset and a series of ever shorter datasets until a start date of April 1995 is reached.[46]

[46] See footnote 41 in Section 4.3 for an explanation of why the shortest dataset uses April 1995 as the initial starting month of the first regulatory cycle.

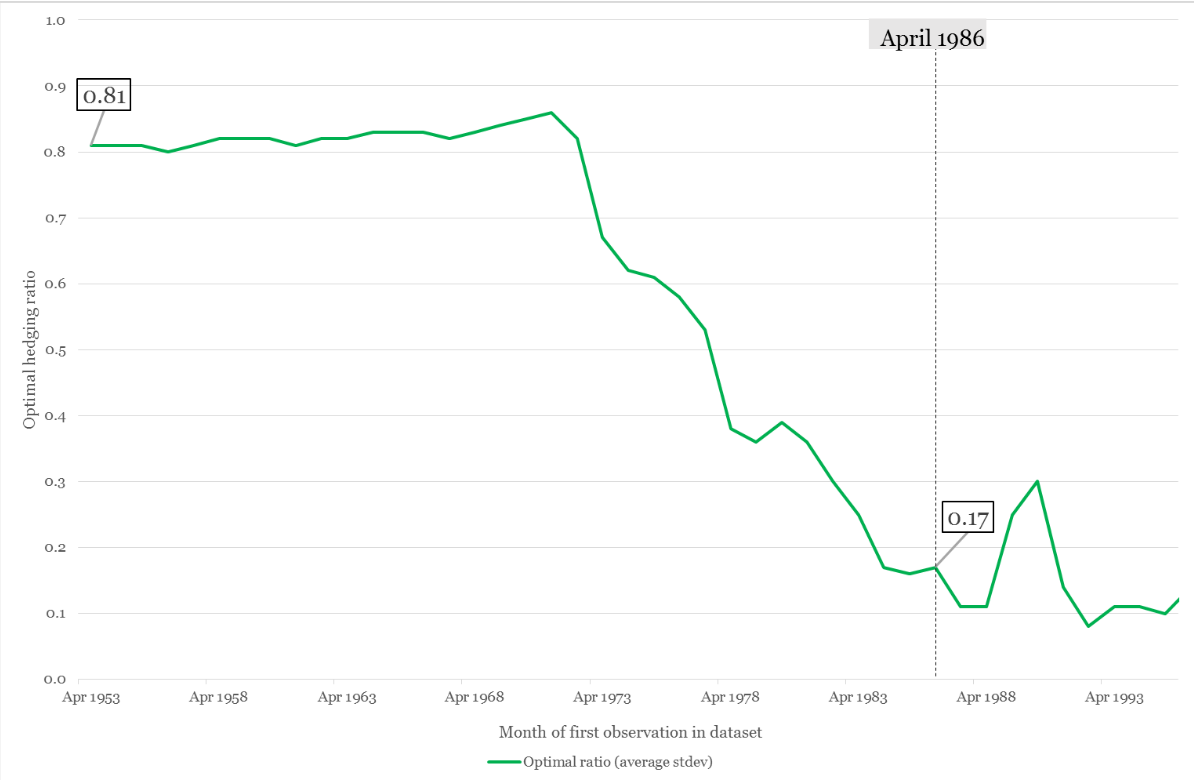
4.4.3 Results

150. The optimal hedging ratios that minimise Lally's average standard deviation statistic are shown in Figure 6 of Section 3.4 for different initial starting months of Lally's US FRED dataset. The chart is also replicated in Figure 11 below for convenience. The very first point on the left hand side of the chart indicates that the optimal hedging ratio for Lally's full dataset starting in April 1953 is 81%.

151. Had the analysis excluded the high and unstable inflationary environments in the 1970s and 1980s, and considered only the data from 1986 onwards, the optimal hedging ratio would have been a substantially lower (17%).

152. In any case, it is clear from Figure 11 that Lally's analysis does not support an assumption that 100% hedging minimises risk – over all possible start dates standard deviation is minimised using less than 100% interest rate swap hedging.

Figure 11: Hedging ratios which minimise interest rate risk for different starting observations



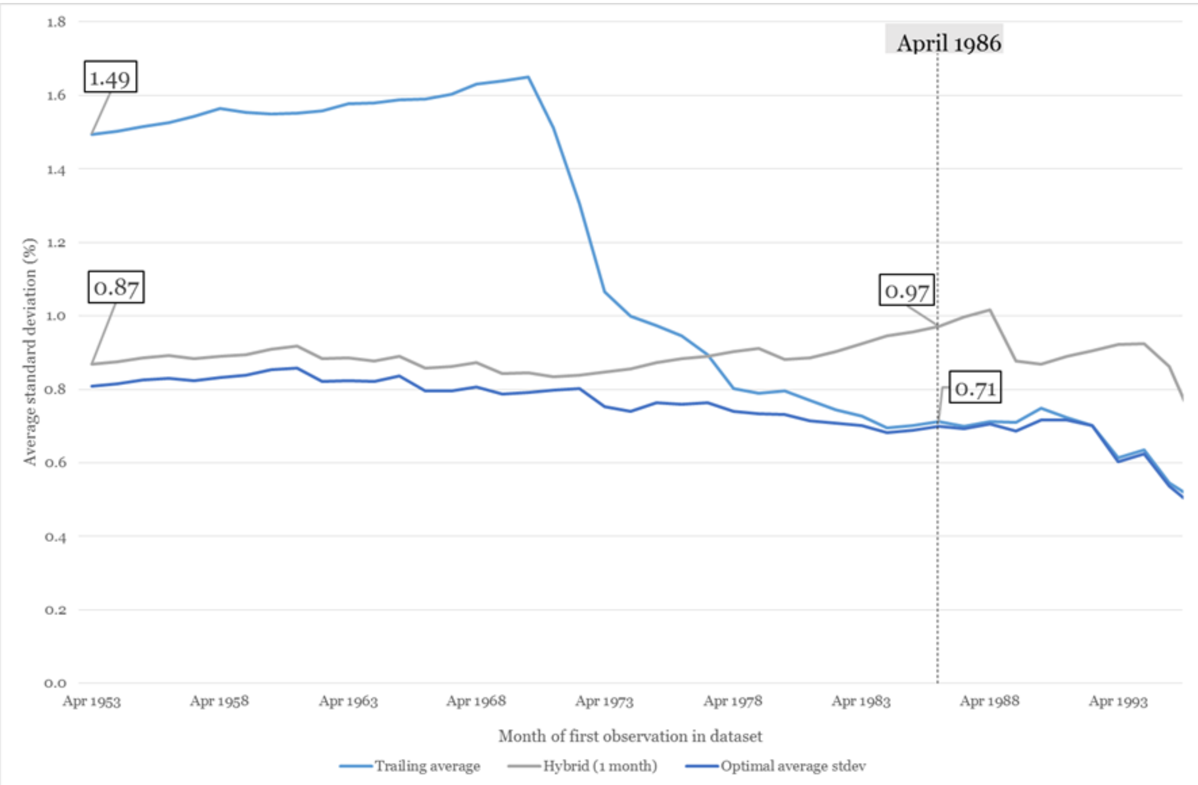
Source: CEG analysis

153. Figure 12 replicates the average standard deviations of the trailing average and two hybrid (100% interest rate swap hedging strategy) approach shown in Figure 8, but further plots the optimal average standard deviations that would have been

obtained had the benchmark firm applied the optimal hedging ratios shown in Figure 11.

154. As expected, the average standard deviation associated with the hedging ratio that minimises standard deviation is a lower bound of the trailing average (0% hedging) and 1-month hybrid (100% interest rate swap hedging) approaches. It can also be seen that if the dataset begins in April 1983 and onwards, the trailing average approach produces average standard deviations that are very close to (nearly indistinguishable from) minimal risk. By contrast, the standard deviation associated with the 100% use of interest rate swaps is demonstrably higher than the standard deviation associated with the use of swaps which minimises interest rate risk.

Figure 12: Standard deviation associated with hedging ratios which minimise interest rate risk for different starting observations



Source: CEG analysis

155. As was the case with Figure 8 in Section 4.3, the charts in Figure 11 and Figure 12 must be carefully interpreted, because they are not obtained from single five-year regulatory cycles. Paragraphs 112 to 113 explain that the horizontal axis represents the month of the first observation in the dataset, with the average standard deviations in Figure 12 being computed as the average of five standard deviations obtained from five separate sets of regulatory cycles, each with resets occurring

every five years. Similarly, the optimal hedging ratios in Figure 11 correspond to the hedging ratios that minimise the average of the five standard deviations that would have been obtained for a particular starting observation of the dataset, such that each point in both figures will incorporate all subsequent observations. Once again, in Appendix G, I confirm that the relatively higher standard deviations obtained for the 0% swaps strategy from datasets that correspond to starting months in the 1950s and 1960s can mostly be attributed to inflation in the 70s and 80s, with no influence from the 50s and 60s.

156. Figure 13 shows the average standard deviations (vertical axis) of 101 debt management strategies (horizontal axis), ranging from 0% to 100% hedging in 1% increments. It does so for both:

- Lally's full dataset beginning in April 1953; and
- the dataset with the first observation in April 1986.

157. The points on the left most side of the series correspond to a trailing average approach with 0% hedging, while the right most points correspond to a 1-month hybrid approach with 100% hedging.

158. With Lally's full dataset, the hedging ratio which minimises interest rate risk is 81% (horizontal axis), which generates an average standard deviation of 0.81%. This is lower than the 1.49% and 0.87% average standard deviations for the trailing average and 1-month hybrid approaches shown at both ends of the chart and presented in Table 4 of Lally's report.

159. For the dataset that begins in April 1986, the relevant hedging ratio is 17%, with a corresponding average standard deviation of 0.70%. This is lower than the 0.71% and 0.97% standard deviations shown at the ends of the chart.

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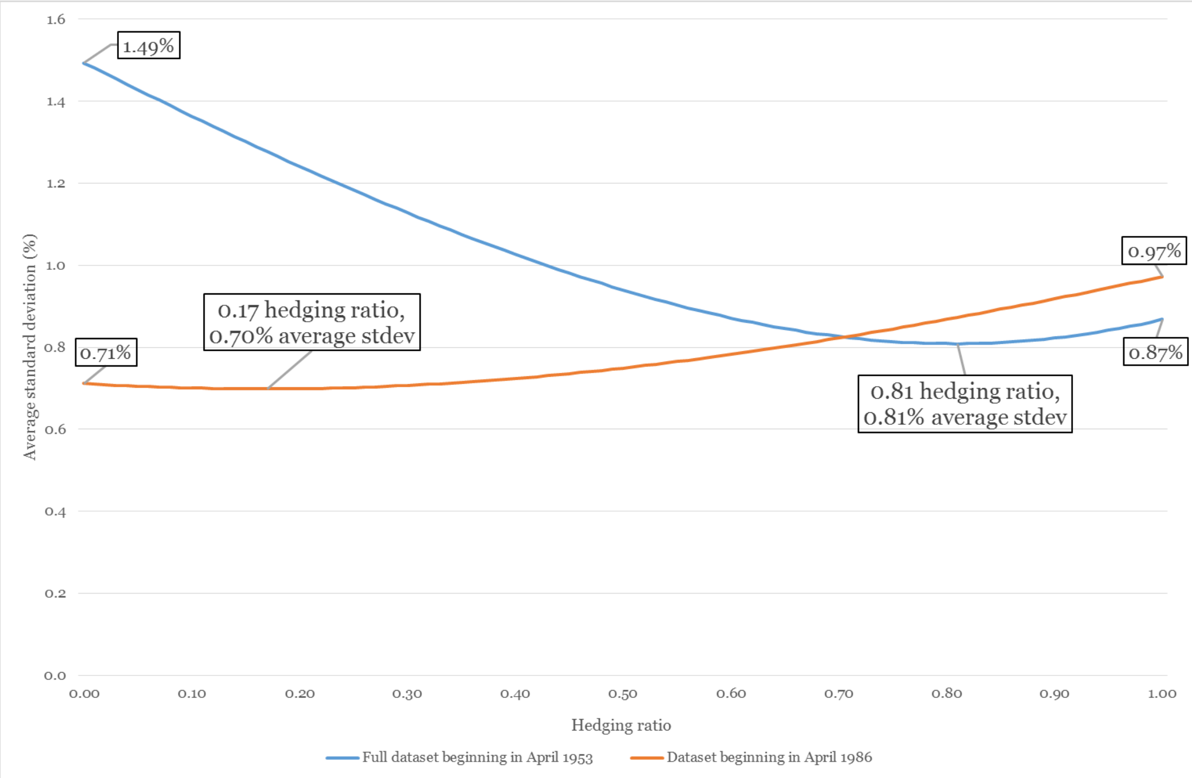
Figure 13: Average standard deviations from 0% to 100% hedging for data beginning in April 1953 and April 1986



Source: CEG analysis

4.5 Summary

160. This section has replicated Lally's methodology with only two minor modifications to address the criticisms that I made in Sections 4.3 and 4.3.1. First, the impact of varying the first observation in the dataset was investigated. Second, the hedging strategy was allowed to vary between 0% and 100% hedging ratios.

161. When the first observation in the dataset is April 1977 or later, such that the five initial regulatory starting months are in March 1987 to March 1991 or later, the trailing average approach produces lower average standard deviations than the 1-month swaps approach.

162. When hedging ratios are allowed to vary between 0% and 100%, Lally's original full US FRED dataset identifies 81% as the hedging ratio that minimises interest rate risk. When all observations up to December 1985 are excluded, the relevant hedging ratio falls to 17%.

5 Amendments to Lally's methodology

5.1 Weaknesses in Lally's methodology

163. In addition to his failure to adjust for unstable inflation in the 1970s and the first half of the 1980s, Lally's methodology can be made more robust by considering the following variations/sensitivities:

i. Evaluate the effect of changing the regulatory reset month from March in each year – so that instead of examining 5 unique regulatory cycles I examine 60 unique regulatory cycles. In addition, increase the number of valid observations by allowing the regulatory period to start at any time in the four years and 11 months prior to a full ten years of data becoming available.[47]

ii. Use standard deviation measured across all regulatory cycles concurrently rather than estimating the standard deviation for each cycle and then taking an average;

iii. Report the uncentred standard deviation as well as the standard deviation of the difference between the incurred cost and the regulatory allowed rate;

iv. Use Australian data;

v. Examine whether the results are affected by trends in the base interest rate.

vi. Identify the optimal hedging ratio that minimises the metric of risk (standard deviation in Lally and the uncentred standard deviation measure introduced by me);

5.1.1 60 rather than 5 regulatory cycles examined

164. There are sixty unique hypothetical 5 year averaging period cycles – each one starting in a different month of any 5 year period; and then repeating with a new regulatory period starting in the same month five years later. For example, there are five unique regulatory periods starting in January; being January 1986, 1987, 1988, 1989 and 1990. The regulatory cycle beginning in January 1991 is not an additional unique cycle because it is a subset of the regulatory cycle beginning in

47 For example, if 10 years of data become available, such that a cost estimate is available for the trailing average cost of debt/DRP in March 1976, then the difference for that incurred cost of debt (in March 1976) is estimated relative to the on-the-day cost of debt for any one of 59 regulatory periods that could possibly have started in any one of the preceding 59 months.

January 1986. The same logic applies for each month of the year and, consequently, there are 60 (5*12) unique regulatory cycles.[48]

165. Lally keeps the month in which the regulatory cycle is assumed to start constant (March) but allows the year in which the regulatory cycle starts to vary; such that there are five regulatory cycles that all begin in March of five different years. Varying the month as well as the year is a more robust way to perform the analysis because there are intra-year variations in interest rates.

166. For the US dataset, I allow the regulatory cycles to begin in each of the 60 months from January 1991 to December 1995. This effectively makes two changes to the Lally methodology. The first is to use 60 regulatory cycles rather than 5. The second is to allow a comparison of costs and allowance for partial regulatory periods, such that the later regulatory cycles will have only partial data for the initial regulatory period, but all 60 sets of regulatory cycles will have the same number of observations overall.[49] Charts of the 60 standard deviations and uncentred standard deviations obtained from the post-Volcker dataset can be found in Figure 37 and Figure 38.

167. For the purpose of Table 6 below, only the first of these changes has been implemented in order to be able to compare Lally's results for regulatory cycles beginning in March (the row that corresponds to March generates identical average numbers to Table 4 in Lally (2015)).

48 As explained in Section 4.2.3, each standard deviation is calculated with reference to a set of observations, assuming that the regulatory cycle resets every 5 years starting with the first month of the initial regulatory cycle. As such, my modification of evaluating 60 initial regulatory cycles means that the reported average standard deviation is calculated as the average of 60 standard deviations corresponding to 60 sets of observations, whose initial regulatory cycles have different starting months.

49 Lally's methodology sets the initial regulatory cycles to begin 10 years after the month of the first observation in order to produce a 10-year trailing average. By doing so, Lally's methodology causes the subsequent, initial regulatory cycles to have less observations. Specifically, Lally investigates five different initial regulatory cycles, beginning in March 1963, March 1964, March 1965, March 1966, and March 1967. Lally's methodology causes the preliminary regulatory cycles which commence later to be shorter, with the March 1964 initial cycle having 12 observations less than the March 1963 cycle, while the March 1967 cycle has 48 less observations. This difference is immaterial for Lally's long dataset, but becomes more important for the shorter Australian datasets.

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Table 6: Standard deviations and uncentred standard deviations for Lally's full US dataset with different calendar months in 60 regulatory cycles (initial partial regulatory periods not analysed)

	Average Standard Deviation (%)						Average Uncentred Standard Deviation (%)					
	0% swaps	25% swaps	50% swaps	75% swaps	100% swaps	5-month swaps	0% swaps	25% swaps	50% swaps	75% swaps	100% swaps	5-month swaps
Jan	1.46	1.17	0.93	0.80	0.85	0.85	1.49	1.19	0.97	0.90	1.00	0.99
Feb	1.50	1.19	0.94	0.80	0.86	0.83	1.53	1.20	0.96	0.87	0.98	0.95
Mar	1.49*	1.18	0.94	0.81	0.87*	0.82*	1.52	1.20	0.97	0.88	0.98	0.92
Apr	1.46	1.15	0.90	0.75	0.77	0.78	1.49	1.17	0.93	0.82	0.87	0.89
May	1.42	1.11	0.86	0.72	0.77	0.73	1.46	1.14	0.89	0.77	0.85	0.83
Jun	1.46	1.12	0.83	0.66	0.70	0.72	1.48	1.14	0.86	0.72	0.78	0.80
Jul	1.47	1.11	0.81	0.64	0.71	0.71	1.49	1.13	0.84	0.70	0.79	0.79
Aug	1.45	1.09	0.78	0.61	0.70	0.69	1.47	1.11	0.80	0.66	0.77	0.78
Sep	1.46	1.10	0.79	0.63	0.72	0.69	1.48	1.12	0.82	0.69	0.81	0.80
Oct	1.47	1.16	0.90	0.77	0.85	0.80	1.49	1.18	0.95	0.87	0.98	0.94
Nov	1.44	1.17	0.95	0.84	0.89	0.87	1.46	1.19	1.00	0.94	1.04	1.00
Dec	1.45	1.17	0.95	0.83	0.88	0.85	1.47	1.19	1.00	0.95	1.06	1.01
Ave.	1.46	1.14	0.88	0.74	0.80	0.78	1.49	1.16	0.92	0.81	0.91	0.89

**These numbers for March are identical to Table 4 in Lally (2015), page 73*

168. These results show that there is some, although not dramatic, variation in the statistics for different calendar months. However, as noted above it is more robust to take the different possible regulatory months into account when calculating the two statistics. As such, only the average values in the final row will be presented in the tables in subsequent sections. This is equivalent to calculating the two statistics for 60 different regulatory cycles and presenting their averages.

5.1.2 Averaging standard deviations for each regulatory cycle vs calculating a single standard deviation

169. Lally's methodology is described in Section 4.2, with the key equations set out in Section 4.2.3. As stated in Section 4.2.3, Lally defines the risk associated with each debt strategy as the standard deviation of the difference between the regulatory allowed rate and actual costs.

170. In addition, Lally obtains the average of five standard deviations corresponding to five different regulatory starting months (March in each of 5 different years). Although this is not represented in an equation in his report, the following equation is implied in his analysis, where the subscript represents the starting year of an individual regulatory cycle:

$$Average\ SD = \frac{SD_{1963} + SD_{1964} + SD_{1965} + SD_{1966} + SD_{1967}}{5}$$

171. Lally's reasoning for calculating the average standard deviation is that it reduces the impact of the "arbitrary choice of March 1963 as the first reset date".[50] However, the average standard deviation does not accurately reflect riskiness across different sets of regulatory cycles for three reasons.

172. First, each standard deviation is measured with reference to its own mean. Averaging standard deviations across five regulatory cycles thus incorrectly references five different mean estimates instead of a single mean.

173. For example, consider a scenario in which a particular debt strategy is always 5 percentage points higher than the allowed rate in the first regulatory cycle and 5 percentage points lower than the allowed rate in the second cycle. The individual standard deviations of both cycles would be zero, and thus produce an average standard deviation of zero, which is clearly not consistent with the fact that there is a 50% probability of the strategy resulting in a cost of debt that is 5% higher and 50% probability that the resulting cost of debt is 5% lower than the allowance. This increases the risk associated with the debt strategy, and must be accounted for.

174. Second, since the five initial regulatory cycles are each separated by increments of one year, the five sets of underlying data are likely to be correlated. In turn, this

50 Lally, Review of Submissions on the Cost of Debt, 21 April 2015, pg 72.

correlation will trickle into the standard deviation estimates, which will also be correlated. Lally's approach of calculating the average of the standard deviation estimates does not take this correlation into account.

175. Third, Lally's approach of obtaining five datasets for five different initial regulatory starting months involves excluding observations that fall before each starting month, with the implication that the datasets for regulatory cycles that commence after the first regulatory cycle will each be one year shorter than the regulatory cycle directly before it.

176. The correct measure that resolves the issues highlighted above would be to obtain a single standard deviation estimate that is calculated from all regulatory cycles combined.[51] Calculating the standard deviation from a single combined dataset correctly references a single mean, incorporates the correlations between the datasets, and assigns the correct weight to regulatory cycles of different lengths. This approach to estimating standard deviations is elaborated upon in Appendix H.

5.1.3 Standard deviation and uncentred standard deviation

177. Lally's assessment of the three debt management strategies is restricted only to the resulting standard deviation of the difference between the incurred cost and the regulatory allowed rate, which Lally interprets as the risk associated with a mismatch between the on-the-day allowance and the incurred costs of debt.

178. However, the standard deviation is a measure of the spread of the underlying data, centred around its average value. This means that, even if a debt management strategy gives rise to a cost of debt that is always materially different to the regulatory allowance, so long as the difference is stable, it will have a low standard deviation.

179. Consider a hypothetical scenario with two debt management strategies, whereby the first strategy always produces a cost of debt that is exactly 5 percentage points higher than the regulatory allowed rate, while the second produces a cost of debt that fluctuates between 1 percentage point above and below the allowed rate. The standard deviation statistic will identify the first strategy as less risky even though it produces a larger mismatch to the allowed rate compared to the second strategy.

180. In order to address this issue I report an additional statistic in my empirical analysis. This is the uncentred standard deviation, which measures the spread of

51 In other words, if the first and second regulatory cycles contain P and Q observations respectively, then the standard deviation should be obtained from the combined dataset of P + Q observations etc. Applying the modification in Section 5.1.1, this would involve combining 60 sets of observations (each with different initial regulatory cycles that reset every 5 years) into a single dataset and then calculating one standard deviation across the entire combined dataset. In contrast, Lally's approach would have involved computing one standard deviation for each separate set of observations and then taking the average of said standard deviations.

the mismatch around zero rather than around the mean mismatch. Thus, in the example above, the first debt management strategy that is always exactly 5% above the regulatory allowance will have a higher uncentred standard deviation than the second strategy – which gives rise to a more variable difference but which is closer to zero on average.

5.1.4 Use of Australian data

181. Lally restricts his analysis to US data. I consider that the US market data is a useful proxy for the relationships that we expect to observe in Australia. Nonetheless, I also consider that it is appropriate to perform the same analysis on the available Australian data. In this regard I have used both the CEG dataset used in our submission for Ausgrid[52] discussed previously and the Australian data series preferred by Chairmont – both of which are set out in detail in Appendix C.

5.1.5 Examining the impact of de-trending the data

182. If there is an *ex post* trend in interest rates over the period of study then this trend, as opposed to variability around the trend, may affect the comparison of the riskiness of different hedging strategies. For this reason, I examine the properties of each hedging strategy based on a de-trended data series. More information on the de-trending procedure I use is available in Appendix E. The results using de-trended data are used as a cross-check on the original data. The de-trended results are broadly consistent with the results from the original data and, so, do not cause me to alter any conclusions based on the original data.

5.1.6 Report hedging ratio which minimises interest rate risk

183. Lally restricts himself to a binary comparison of 0% and 100% hedging. I consider that it is appropriate to determine the hedging ratio which minimises risk.

5.2 Finding the hedging ratios that minimise interest rate risk

184. In Section 4.3 above, I noted that Lally's (2015) analysis only sought to test whether a 100% hedge strategy has lower interest rate risk than a 0% hedge strategy. I further argued that the correct question that Lally and the AER must address is not whether one extreme is better than the other, but what percentage use of interest rate swaps was most efficient.

52 CEG, Efficient debt financing costs, a report for Networks NSW, January 2015, section 4.5.

185. This section furthers Lally's analysis by setting out the methodology that I used to identify the required hedging ratio, before analysing the results.

186. The methodology that identifies the hedging ratio which minimises interest rate risk with minimal changes to Lally's approach is set out in Section 4.4.1 above. I repeat this process but with the above amendments to Lally's methodology. That is, I computed the optimal hedging ratio using the following steps:

    i. Collect and combine the 60 sets of allowed and actual (0% swaps and 100% swaps) costs of debt series produced from the 60 unique regulatory cycles;[53]

    ii. Compute the standard deviations for 101 debt management strategies, ranging from 0% to 100% hedging in 1% increments. These 101 standard deviations are calculated across the entire 60 sets of costs collected in step (i);

    iii. Determine the optimal hedging ratio as the one that has the lowest standard deviation out of the 101 obtained in step (ii).

187. In addition, I also compute the required hedging ratio that minimises the uncentred standard deviation of the difference between the allowed and actual costs of debt.

188. The above methodology involves the same set of assumptions that were adopted for Lally's analysis. Those assumptions were set out in Section 4.2.4. However, the methodology makes an additional assumption that the strategy that minimises interest rate risk can be chosen from any level of hedging that ranges from 0% to 100%. (It continues to be assumed that this hedging ratio does not change across regulatory cycles and across different sets of regulatory cycles with different initial starting months).

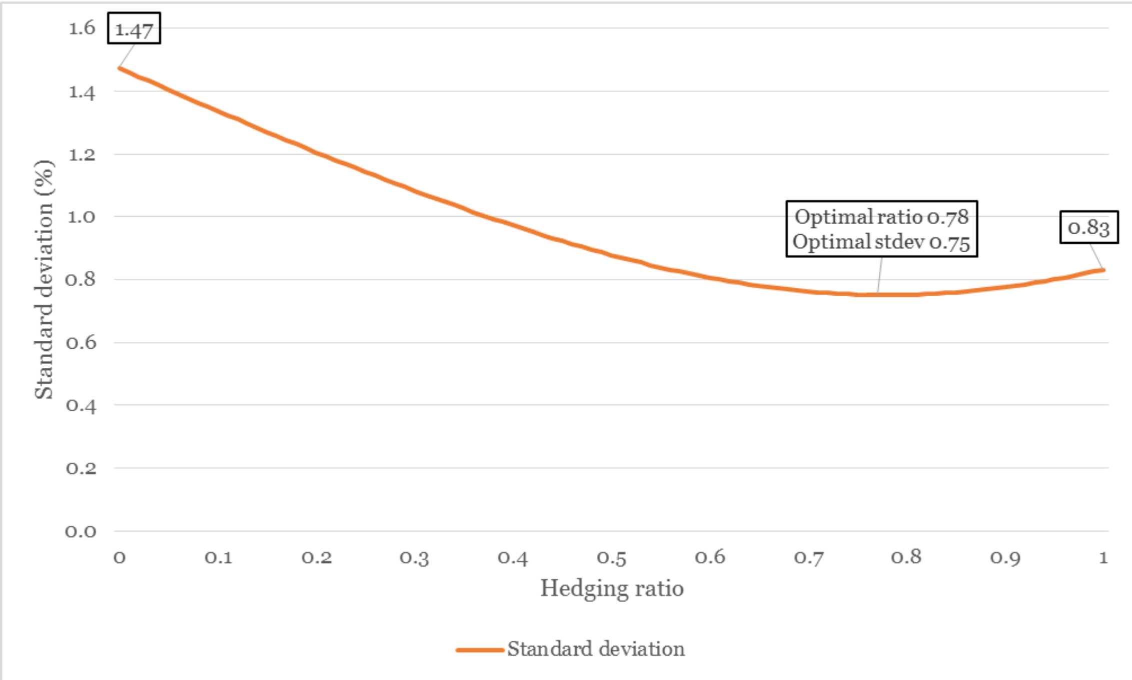
189. The sets of 101 standard deviations and uncentred standard deviations corresponding to different debt management strategies are shown in Figure 14 to Figure 21 for the different datasets.

190. Figure 14 shows how standard deviation varies with the proportion of the base that is hedged for the US FRED full dataset. The standard deviation under 0% hedging is 1.47%, while the standard deviation under 100% hedging is 0.83%. These values are close to the 1.49% and 0.87% standard deviations in Table 4 of Lally (2015), which were obtained as an average of 5 standard deviations instead of the standard deviation from 60 combined datasets. As seen in Figure 15, the corresponding uncentred standard deviations under 0% and 100% hedging are 1.48% and 0.92% respectively.

53 These 60 sets of costs of debt have incorporated the modifications to Lally's approach as listed in Sections 5.1.1 to 5.1.6. Once again, each of the 60 sets of observations assumes that the regulatory cycle resets every 5 years from the starting month of the initial regulatory cycle.

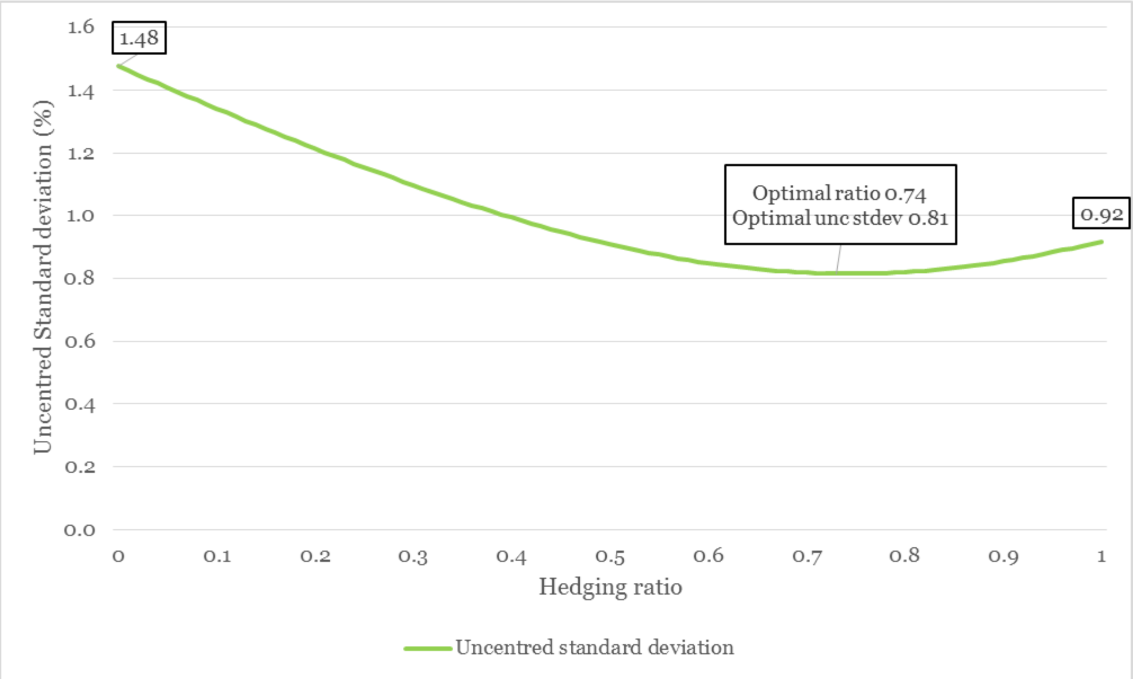
191. The required hedging ratio that minimises the standard deviation for the US FRED full dataset is 78% (this is slightly lower than the 81% calculated in section 4.4 using Lally's methodology without amendment), which corresponds to a standard deviation of 0.75%. The required hedging ratio that minimises the uncentred standard deviation is 74%, which corresponds to an uncentred standard deviation of 0.81%. (No de-trending of the full US data set is attempted due to the lack of any clear trend across the entire period.)

Figure 14: Standard deviations for different hedging ratios – US FRED full dataset



Source: CEG analysis

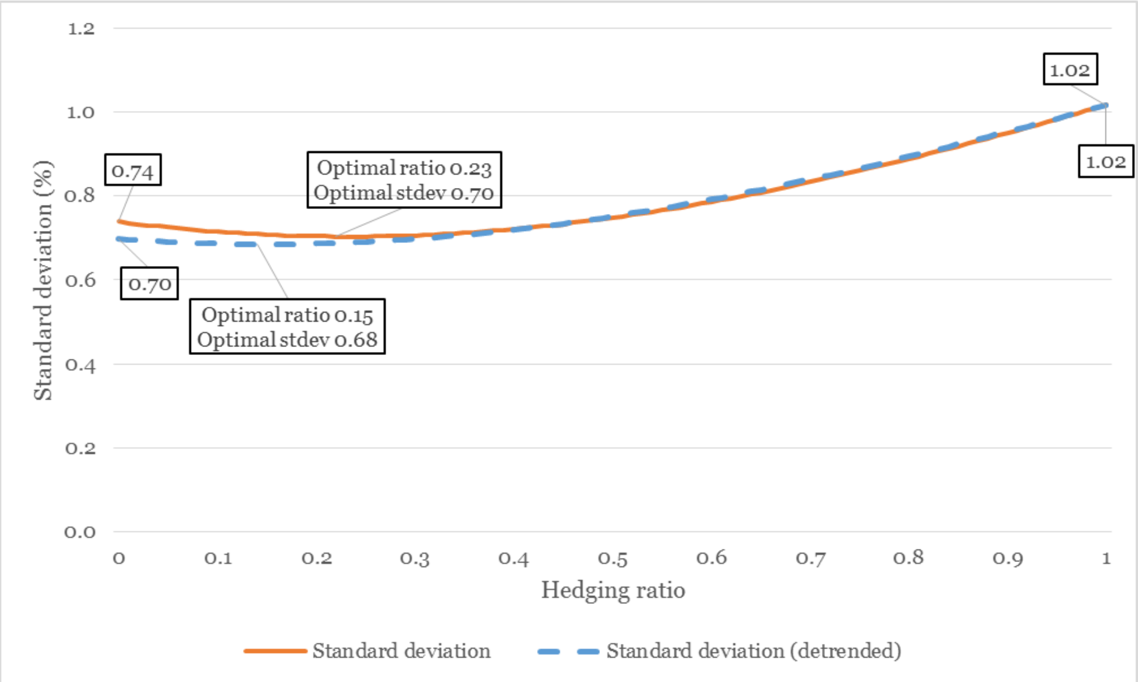
Figure 15: Uncentred standard deviations for different hedging ratios – US FRED full dataset



Source: CEG analysis

192. Figure 16 shows the standard deviations for the US FRED post-Volcker dataset. The standard deviation under 0% hedging is 0.74%, while the standard deviation under 100% hedging is 1.02%. (In contrast, the average of 60 standard deviations (i.e., using Lally's methodology) are 0.67% and 0.88% respectively.) Figure 16 also shows the minimal impact that de-trending the data has on the required hedging ratio.

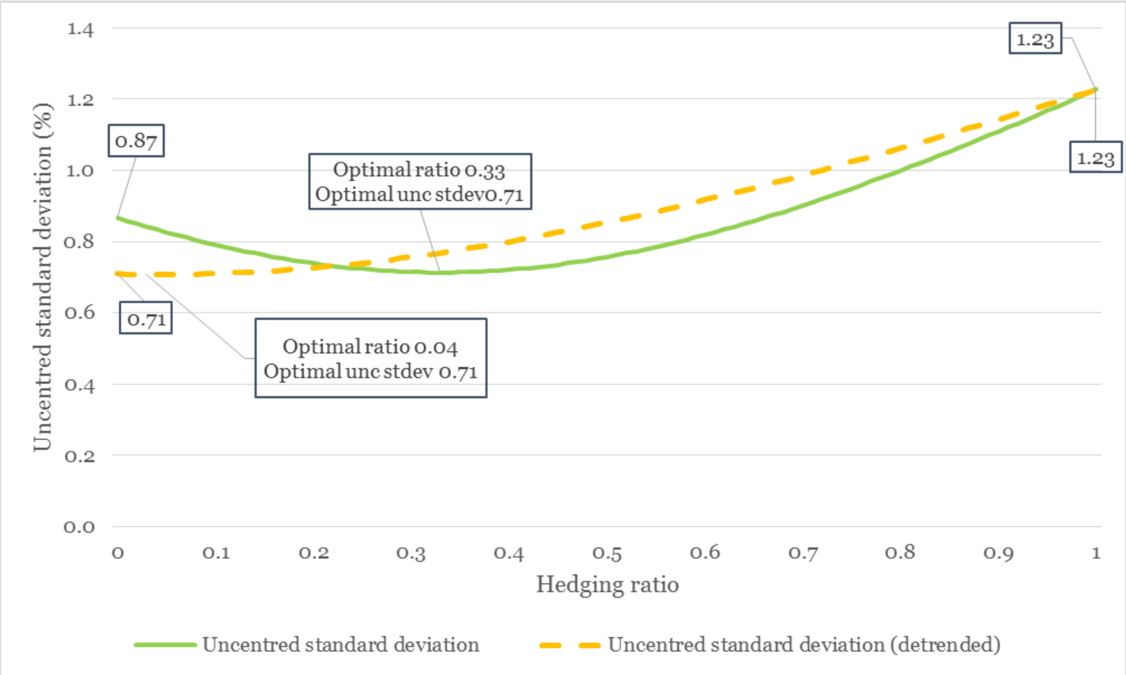
Figure 16: Standard deviations for different hedging ratios – US FRED; Post-Volcker dataset



Source: CEG analysis

193. Figure 17 shows the uncentred standard deviations for the US FRED post-Volcker dataset – both original and de-trended. The required hedging ratio that minimises the original/de-trended uncentred standard deviation for the US FRED post Volker dataset is 33%/4%.

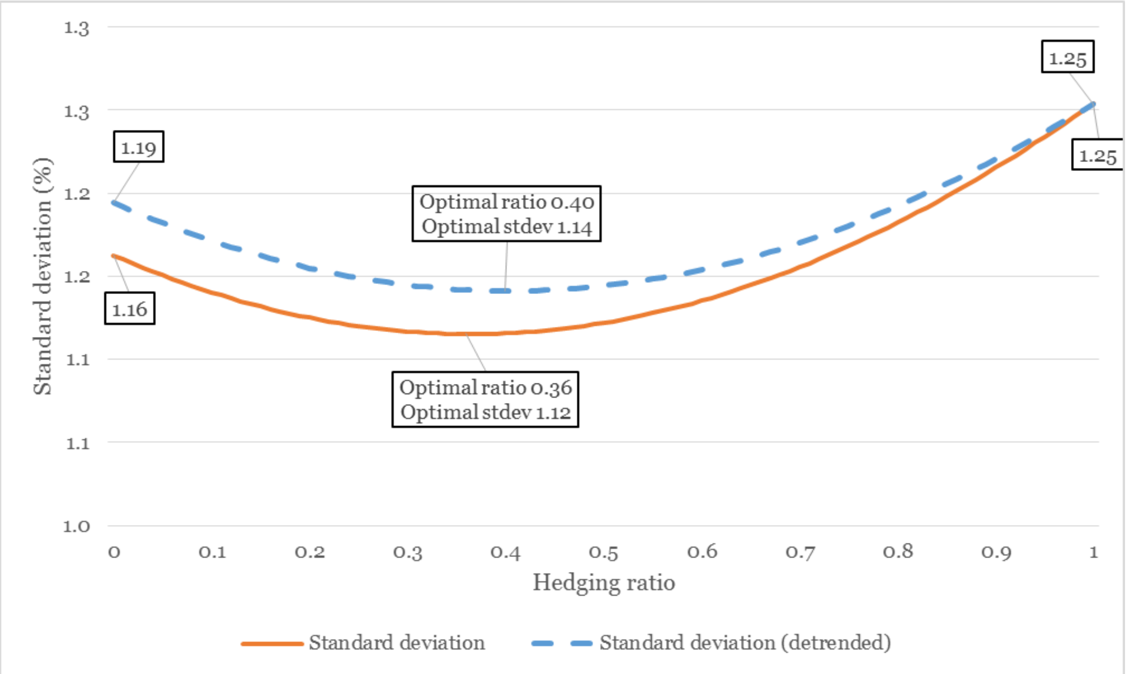
Figure 17: Uncentred standard deviations for different hedging ratios – US FRED; Post-Volcker dataset



Source: CEG analysis

194. Figure 18 shows the standard deviations for the CEG Australian dataset. The required hedging ratio that minimises the original/de-trended standard deviation for that dataset is 36%/40%.

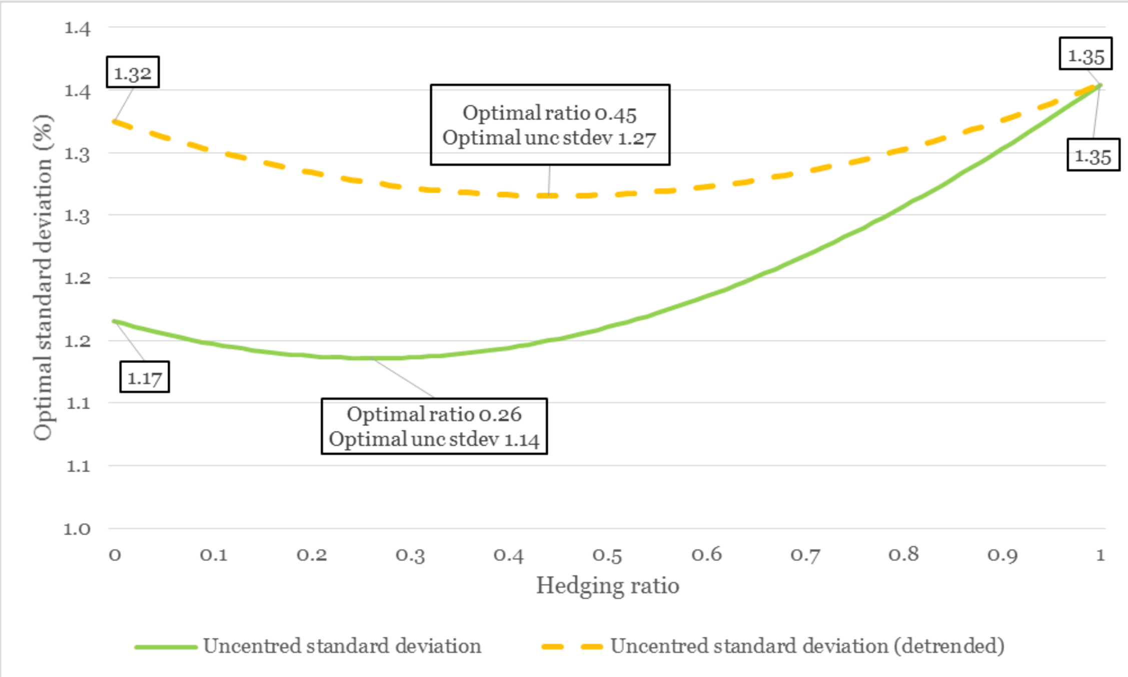
Figure 18: Standard deviations for different hedging ratios – CEG Australian dataset



Source: CEG analysis

195. Figure 19 shows the uncentred standard deviations for the CEG Australian dataset – both original and de-trended. The required hedging ratio that minimises the original/de-trended standard deviation for is 26%/45%.

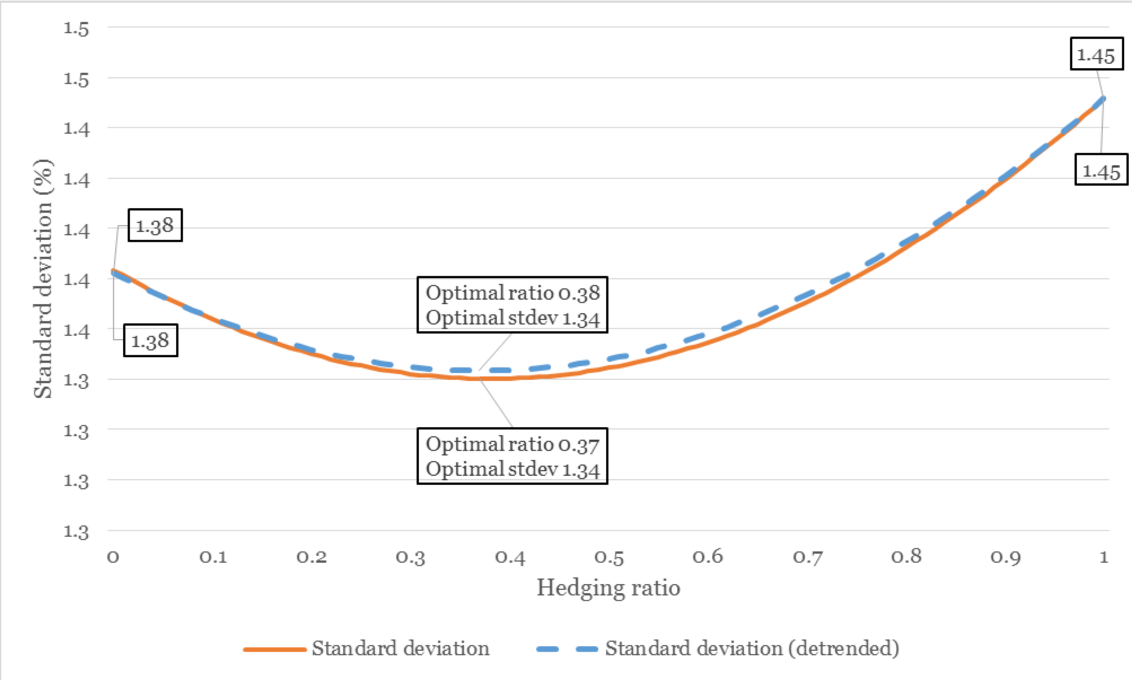
Figure 19: Uncentred standard deviations for different hedging ratios – CEG Australian dataset



Source: CEG analysis

196. Figure 20 shows the standard deviations for the Chairmont Australian dataset – both original and de-trended. The required hedging ratio that minimises the original/de-trended standard deviation for is 37%/38%.

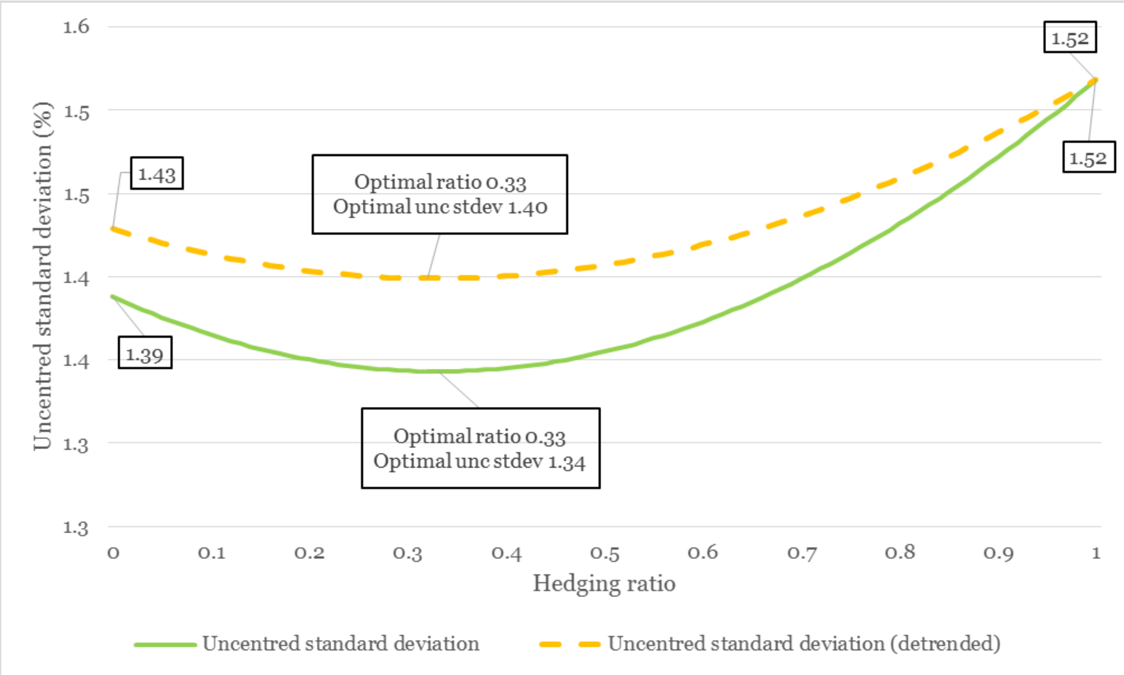
Figure 20: Standard deviations for different hedging ratios – Chairmont Australian dataset



Source: CEG analysis

197. Figure 19 shows the uncentred standard deviations for the Chairmont Australian dataset – both original and de-trended. The required hedging ratio that minimises the original/de-trended standard deviation for is 33%/33%.

Figure 21: Uncentred standard deviations for different hedging ratios – Chairmont Australian dataset



Source: CEG analysis

5.3 Results with Lally averaging method

198. The results described in the previous section are associated with identifying the hedging ratio that minimises the standard deviation in a calculation in which a single standard deviation is estimated across all regulatory cycles. Lally's original approach was to estimate a separate standard deviation for each regulatory cycle and then average them. Table 7 below provides a summary of results when this aspect of Lally's approach is adopted, which I use as a cross-check against the results presented above. This means that the average standard deviations and average uncentred standard deviations in Table 7 are obtained by first computing 60 separate standard deviations and uncentred standard deviations for 60 sets of observations, each of which assumed that the regulatory cycle reset every 5 years from the start of the initial regulatory cycle. These 60 standard deviations or alternatively, 60 uncentred standard deviations were then averaged.

199. In summary, when the dataset is confined to the post-Volcker period (of low and stable inflation after 1985), 0% hedging performs better than 100% hedging and 50% hedging performs better than both 0% and 100% hedging. These outcomes are broadly consistent with the results applied with the modifications to Lally's analysis.

Table 7: Summary of key results (Lally's approach to averaging standard deviations estimated for each regulatory cycle)

	0% swaps	25% swaps	50% swaps	75% swaps	100% swaps over 1 month	100% swaps over 5 months
Full US data set; no detrending						
average standard deviation	1.43	1.11	0.86	0.72	0.78	0.76
average uncentred standard deviation	1.45	1.14	0.90	0.80	0.89	0.87
Post-Volcker data set; no detrending						
average standard deviation	0.67	0.63	0.66	0.75	0.88	0.88
average uncentred standard deviation	0.84	0.68	0.69	0.88	1.15	1.15
AU CEG data set; no detrending						
average standard deviation	0.93	0.85	0.81	0.82	0.89	0.89
average uncentred standard deviation	1.03	0.95	0.93	0.98	1.10	1.09
AU Chairmont data set; no detrending						
average standard deviation	1.04	0.96	0.92	0.92	0.98	0.98
average uncentred standard deviation	1.20	1.10	1.04	1.05	1.14	1.14

Source: CEG analysis

5.4 Summary

200. The results presented above are summarised in Table 8. As has been noted, the statistics in Table 8 are obtained as single statistics derived using data combined from 60 different regulatory cycles.

201. Based solely on Lally's standard deviation as the metric of risk, Table 8 shows that, excluding the ratios obtained from the full US dataset which includes the period of high and unstable inflation in the 70s and 80s, the required ratios for the other three datasets range from 23% to 38%. Based on the alternative uncentred standard deviation metric of risk, the range is 26% to 33%. Introducing detrending results in the standard deviation range widening to 15% to 40% and the uncentred standard deviation range widening to 4% to 45%.

Table 8: Summary of hedging ratios that minimise interest rate risk from different datasets

	Hedging ratio (no detrendng)	Hedging ratio with detrendng
Full US data set;		
standard deviation	0.78	NA*
uncentred standard deviation	0.74	NA
Post-Volker data set;		
standard deviation	0.23	0.15
uncentred standard deviation	0.33	0.04
AU CEG data set;		
standard deviation	0.36	0.40
uncentred standard deviation	0.26	0.45
AU Chairmont data set;		
standard deviation	0.38	0.37
uncentred standard deviation	0.33	0.33
Average (not including full US dataset)	32%	29%

*Source: CEG analysis. * Detrended results for the full US dataset in this table since the shape of the full 10-year Treasury rate is not suitable for de-trending.*

Appendix A Impact of the negative correlation for DRP and swap rates

202. The AER's position (that using interest rate swaps to hedge 100% of the debt portfolio would best align actual costs to an 'on the day' allowance for the cost of debt) is built, implicitly, on an assumption that the prevailing DRP is independent of the base level of interest rates. That is, credit spreads and the base level of interest rates are uncorrelated, which, if correct, implies that using interest rate swaps to hedge 100% of the debt portfolio will minimise interest rate risk.

203. As discussed in Section 3.3, it is well established in the finance literature since at least Longstaff and Schwartz (1995),[54] that credit spreads are inversely related to the base level of interest. That is, credit spreads and the base level of interest rates are negatively correlated. This section describes, at a conceptual level, why, in the presence of negative correlation, leaving *at least some* of the base rate of interest unhedged will be the most efficient strategy for hedging the cost of debt allowance – which is comprised of both the base rate of interest and the DRP.

204. The intuition behind leaving part of the base level of interest unhedged is best explained through a series of examples. In this section, I explore three stylised examples where:

   i. The correlation between swap rates and DRP is zero – achieved in our stylised example by assuming that the DRP is constant (such that it has no relationship to swap rates and zero standard deviation);

   ii. The correlation between swap rates and DRP is negative 1 and movements in the DRP and swap rates exactly and perfectly offset each other ; and

   iii. The correlation between swap rates and DRP is negative 0.5 and DRP and swap rates have the same standard deviation (such that $\frac{sd(DRP_{10})}{sd(SW_{10})}$ =1).

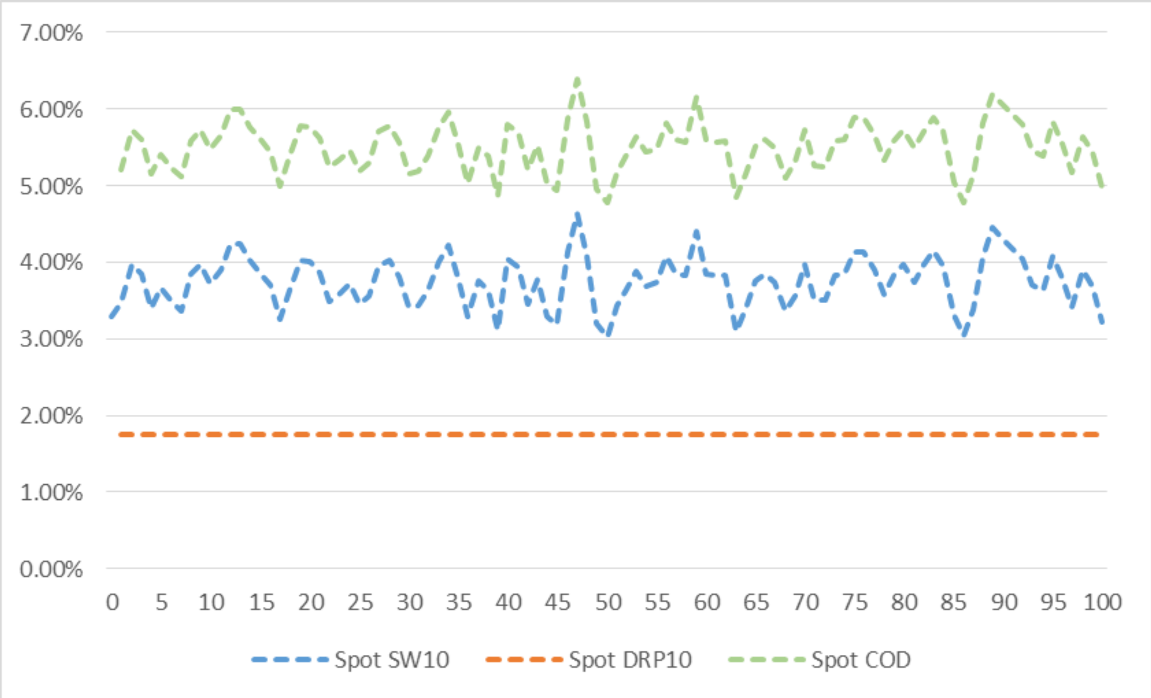
A.1 Scenario 1: DRP is constant

205. If the DRP is constant then, by definition, the DRP has zero correlation with swap rates. Consequently, the optimal hedging ratio is 100%. Such a scenario is depicted in Figure 22, which shows a simulation of the prevailing 10 year swap rate (consistent with an underlying standard deviation of 0.25%) and a constant DRP –

54 Longstaff, and Schwartz, A simple approach to valuing risky fixed and floating rate debt, *Journal of Finance*, July 1995. They find that "Using Moody's corporate bond yield data, we find that credit spreads are negatively related to interest rates and that durations of risky bonds depend on the correlation with interest rates: (p. 789).

such that the prevailing cost of debt (COD) is simply the swap rate curve shifted up by a (constant) DRP factor.

Figure 22: Simulated variable base rate of interest with constant DRP



Source: CEG analysis

206. Under the on-the-day approach, the cost of debt allowance is set equal to the prevailing cost of debt at the beginning of a five year regulatory cycle (which is why the data is broken into 5 year blocks on the horizontal axis). The allowed cost of debt is represented in Figure 23 by the grey line – which is simply equal to the value of the green line in Figure 22 at the beginning of each 5 year regulatory cycle (where this is assumed to begin at year 10 and repeat at years 15, 20, 25 etc).[55]

[55] The analysis begins at year 10 because 10 years is required to calculate a 10 year trailing average of DRP and total cost of debt.

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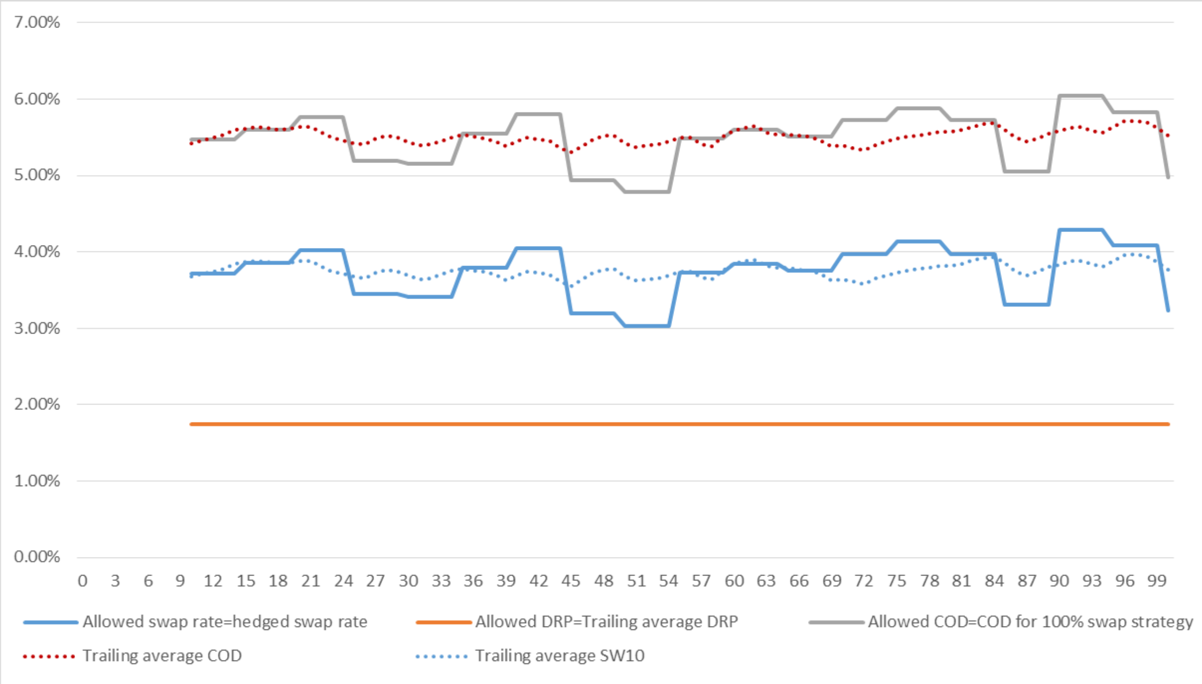
Figure 23: Simulated trailing average and 100% swap strategy with variable base rate and constant DRP



Source: CEG analysis

207. The allowed cost of debt (prevailing swap rate plus prevailing DRP) is also the cost of debt for a 100% swap strategy (prevailing swap rate plus trailing average DRP) because:

   a. the business locks in the same swap rates[56] that underpin the cost of debt allowed by the regulator; and

   b. the DRP is constant – such that the prevailing and trailing average DRP are the same.

208. In this example, the 100% hedging ratio is a perfect hedge. By contrast, a strategy that uses 0% swap rates (dotted red line) is an imperfect hedge because the cost of debt is given by:

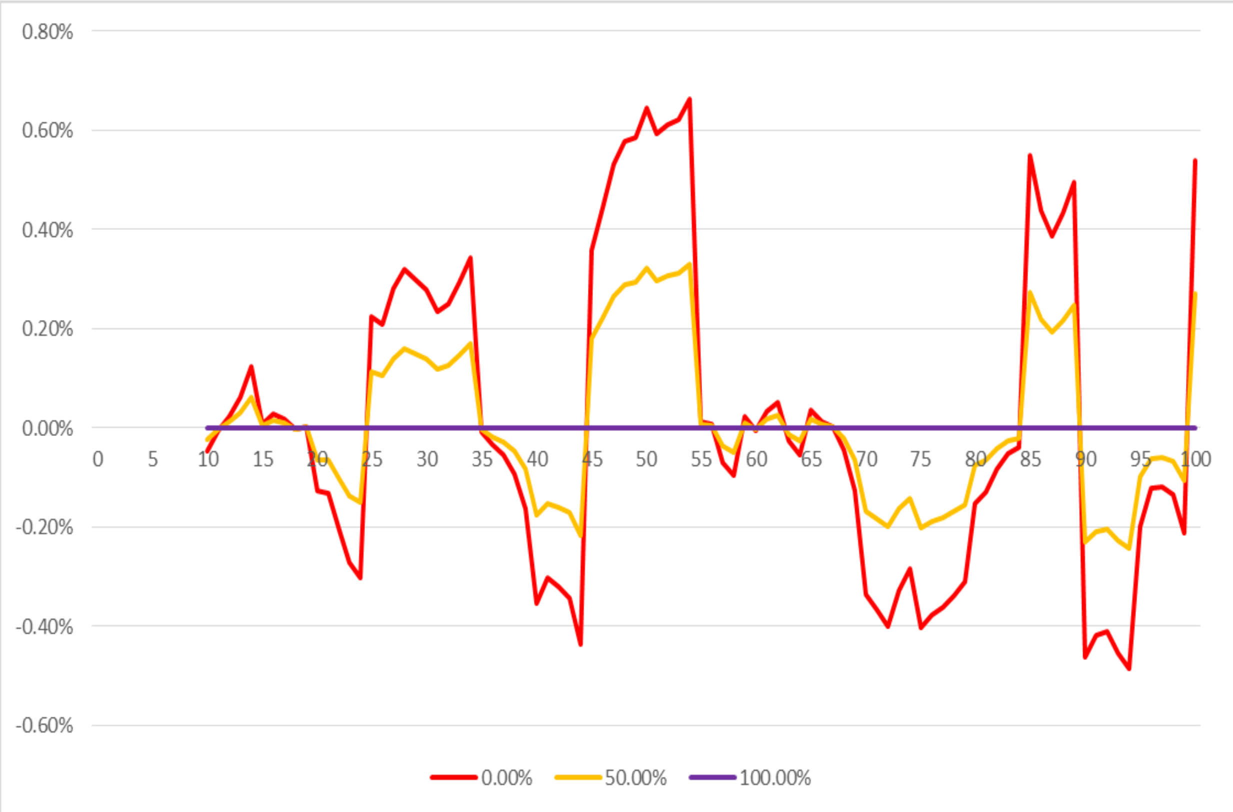
   - a trailing average of swap rates which will not necessarily equal the prevailing swap rate used by the regulator; plus
   - a trailing average DRP which, in this example, is equal to the prevailing DRP used by the regulator.

---

56 For simplicity it is assumed that the 10 year swap rate is broadly similar to the 5 year swap rate plus swap transaction costs. To the extent that this is not the case then the 100% swap strategy will not be a perfect hedge.

209. As seen in Figure 24, a strategy that uses a 50% hedging ratio will always fall between the 100% and 0% strategies because it is, in essence, simply the average of the two extremes. It will be a better hedge than a 0% hedging ratio but will still be an imperfect hedge.

Figure 24: Deviation of costs from allowance for various debt management strategies

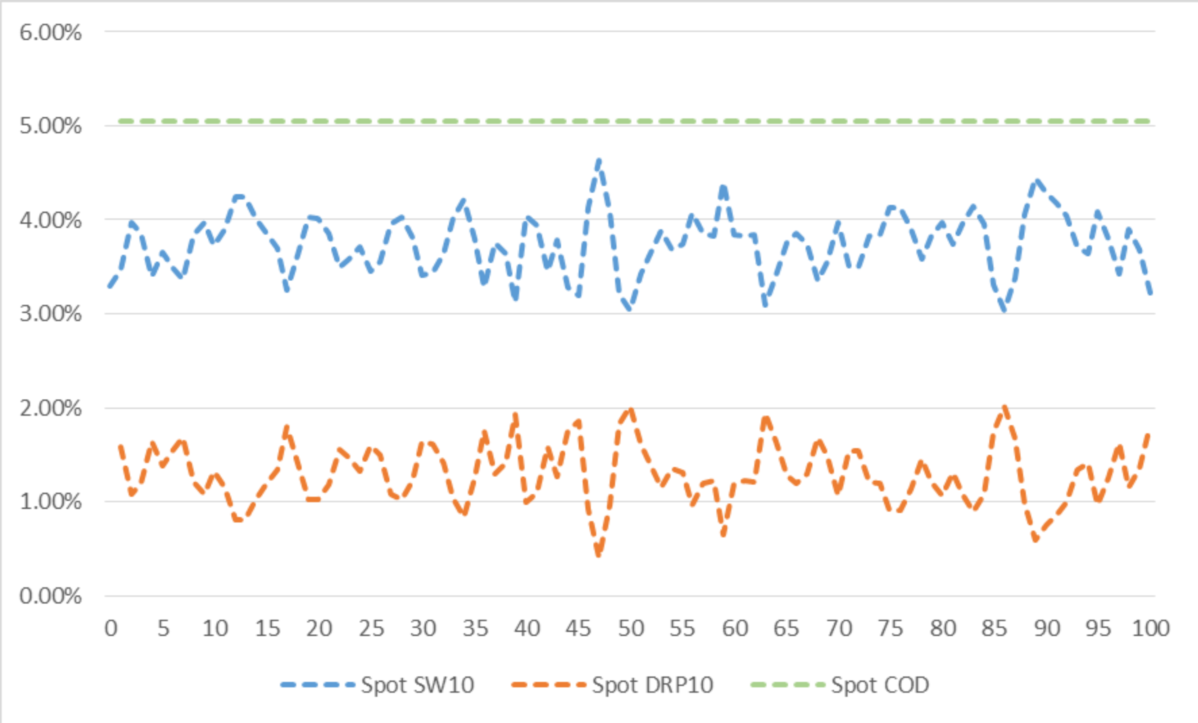


A.2 Scenario 2: DRP has perfect inverse relationship with swap rates

210. At the other extreme to a constant DRP is a scenario where the DRP always moves in an exactly offsetting fashion to the prevailing swap rate – such that the cost of debt is constant. Consequently, the optimal hedging ratio is 0%. Such a scenario is depicted in Figure 25, which shows the same variable swap rates as shown in Figure 22[57] and a DRP series with an exactly offsetting shape – such that the prevailing cost of debt (COD) is constant.

57 Based on a simulation of the prevailing 10 year swap rate consistent with an underlying standard deviation of 0.25%)

Figure 25: Variable base rate of interest with perfect offsetting variation in DRP



Source: CEG analysis

211. Under the on the day approach, the cost of debt allowance is set equal to the prevailing cost of debt at the beginning of a five year regulatory cycle (which is why, as before, the data is broken into 5 year blocks on the horizontal axis). The allowed cost of debt is represented in Figure 26 by the grey line – which is constant by construction. Superimposed on this is the trailing average cost of debt (with 0% use of swap rates) which is also constant by construction (given that it is simply a trailing average of the constant cost of debt).

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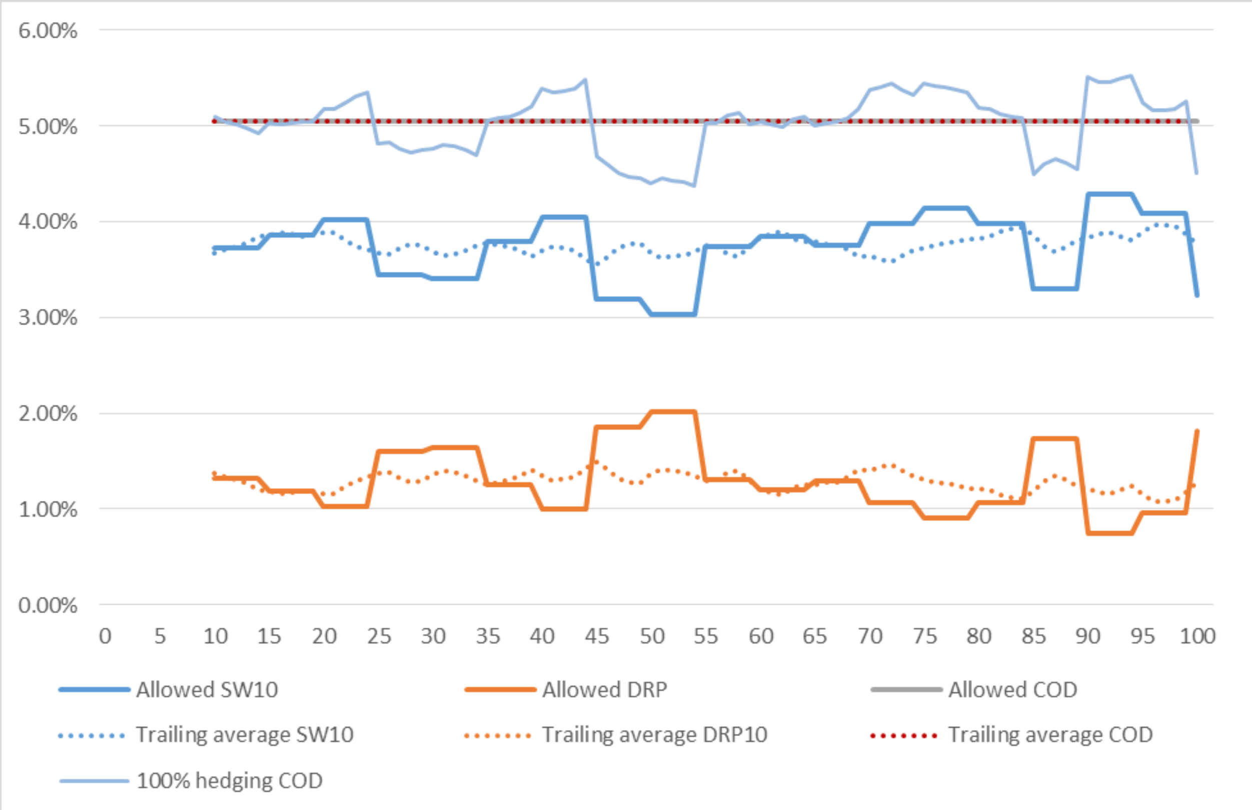
Figure 26: Trailing average and 100% swap strategy with perfect offsetting variation in swap rates and DRP



Source: CEG analysis

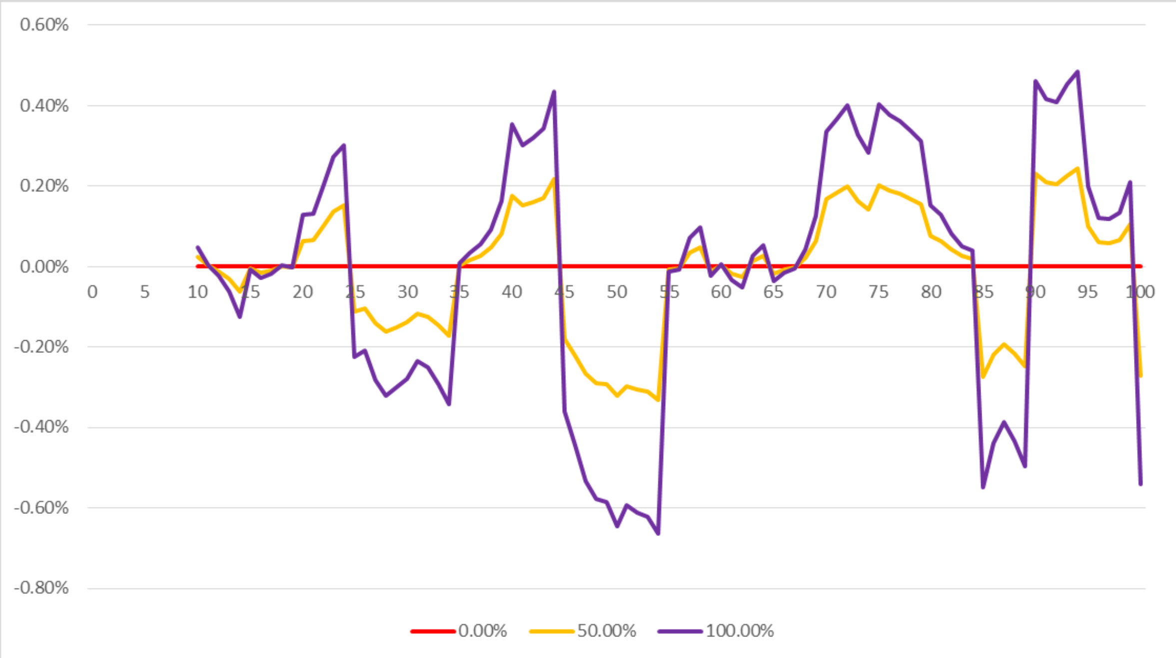
212. In contrast, the cost of debt associated with a 100% swap strategy is not constant but, rather, has much the same variability as the swap rate at the beginning of the regulatory period (which is locked in under the 100% swap strategy). It does not have exactly the same volatility as the prevailing swap rate because the trailing average DRP, which is a component of the costs for both strategies, has low, but non zero, variability.

213. It can be seen that, despite the 100% swap strategy 'locking in' the prevailing swap rate used by the regulator, it provides a worse hedge to the total regulatory allowance because the swap contracts undo (or double up on) a natural hedge that already existed. Specifically, variability in the swap rates was dampened (in this example perfectly dampened) by offsetting variability in the DRP (a negative correlation). By entering into 100% swap contracts, the business made the actual cost of debt more volatile than the regulatory allowance because it failed to take into account the existence of a natural hedge.

214. A strategy that uses a 50% hedging ratio will always fall between the 100% and 0% strategies because it is, in essence, simply the average of the two extremes. In this

scenario, it will be a better hedge than a 100% hedging ratio but will still be an imperfect hedge.

Figure 27: Deviation of costs from allowance for various debt management strategies

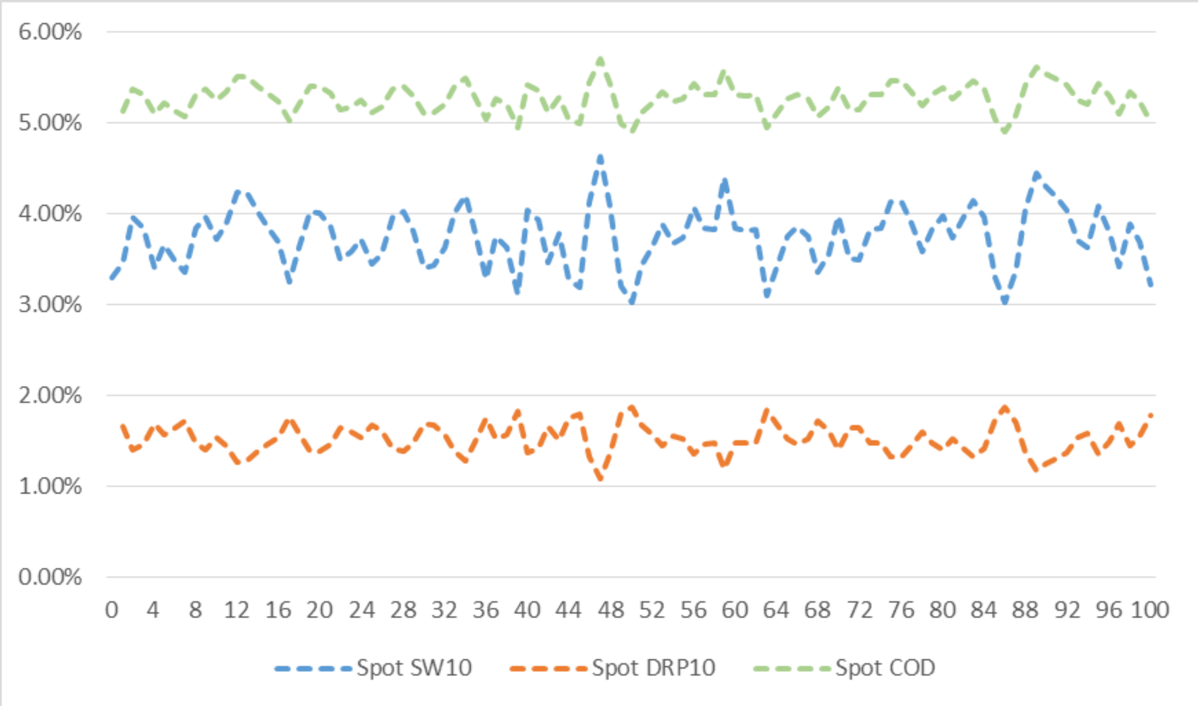


Source: CEG analysis

A.3 Scenario 3: DRP has imperfect inverse relationship with swap rates

215. In this example I examine a scenario where DRP is inversely related to swap rates but moves by less than a perfectly offsetting amount. Specifically, the DRP moves in the opposite direction to swap rates but only with half of the magnitude. Consequently, the optimal hedging ratio is 50%. Such a scenario is depicted in Figure 28 which shows the same variable swap rates as shown in Figure 22 and Figure 25 but with a DRP series that has an offsetting but smaller magnitude variation. The cost of debt in this scenario is variable – but less variable than the swap rate by virtue of the dampening effect of the inverse relationship with DRP.

Figure 28: Variable base rate of interest with imperfect offsetting variation in DRP



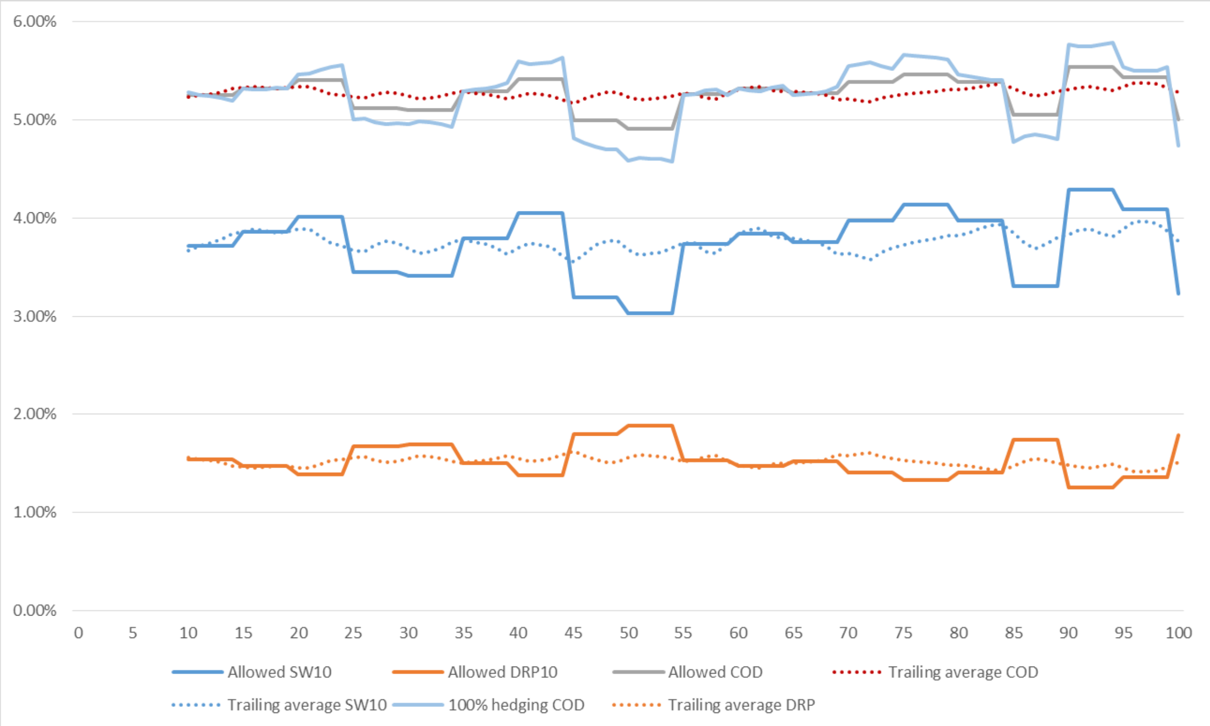
Source: CEG analysis

216. Under the on the day approach, the cost of debt allowance is set equal to the prevailing cost of debt at the beginning of a five year regulatory cycle (which is why, as before, the data is broken into 5 year blocks on the horizontal axis). The allowed cost of debt is represented in Figure 29 by the grey line – which is constant by construction. Superimposed around this are:

- the trailing average cost of debt (with 0% use of swap rates); and
- the cost of debt with a 100% swap strategy.

217. It can be seen that the 100% swap strategy results in a cost of debt that is more volatile than the allowed cost of debt, while the 0% swap strategy is less volatile than the allowed cost of debt.

Figure 29: Trailing average and 100% swap strategy with imperfect offsetting variation in swap rates and DRP



Source: CEG analysis

218. In fact, the 100% swap strategy results in a cost of debt that is above the allowed cost of debt roughly half the time and below the allowed cost of debt roughly half the time. The same is true of the cost of debt associated with the 0% swap strategy. However, critically, when one is above the allowed cost of debt the other is below the allowed cost of debt by the same amount. Consequently, a 50% swap strategy will provide a perfect hedge to the allowed cost of debt. That is, the average of the trailing average cost of debt (dotted red line) and the 100% swap cost of debt (light blue solid line) will be equal to the allowed cost of debt (grey solid line).

219. A 50% swap strategy minimises interest rate risk in this example because, unlike scenario 1 there is some natural hedge against volatility in swap rates provided by movements in the DRP. Consequently, less than 100% use of interest rate swaps minimises interest rate risk. However, unlike scenario 2, the natural hedge for movements in the swap rates is not perfect. Therefore, the strategy which minimises interest rate risk will use greater than 0% of interest rate swaps. With this particular example, the natural hedge provided a 50% hedge against movements in swap rates. Therefore, the swap strategy which minimises interest rate risk involves only hedging 50% of the debt portfolio using interest rate swaps – such that the total hedge (natural plus contractual) is 100%.

220. As noted previously, a strategy that uses a 50% hedging ratio will always fall between the 100% and 0% because it is, in essence, simply the average of the two extremes. In this scenario, a 50% hedge provides the best outcome because the allowed cost of debt falls midway between the costs associated with either extreme strategy (0% vs 100% interest rate swaps).

Figure 30: Deviation of costs from allowance for various debt management strategies

Source: CEG analysis

Appendix B Empirical literature

221. This appendix reviews the empirical literature that investigates the relationship between DRP and base interest rates, consisting of a long line of papers that each found a negative association between DRP and interest rates. These papers formulated regression models using DRP as the dependent variable and risk-free rates as one of the independent variables. Consequently, if the regression coefficient is negative then less than 100% swap hedging is efficient, and the more negative the coefficient the smaller the percentage of swap hedging that is efficient.

222. A summary of the coefficients on the risk-free rate explanatory variable as estimated in various empirical studies is shown in Table 9 along with the explanatory variables used in each respective model. These results show that a change in the risk-free rate is typically associated with a negative change in the debt risk premium, and that such an observation holds across almost all credit ratings, maturities, and leverage values.

Table 9: Summary of empirical estimates in literature

	Coefficient of the risk-free rate	Category	Explanatory variables
Longstaff and Schwartz (1995)	-0.184	Baa utilities	• Change in Treasury bond yield • Return on stock index
Duffee (1998)	-0.424	Baa non-callable bonds with long maturities (15 to 30 years)	• Change in 3-month Treasury bill yield • Change in slope of the Treasury term structure (difference between 30-year and 3-month Treasury bill yield)
Collin-Dugresene et al (2001)	-0.211	Bonds with >55% leverage and remaining term to maturity exceeding 12 years	• Change in firm leverage ratio • Change in yield on 10-year Treasury • Squared change in yield on 10-year Treasury • Change in 10-year minus 2-year Treasury yields • Change in implied volatility of S&P 500 • Return on S&P 500 • Change in slope of Volatility Smirk
Huang and Kong (2003)	-22.4 (bp)	BBB-A bonds with maturities exceeding 15 years	• Changes in yield of Merrill Lynch Treasury Master Index • Changes in yield of Merrill Lynch 15+ years Treasury Index minus yield of Merrill Lynch 1-3-year Treasury Index • Changes in historical volatility of Merrill Lynch Treasury Master Index yields
Landschoot (2008)	-0.40	US BBB bonds	• Default risk factors (interest rate and stock market variables) • Liquidity risk factors • Credit cycle • Taxation
Lepone and Wong (2009)	-16.44 (bp)	BBB Australian Corporate bonds	• Changes in the 10 year government bond yield • Changes in the squared value of the 10 year government bond yield • Changes in the yield of 10 year government bonds minus the yield of 3 year government bonds • Changes in the volatility implied by options on 3 year government bond futures • Changes in the leverage ratio of banks and financial institutions • Returns on SPI 200™ Index Futures • Changes in the volatility implied by options on SPI 200™ Index futures • Changes in the dollar value of outstanding corporate bonds • Changes in the total net fund flow to bond mutual funds, standardised by net assets
QTC (2012)	-0.4 (correlation coefficient)		• The correlation between the DRP from the Bloomberg 7-year BBB Fair Value Curve and the 7 year risk-free rate from 2001 onwards

223. The published literature provides strong support for the existence of the negative relationship between risk free rates and the DRP, which in turn suggests that the optimal hedging ratio should be less than 100%.

B.1 Longstaff and Schwartz (1995)[58]

224. Longstaff and Schwartz (1995) carried out an empirical study using monthly data from Moody's corporate bond yield indexes, as well as the yields of 10-year and 30-year Treasury bonds. The corporate bonds consisted of utilities, industrials, and railroads, each with credit ratings ranging from Baa to Aaa (except railroads, which did not have any Aaa-rated bonds). Based on this data, credit spreads could then be computed as the difference between the yields of corporate bonds and Treasury bonds.

225. In order to determine the impact of interest rates on credit spreads, Longstaff and Schwartz (1995) used a linear regression with the change in credit spread as the dependent variable, while the explanatory variables consisted of the return on the corresponding index and the change in the 30-year Treasury yield.

226. The coefficient of the 30-year Treasury yield was negative for all 11 categories of bonds investigated, ranging from -0.044 for Aaa utilities to -0.823 for Baa railroads. The coefficient for Baa utilities was -0.184, which meant that a 100-basis-point increase in the 30-year Treasury yield led to an 18-basis-point fall in Baa-utility credit spreads. The estimates were statistically significant for 10 of the 11 categories, and generally became more negative for bonds with lower credit ratings.

B.2 Duffee (1998)[59]

227. Duffee carried out a study on the relation between yields on non-callable Treasury bonds and spreads of corporate bond yields over Treasury yields. He did so using a model similar to Longstaff and Schwartz (1995), but distinguished between callable and non-callable corporate bonds.

228. This study was motivated by the observation that higher prices of non-callable Treasury bonds were associated with higher values of call options, and that this relation should also be reflected in the relation between Treasury yields and non-callable corporate bond yields. Specifically, Duffee argued that the relation between Treasury yields and yield spreads of callable corporate bonds should be more

58 Longstaff and Schwartz (1995), Valuing credit derivatives, *Journal of Fixed Income*, 5, pg 6-12.

59 Duffee (1998), The relation between treasury yields and corporate bond yield spreads, *Journal of Finance*, 53, pg 2225-2241.

negative than the relation between Treasury yields and non-callable corporate bonds.

229. Duffee obtained month-end data for non-callable bonds using the University of Houston's Fixed Income Database for the period January 1985 through March 1995. The data was separated into 48 different time series indexes, consisting of:

- four business-sector categories (all sectors' bonds, industrial-sector bonds, utility-sector bonds, and financial-sector bonds);
- four Moody's rating categories (Aaa, Aa, A, and Baa); and
- three bands of remaining maturities (2-7 years, 7-15 years, and 15-30 years).

230. Duffee's model involved a regression of the monthly change in spreads, with the change in three-month Treasury yields and the change in slope of the Treasury yield (defined as the spread between the 30-year and three-month Treasury yields) as explanatory variables.

231. The model found that an increase in the three-month bill yield was associated with a decline in yield spreads, and that this relation applied to all combinations of maturity and credit rating. The relation was weaker for Aaa-rated bonds and stronger for bonds of lower credit quality. In addition, the relation tended to be stronger for bonds for higher maturities.

232. In particular, the coefficient for short-term Aaa bonds was -0.103, which meant that an increase in the Treasury yield by 10 basis points was associated with a decrease in yield spreads by 1.03 basis points. On the other hand the coefficient for long-term Baa bonds was -0.424, such that the same increase in the Treasury yield resulted in a 4.24 basis points reduction in yield spreads.

233. Duffee did not present the regression results for the callable bonds in his dataset, but stated that the coefficients for indexes containing both callable and non-callable bonds were far more negative than the corresponding coefficients in the regression with non-callable bonds alone. For example, the coefficient for the Aaa Industrials Index was roughly eight times the corresponding estimate for non-callable bonds. This observation was further confirmed with estimates using a different dataset constructed with Lehman Brothers Corporate Bond Indexes.

B.3 Lepone and Wong (2009)[60]

234. Lepone and Wong (2009) carried out an empirical study of the determinants of credit spread changes of Australian corporate bonds, using weekly data during the period 29 June 2003 through 2 March 2007.

[60] Lepone and Wong (2009), Determinants of Credit Spread Changes: Evidence from the Australian Bond Market, *Australasian Accounting, Business and Finance Journal*, 3(2).

235. Data on bond index levels and their corresponding yields were obtained from the Australian Financial Markets Association Services (AFMA), while the yield on the 10-year government bond rate was used as a proxy for the risk-free rate. In addition, similar to Collin-Dufresne et al (2001), the squared value of the 10-year government bond rate was also included to account for non-linear effects.

236. The model had the change in credit spreads as the dependent variable, along with the following explanatory variables:

a. Changes in the 10-year government bond yield;

b. Changes in the squared value of the 10-year government bond yield;

c. Changes in the yield of 10-year government bonds minus the yield of 3-year government bonds;

d. Changes in the volatility implied by options on 3-year government bond futures;

e. Changes in the leverage ratio of banks and financial institutions;

f. Returns on SPI 200™ Index Futures;

g. Changes in the volatility implied by options on SPI 200™ Index Futures;

h. Changes in the dollar value of outstanding corporate bonds; and

i. Changes in the total net fund flow to bond mutual funds, standardised by net assets.

237. The authors analysed eight different credit spread changes, corresponding to four different credit ratings and four different maturity ranges. Of these, six categories had negative coefficients on both the change in 10-year government bond yield and the change in squared value of the 10-year government bond yield. The remaining two categories corresponded to the BBB credit rating and 5-7 years maturity categories.

238. The BBB credit rating category had a coefficient of -16.44 on the change in 10-year government bond yield, which was significant at the 1% level. Its coefficient on the change in squared government bond yield was 5.02, but this was insignificant even at the 10% level.

239. With the 5-7 years maturity category, the coefficient on the change in government bond yield was 0.53, while the coefficient on the change in squared government bond yield was -15.04. Both coefficients were insignificant.

B.4 Collin-Dugresene, Goldstein and Martin (2001)[61]

240. Collin-Dusgresene et al (2001) examined the determinants of credit spread changes, with the primary conclusion being that the monthly credit spread changes in the corporate bond market were predominantly driven by local supply/demand shocks that were independent of changes in credit risk and other measures of liquidity.

241. While the study did not focus specifically on the relationship between credit spreads and the risk-free rate as proxied by Treasury yields, the model nevertheless concurred with Longstaff and Schwartz (1995) and Duffee (1998) that an increase in the risk-free rate lowered the credit spreads for all bonds.

242. The dataset was obtained from a range of sources:

- **Credit spreads**: Corporate bond data was obtained from Lehman Brothers via the Fixed Income (or Warga) Database. Monthly bond data was obtained from July 1988 to December 1997. The risk-free rate was obtained using Benchmark Treasury rates from Datastream, with the yield curve estimated based on a linear interpolation of rates at 3, 5, 7, 10, and 30 years maturity. The credit spread was then defined as the difference between the yield of bond i and the yield of the Treasury curve at the same maturity.
- **Treasury rate level**: Obtained from Datastream's monthly series of 10-year Benchmark Treasury rates.
- **Slope of the yield curve**: Defined as the difference between Datastream's 10-year and 2-year Benchmark Treasury yields.
- **Firm leverage**: Quarterly data was obtained from COMPUSTAT and linear interpolation was used to estimate monthly debt figures. Firm leverage was calculated according to the formula:

$$Firm\ leverage\ = \frac{Book\ value\ of\ debt}{Market\ value\ of\ equity + Book\ value\ of\ debt}$$

  For robustness, each firm's monthly equity return was also obtained from CRSP and used as an explanatory variable.
- **Volatility**: Since most of the investigated firms did not have publicly traded options, the authors used changes in the VIX index provided by the Chicago Board Options Exchange as a measure of volatility. This index corresponds to a weighted average of eight implied volatilities of near-the-money options on the OEX (S&P 100) index.
- **Jump magnitudes and probabilities**: Obtained based on changes in the slope of the "smirk" of implied volatilities of options on S&P 500 futures.

61 Collin-Dufresne, Goldstein, and Martin (2001), The determinants of credit spread changes, *Journal of Finance*, 56(6), pg 2177-2207.

Options and futures prices were obtained from Bridge using the shortest maturity on the nearby S&P 500 futures contract. The jump magnitude was then calculated from implied volatilities and a linear-quadratic regression.

- **Changes in business climate**: Obtained using monthly S&P 500 returns from the Center for Research in Security Prices.

243. The model grouped the bonds according to leverage ratios and then regressed the monthly change in credit spreads against the following explanatory variables:

- Change in firm leverage ratio;
- Change in yield on 10-year Treasury bonds;
- Square of the change in yield on 10-year Treasury bonds;
- Change in 10-year minus 2-year Treasury yields;
- Change in implied volatility of S&P 500;
- Return on S&P 500; and
- Change in slope of Volatility Smirk.

244. The coefficient of the change in yield on 10-year Treasury bonds was negative for all leverage groups, and this observation also applied when the data was further separated into bonds with short maturities and bonds with long maturities. In particular, when firm leverage (D/E) is assumed to be above 55% (implies D/(E+D)>35%), the coefficient of the change in Treasury yields is -0.342 for all maturities, -0.414 for short maturities, and -0.211 for long maturities. This implies that a 10 basis points increase in the Treasury yields will result in a reduction of the credit spread by 3.42, 4.14, and 2.11 basis points respectively in the three datasets.

B.5 Huang and Kong (2003)[62]

245. Similar to Collin-Dugresene et al (2001), Huang and Kong (2003) examined the determinants of credit spread changes, but with additional macroeconomic factors as explanatory variables.

246. Specifically, the authors constructed sets of explanatory variables that characterised:

- The realised overall default rate in the U.S. corporate bond market;
- The dynamics of the risk-free interest rate;
- U.S. equity market factors such as return and volatility;

62 Huang and Kong (2003), Explaining credit spread changes: New evidence from option-adjusted bond indexes, *Journal of Derivatives*, Fall 2003, pg 30-44.

- Liquidity indicators from corporate bond mutual funds; and
- State of the U.S. economy.

247. Unlike other empirical studies that used the three-month or ten-year Treasury yield curve as measures of the general interest rate level, the authors argued that a Treasury yield index was a more appropriate proxy. As such, the Merrill Lynch Treasury Master Index was used as a measure of the general interest rate level, while the difference between the Merrill Lynch 15+ year Treasury index yield and the 1- to 3-year yield was used as a measure of the yield curve slope.

248. The paper carried out regressions at two levels. First, group-level regressions were used to examine the explanatory power of individual sets of variables, separated into variables that captured the realised default rates, interest rates, equity market factors, liquidity indicators, and macroeconomic indicators. These group-level regressions served to identify which sets of explanatory variables had the highest influence on credit spread movements. It was found that interest rate dynamics, equity market returns and volatility, and the general state of the economy had the largest explanatory power.

249. The explanatory variables in the group-level interest rate model were:

    a. Changes in yield of Merrill Lynch Treasury Master Index;

    b. Changes in yield of Merrill Lynch 15+ years Treasury Index minus yield of Merrill Lynch 1-3-year Treasury Index; and

    c. Changes in historical volatility of Merrill Lynch Treasury Master Index yields.

250. The coefficients for the changes in Treasury index yields were negative across all of the credit ratings investigated, and were generally higher for bonds of lower credit rating, with a coefficient of -7.14 for AA to AAA bonds with 1-10-year maturities and -21.92 for BBB to A bonds with 1-10-year maturities. There was no obvious trend for bonds with different maturities in the same credit rating. For example, the coefficients were -14.18 and -22.4 for BBB-A bonds with 10-15-year maturities and >15-year maturities respectively.

251. Alternative model specifications were also tested using:

- option-implied interest rate volatility instead of the historical volatility of Treasury Indexes; and
- combined regression specifications.

252. Under these specifications the coefficients were still generally negative but were not as negative as in the previous specifications and were sometimes positive.

B.6 Landschoot (2008)[63]

253. Landschoot (2008) compared the determinants of Euro and US dollar yield spread dynamics using a dataset of bonds identified from the Merrill Lynch Euro and US dollar Corporate Broad [sic] Market Indices, with the price data obtained using Bloomberg Generic (BGN) prices. The 3 month Euribor and US Treasury bill rates were used as proxies of the Euro and US dollar default-free rates. In addition, the model also included other explanatory variables that accounted for liquidity risk factors, the credit cycle, and differences in taxation systems.

254. The study concluded that US yield spreads were more sensitive to interest rate variables than Euro yield spreads, which was explained by the fact that financial sector bonds – which were less sensitive to interest rate changes – dominated the Euro sample. In addition, the Euro yield spreads were significantly affected by the level and slope of US interest rates instead of Euro interest rates.

255. The coefficient of the change in US interest rate level was negative for both Euro and US bonds at all credit ratings. Euro and US AA-rated bonds had coefficients of -0.03 and -0.15 respectively, while the corresponding coefficients for A rated bonds were -0.11 and -0.18. For BBB rated bonds, the coefficients were -0.22 and -0.40.

256. Analysing the dataset by sector produced the same observations. For the financial sector, the coefficients of the change in US interest rate level for Euro and US bonds were -0.05 and -0.18 respectively, while the industrial sector had coefficients of -0.19 and -0.18.

B.7 Queensland Treasury Corporation (2012)[64]

257. In its submission into the Productivity Commission's inquiry regarding Electricity Network Regulation, the Queensland Treasury Corporation (QTC) submitted that several interrelationships between WACC parameters needed to be recognised, including a negative relationship between the debt risk premium and the risk-free rate.

258. The QTC further stated that the correlation between the DRP from the Bloomberg 7-year BBB Fair Value Curve and the 7 year risk-free rate was -0.4 based on monthly data from 2001 onwards.[65]

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63 Landschoot (2008), Determinants of yield spread dynamics: Euro versus US dollar corporate bonds, *Journal of Banking and Finance*, 32, pg 2597-2605.

64 Queensland Treasury Corporation, "QTC Submission to the AEMC Directions Paper on Economic Regulation of Network Service Providers", Attachment 1 – Response to the AEMC Directions Paper, April 2012; http://www.pc.gov.au/inquiries/completed/electricity/submissions

65 Ibid, p 4.

COMPETITION ECONOMISTS GROUP

Appendix C Negative correlation in Lally, CEG and Chairmont data

259. In the previous section and in Appendix A, I identified the long strand of empirical literature that found a negative correlation between DRP and base interest rates, in the form of a negative regression coefficient when the former is regressed against the latter and a range of other explanatory variables.

260. I now confirm in this section that the same negative correlation is observed in the datasets that have previously been used in analysis for the AER – namely, the US FRED dataset used by Lally,[66] and the two Australian DRP datasets developed by CEG[67] and Chairmont.[68]

C.1 Description of datasets

C.1.1 Lally's US FRED dataset

261. Lally's dataset was obtained from the FRED database, which is available on the website of the US Federal Reserve Bank of St Louis.[69] Lally used the following monthly series in his analysis:

   i. Moody's seasoned Baa Corporate Bond Yield Relative to Yield on 10-Year Treasury Constant Maturity;

   ii. 10-Year Treasury Constant Maturity Rate; and

   iii. 5-Year Treasury Constant Maturity Rate.

262. All three of these series are available from April 1953 onwards, and Lally's full dataset extends to January 2015.

C.1.2 CEG's Australian DRP dataset

263. CEG's Australian BBB yield data is obtained as a combination of three sources – Bloomberg, RBA, and CBASpectrum. Yield data from Bloomberg and RBA are extrapolated to a 10-year term using the AER's methodology set out in its final

66 Lally (2015), Review of Submissions on the Cost of Debt, April 2015.

67 CEG, Efficient debt financing costs, A report for Network NSW, 19 January 2015.

68 Chairmont, Cost of Debt: Transitional Analysis, April 2015, p. 41.

69 Lally (2015), Review of Submissions on the Cost of Debt, April 2015; see description on page 72.

decision for JGN.[70] In a previous CEG report, I have argued that, historically, the AER's methodology for extrapolation resulted in a "minimisation of the difference between the Bloomberg fair value curve and the other two fair value curves over the relevant period."[71] I therefore use the AER's methodology for extrapolation in this report instead of the SAPN method.[72]

C.1.2.1 CBASpectrum

264. The CBASpectrum 10-year BBB series contains daily data from 1 July 1998 to 13 August 2010. The series is provided on a nominal semi-annual basis, and was first annualised to obtain the effective annual yield. This was converted to monthly data by taking the last observation of each month, before deducting the 10-year swap rate on that day, which results in a monthly BBB spread to swap series. The 10-year swap rate was obtained from Bloomberg's "ADSWAP10 Curncy" series.

C.1.2.2 RBA

265. RBA data was obtained from Statistical Table F3 – "Aggregate Measures of Australian Corporate Bond Spreads and Yields". This table contains the RBA's estimates of yields for target tenors of 3-, 5-, 7-, and 10-year on non-financial corporate BBB-rated bonds, provided monthly from January 2005 to present.

266. The RBA estimation methodology based on the Gaussian Kernel leads to shorter effective tenors than the target tenor. These yield estimates thus had to be reinflated to a 10 year effective tenor using a linear extrapolation based on the estimate slope between the 7-year and 10-year yields, obtained by dividing the RBA's estimated yield spread by the corresponding difference in effective tenors. This approach mirrors the AER's extrapolation methodology set out in its final decision for JGN.

267. The final step deducts the tenor-corrected RBA 10-year yields by Bloomberg's "ADSWAP10 Curncy" series, resulting in the RBA 10-year BBB spread-to-swap series.

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70 AER, Jemena Gas Networks (NSW) Ltd Access Arrangement 2015-20 Final Decision, Attachment 3 – Rate of Return, June 2015, p. 3-201.

71 JGN (NSW) Ltd, Response to the AER's draft decision and revised proposal, Appendix 7.12 – Return on debt expert report, February 2015. CEG, Critique of the AER's JGN draft decision on the cost of debt, February 2015, p. 65.

7272 Although, I note that, in any prospective period, the choice between the extrapolation methodologies should be decided by which gives the best fit to the available data.

C.1.2.3 Bloomberg

268. Bloomberg provides two sets of 1- to 10-year BBB fair value curves, the first being "C3561Y Index" to "C35610Y Index", and the second being "BVCSAB01 Index" to "BVCSAB10 Index". The CEG dataset uses the "C356x" series from December 2001 through February 2011, and switches to the "BVCSABx" series from March 2011 onwards till June 2014.

269. Both sets of series contain sporadic gaps during which the 10-year fair value curve is not available and will need to be extrapolated from the shorter-maturity curves by adding a margin to the BBB fair value curve with the longest maturity, based on data provided by the RBA. This is done using the following steps, based on the methodology used by the AER: [73]

    i. Obtain end-of-month Bloomberg fair value spread-to-swap for 1 to 10 years by taking the difference between each fair value curve and its corresponding swap rate.

    ii. Obtain the tenor-corrected RBA BBB yields for maturities of 5 years and above through the linear extrapolation method described in Section C.1.2.2. The 5-year yields are reinflated using the slope derived from 3- and 5-year yields and maturities, while the slopes for yields at 7 years and above are derived from 7- and 10-year yields and maturities.

    iii. Calculate the difference between the tenor-corrected 10-year yield and the tenor-corrected yield for the longest maturity available in Bloomberg data for that month, both of which were obtained in step (ii). For example, if Bloomberg only has data at 5- and 8- year maturities in that month, the margin to a 10-year term to maturity is calculated as the difference between the RBA tenor-corrected 8- and 10-year yields.

    iv. If the 10-year Bloomberg fair value DRP is available in step (ii), then it is used as the estimated spread-to-swap without additional steps. Otherwise, sum the longest-maturity yield obtained in step (ii) with the RBA margin obtained in step (iii).

C.1.2.4 Final spread-to-swap dataset

270. The three spread-to-swap sources described in Sections C.1.2.1 to C.1.2.3 are combined using the following procedure:

73 AER, Jemena Gas Networks (NSW) Ltd Access Arrangement 2015-20 Final Decision, Attachment 3 – Rate of Return, June 2015, p. 3-201.

i. If spread-to-swap estimates from both the RBA (Section C.1.2.1) and Bloomberg (Section C.1.2.3) methodologies are available for that month, then take the average of the two.

ii. If either one of the spread-to-swap estimates from the RBA and Bloomberg methodologies is not available for that month, then use the available one as the spread-to-swap estimate.

iii. If both the RBA and Bloomberg estimates are not available, then use the CBASpectrum estimate.

iv. If all three are not available – as is the case before July 1998 – then use the CBASpectrum estimate on July 1998.

271. The resulting dataset from CEG (2015) spans 20.5 years from August 1994 through January 2015.

C.1.3 Chairmont's Australian DRP dataset

272. Chairmont's dataset features a blend of DRPs from various sources set out in Sections C.1.3.1 to C.1.3.4.

C.1.3.1 Swap rate + (swap-to-CGS spread) x 4

273. The historical CGS rates are obtained from Table F16 "Indicative Mid Rates of Australian Government Securities". These were converted to 10-year maturity rates using linear interpolation.

274. Data on the 10-year Australian swap rates is obtained from Bloomberg's "ADSWAP10 Curncy" series. The estimated DRP is thus equal to the swap rate plus four times the difference between the swap rate and CGS rate.

275. This approach generates the longest series since it can be obtained for any date on which the swap and CGS rates are available, with the earliest observation on 1 July 1992.

C.1.3.2 Bloomberg Fair Value

276. Chairmont does not set out in detail the methodology that was used to obtain Bloomberg fair value estimates whenever there are missing observations for 10-year maturities. As such, I use the AER's extrapolation method described in Section C.1.2.3 to estimate the BBB 10-year yield, with the added step of interpolating between the monthly RBA margins to convert the margins to daily frequencies before adding these margins to the Bloomberg yield with the longest maturity.

C.1.3.3 RBA

277. The methodology for obtaining the BBB 10-year yield using RBA data is similar to the procedure described in Section C.1.2.2, except with the added step of interpolating between the monthly RBA yields to obtain daily frequencies.

C.1.3.4 Final DRP dataset

278. The three sources of the BBB 10-year yields described in Sections C.1.3.1 to C.1.3.3 are combined according to Table 10 below, which replicates Table 4 of Chairmont (2015). In order to produce as long a dataset as possible, I extend the data source in the first row all the way back to July 1992, while the data source in the last row is extended to January 2015, resulting in 22.5 years of data.

Table 10: Chairmont's data sources

Date (from)	Date (to)	Data Source
July 1999	November 2001	Swap Rate + (swap-to-CGS spread) x 4
December 2001	December 2004	Bloomberg Fair Value (BFV)
January 2005	November 2007	Average BFV + RBA
December 2007	March 2010	RBA
April 2010	June 2014	Average RBA + Bloomberg BVAL

Source: Chairmont (2015) Table 4

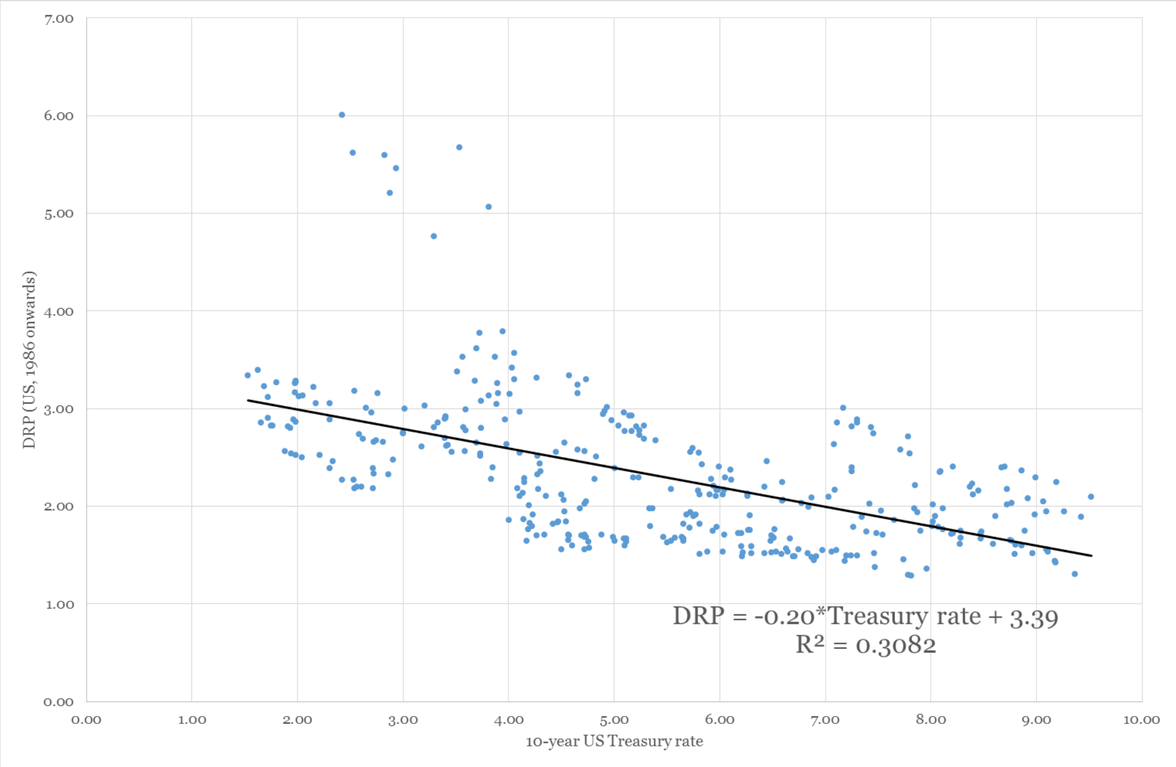
279. Finally, I deduct the 10-year swap rate from the resulting BBB 10-year yields to obtain the corresponding DRPs, before converting the daily data back to a monthly frequency by taking the simple average DRP over each month.

C.2 Correlations obtained from the datasets

C.2.1 Lally's US FRED dataset

280. The scatterplot in Figure 31 uses the US FRED data on DRP and 10-year Treasury rate with a monthly frequency. The regression coefficient is -0.20 with a regression, which matches closely with the regression coefficient of -0.184 found by Longstaff and Schwartz (1995). Taking the square root of the regression R^2 estimate of 0.3082 results in a correlation coefficient of -0.56.

Figure 31: FRED data; 1986 onwards



Source: Federal Reserve Bank of St Louis, CEG analysis

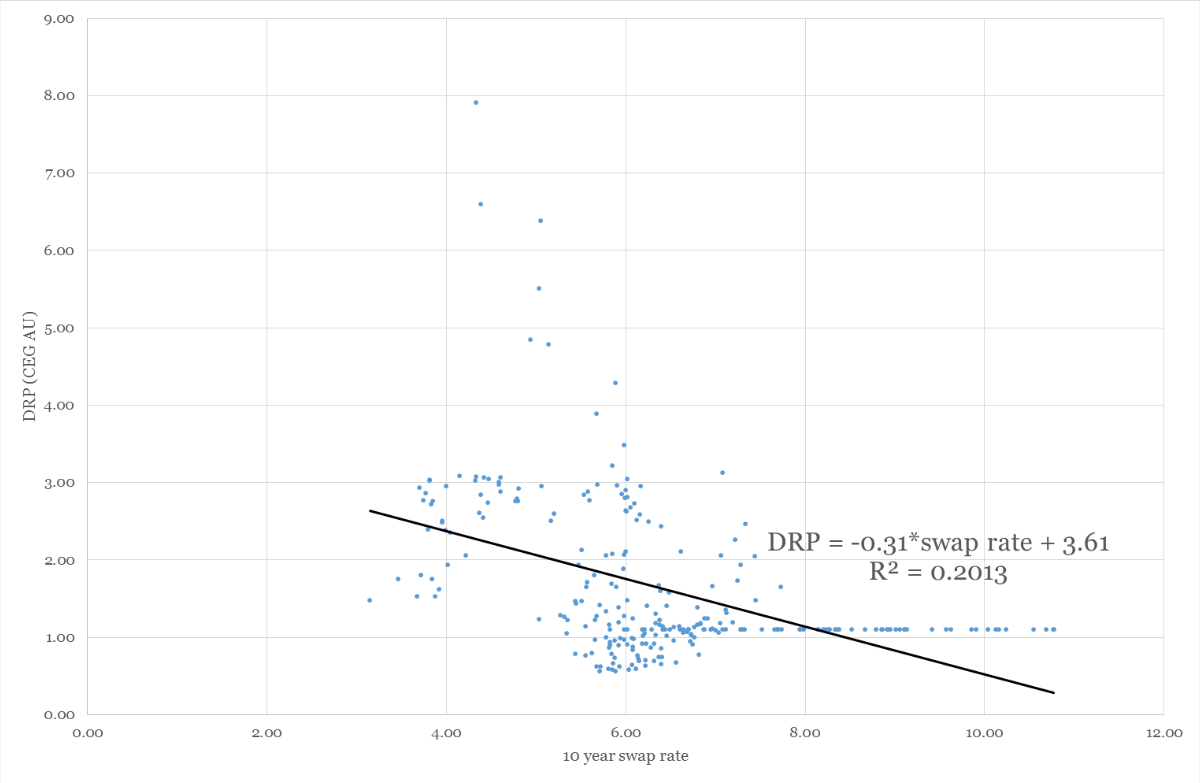
C.2.2 CEG's Australian DRP dataset

281. There is a strong inverse relationship between the 10 year swap rate and the 10 year DRP (measured relative to swap rates) for both the CEG and Chairmont AUD data series. This is captured in the scatterplots reported below.

282. Figure 32 shows the scatterplot of DRP against the 10-year swap rate, using CEG's Australian dataset with a monthly frequency. Based on this data the regression coefficient on the swap rate is -0.31, which is broadly consistent with the -0.40 correlation found by QTC (2012). Taking the square root of the R^2 value of 0.2013 results in a correlation coefficient of -0.45.

283. It should be noted that this dataset includes an assumption that the DRP was constant between July 1994 and July 1998 (in order to feed into a 10 year trailing average DRP/cost of debt from July 2004). If this data is excluded the correlation coefficient becomes -0.51.

Figure 32: CEG AU dataset from section C.1.2

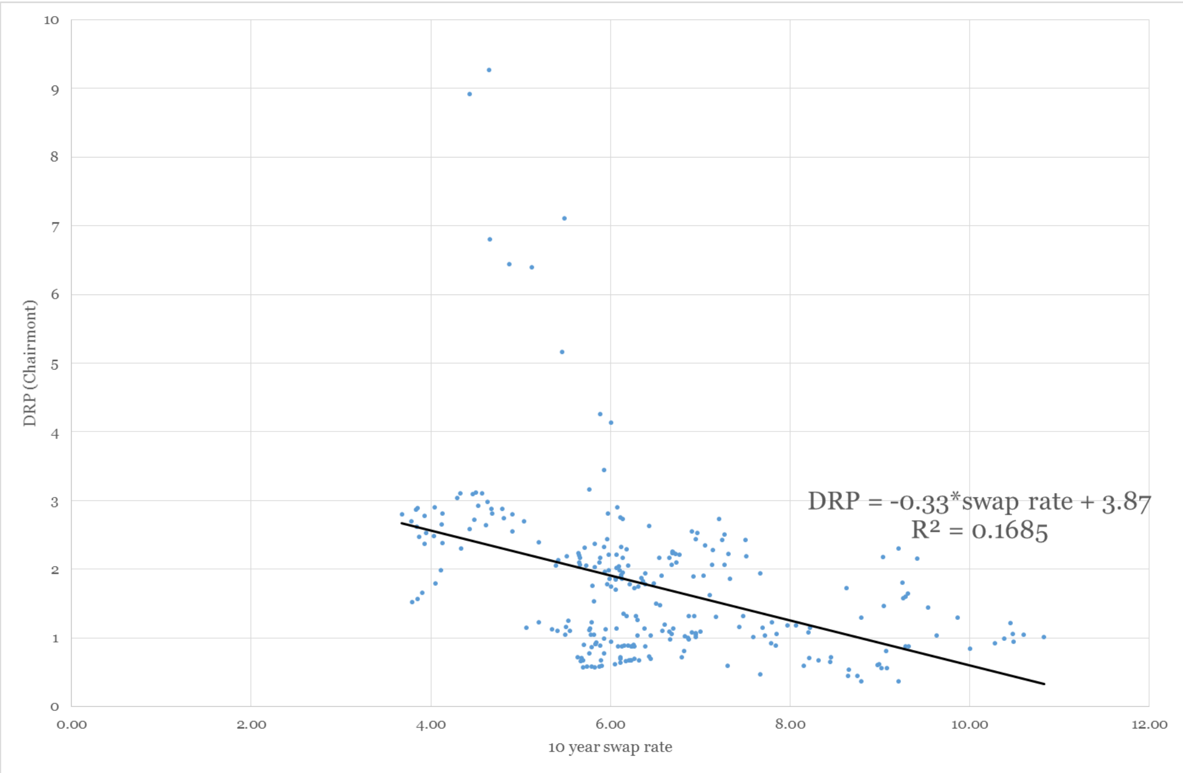


Source: CBASpectrum, RBA, Bloomberg, CEG analysis

C.2.3 Chairmont's Australian DRP dataset

284. The scatterplot in Figure 33 uses Chairmont's Australian dataset with a monthly frequency. The regression coefficient is -0.33, which is very similar to the -0.31 coefficient obtained with CEG's Australian dataset. The estimated R^2 of 0.1685 translates to a correlation coefficient of -0.41, which is also similar to the -0.45 correlation coefficient obtained from CEG's Australian dataset.

Figure 33: Chairmont dataset



Source: Chairmont, CEG analysis

C.3 Summary

285. The results are summarised in Table 11, which shows that the correlation coefficients between DRP and the 10-year swap or Treasury rate are all negative for all datasets. The slope coefficients for all three datasets range between -0.15 to -0.71, which is broadly in line with empirical literature estimates in Table 10.

Table 11: Correlation coefficients for all datasets

Dataset	Correlation
CEG AU (not including pre 1998 DRP)	-0.45
CEG AU (assumed constant DRP pre 1998)	-0.51
Chairmont (1991 to 2001 DRP assumed to move with CGS/swap rate spread)	-0.41
FRED US – 1986 onwards	-0.56

Source: CBASpectrum, RBA, Bloomberg, Chairmont, Federal Reserve Bank of St Louis, CEG analysis

Appendix D Negative correlation evidence from other datasets

286. Having shown in Appendix C that the negative correlation between DRP and base interest rates is also observed in the three DRP datasets currently available before the AER, I further verify the observation by analysing other international datasets as set out in this Section.

D.1 International Bloomberg BBB indices

287. I used Bloomberg's "Security Finder (SECF)" function to identify the Bloomberg Fair Value (BFV) indexes containing estimates of 10-year yields with BBB credit ratings for USD, GBP, EUR, CAD, and JPY.

288. My initial search identified 49 BFV indexes, which were subsequently narrowed down to 10 based on the following criteria:

- BBB rating;
- Industrial, Utility, or Gas Transmissions sectors; and
- Covers at least 2,000 trading days (around 8 years of data).

289. The full list of BFV indexes is shown in Table 12 to Table 16, along with the swap data that corresponds to each currency. I also considered using BVAL indexes, but none of these had sufficient data, though I note that the BFV data series includes BVAL data from the date that Bloomberg supplanted BFV with BVAL data.

Table 12: Bloomberg Fair Value Indexes (USD)

Bloomberg Ticker	Description	No. of Obs	Selection
C00910Y Index	BFV USD US Industrial BBB 10 Year	4495	Yes
C01010Y Index	BFV USD US Industrial BBB- 10 Year	4177	No
C03910Y Index	BFV USD US Utility BBB 10 Year	4495	Yes
C52710Y Index	BFV USD US Gas Transmission (BBB) 10 Year	3713	Yes
C02810Y Index	BFV USD US Finance (BBB) 10 Year	3433	No
C04010Y Index	BFV USD US Utility BBB- 10 Year	4444	No
C55810Y Index	BFV USD US Utility Medium Term Note BBB 10 Year	1805	No
C56710Y Index	BFV USD US Industrial Medium Term Note BBB 10 Year	3578	Yes
C01110Y Index	BFV US Global Industrial (BBB) 10 Year	3179	Yes
Swap data			
USSWAP10 Curncy	USD Swap Semi-Annual 30/360 10Y	4496	

Source: Bloomberg, CEG analysis

Table 13: Bloomberg Fair Value Indexes (GBP)

Bloomberg Ticker	Description	No. of Obs	Selection
C40510Y Index	BFV GBP Euro (BBB) 10 Year	4495	Yes
C68510Y Index	BFV GBP Euro Finance (BBB) 10 Year	2860	No
Swap data			
BPSW10 Curncy	GBP Swap 10YR	4488	

Source: Bloomberg, CEG analysis

Table 14: Bloomberg Fair Value Indexes (EUR)

Bloomberg Ticker	Description	No. of Obs	Selection
C67310Y Index	BFV EUR Composite (BBB) 10 Year	3771	No
C46810Y Index	BFV EUR Eurozone Ind BBB 10 Year	3539	Yes
C46910Y Index	BFV EUR Industrial BBB-10 Year	3074	No
C62810Y Index	BFV EUR Telephone (BBB) 10 Year	2009	No
C62910Y Index	BFV EUR Telphone BBB- 10 Year	355	No
C64410Y Index	BFV EUR Finance (BBB) 10 Year	2367	No
Swap data			
EUSA10 Curncy	EUR Swap Annual 10 YR	4228	

Source: Bloomberg, CEG analysis

Table 15: Bloomberg Fair Value Indexes (CAD)

Bloomberg Ticker	Description	No. of Obs	Selection
C28810Y Index	BFV CAD Canada Corporate (BBB) 10 Year	4495	No
C29710Y Index	BFV CAD Canada Utility (BBB) 10 Year	3407	Yes
C33510Y Index	BFV CAD Canada Energy (BBB) 10 Year	1960	No
C32310Y Index	BFV CAD Canada Finance (BBB) 10 Year	2847	No
C29910Y Index	BFV CAD Canada Gas Transmission (BBB) 10 Year	2943	Yes
C30510Y Index	BFV CAD Canada Telephone (BBB) 10 Year	3011	No
Swap data			
CDSW10 Curncy	CAD Swap 10YR	4491	

Source: Bloomberg, CEG analysis

Table 16: Bloomberg Fair Value Indexes (JPY)

Bloomberg Ticker	Description	No. of Obs	Selection
C22810Y Index	BFV JPY Composite (BBB) 10 Year	1872	No
C45410Y Index	BFV JPY Japan Industrial (BBB) 10 Year	2306	Yes
C45510Y Index	BFV JPY Japan Industrial BBB- 10 Year	608	No
Swap data			
JYSW10 Curncy	JPY Swap 10 YR	4488	

Source: Bloomberg, CEG analysis

290. Table 17 shows the estimated correlations between the 10-year spread-to-swap and corresponding 10-year swap rate for each of the 10 indexes selected.

Table 17: Correlations and regression slopes obtained from Bloomberg data

Bloomberg Ticker	Correlation	Regression slope
USD		
C00910Y Index	-0.554	-0.251
C03910Y Index	-0.518	-0.248
C52710Y Index	-0.426	-0.301
C56710Y Index	-0.709	-0.649
C01110Y Index	-0.437	-0.312
GBP		
C40510Y Index	-0.597	-0.254
EUR		
C46810Y Index	-0.003	-0.002
CAD		
C29710Y Index	-0.571	-0.404
C29910Y Index	-0.528	-0.413
JPY		
C45410Y Index	-0.513	-0.251
Interquartile range	**-0.46 to -0.57**	**-0.25 to -0.38**

Source: Bloomberg, CEG analysis

291. The regression coefficients in Table 17 are broadly similar to the regression coefficients found in empirical literature identified in Table 9, while the correlation coefficients are fairly in line with the ones estimated from the three datasets in Table 11, which further confirms the existence of a negative relationship between DRP and base interest rates.

D.2 Federal Reserve Bank of St Louis BBB data

292. I further cross-checked our findings using the following data obtained from the Federal Reserve Bank of St Louis:

   i. Moody’s Seasoned Baa Corporate Bond Yield© (Daily data from 2 January 1986 to 27 March 2015);[74]

[74] This is the same series that was used by Lally (2015) and which I investigated in Sections 4 to 5, except that I used daily frequencies here and obtained the correlation relative to the 10-year swap rate instead of the 10-year Treasury Rate.

ii. BofA Merrill Lynch US Corporate 7-10 Year Effective Yield© (Daily data from 31 December 1996 to 27 March 2015);

iii. BofA Merrill Lynch US Corporate 10-15 Year Effective Yield© (Daily data from 31 December 1996 to 27 March 2015);

iv. BofA Merrill Lynch US Corporate BBB Effective Yield© (Daily data from 31 December 1996 to 27 March 2015); and

v. 10-Year Swap Rate (Daily data from 3 July 2000 to 27 March 2015).

293. I then obtained four sets of spread-to-swap estimates by deducting series (v) from series (i) to (iv). The resulting correlations and coefficient estimates are shown in Table 18.

Table 18: Correlations and regression slopes obtained from the Federal Reserve Bank of St Louis data

Series	Correlation	Regression slope
Moody's Baa Corporate Bond Yield©	-0.577	-0.389
BofA Merrill Lynch US Corporate 7-10 Year Effective Yield©	-0.383	-0.286
BofA Merrill Lynch US Corporate 10-15 Year Effective Yield©	-0.559	-0.387
BofA Merrill Lynch US Corporate BBB Effective Yield©	-0.282	-0.242
Range	**-0.28 to -0.58**	**-0.29 to -0.39**

Source: Federal Reserve Bank of St Louis, CEG analysis

294. Similar to the observations made using Bloomberg data, Table 18 shows that the regression coefficients estimated on data from the Federal Reserve Bank of St Louis are broadly in line with the estimates found in empirical literature. In particular, the regression slopes of all four series once again fall between -0.40 to -0.20.

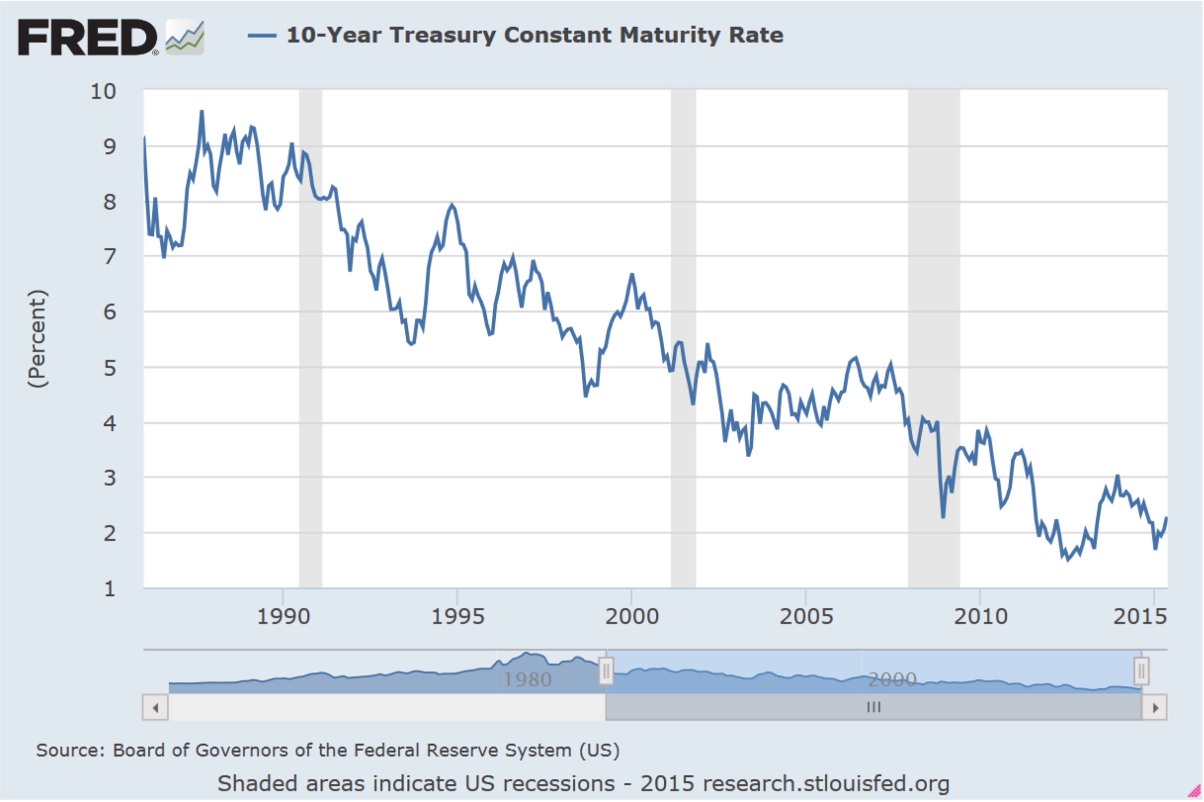
295. I reiterate, however, that the focus of the above analysis is in establishing the existence of a negative correlation between DRP and swap rates, while the regression slopes obtained in Table 18 are only used for comparison with the empirical literature discussed in Section 5 without drawing further inferences from the slope coefficients.

296. The correlation coefficient of -0.58 for the Moody's Baa Corporate Bond Yield is broadly in line with the -0.56 correlation found in Table 11 when the monthly series was plotted against the 10-year Treasury rate.

Appendix E Detrending method

297. FRED data shows that the 10-year US Treasury yield has been on a steady decline from the mid-1980s until now. This is clearly seen in Figure 34.

Figure 34: 10-year US Treasury Constant Maturity Rate



Source: Federal Reserve Bank of St Louis, World Bank

298. From the perspective of an efficient firm that does not attempt to speculate on future interest rate patterns, it would be reasonable to evaluate its debt management strategy on the *ex-ante* assumption that there is no trend in future interest rates. Alternatively, the firm could also assume that even if such a trend did exist, the direction and magnitude of the said trend could not be accurately predicted beforehand. It would then be prudent for the firm to proceed on the assumption that the future long-run trend would be zero on average.

299. The standard econometric method for removing a deterministic trend in time series is to use the residuals obtained from regressing the series against time. This is analogous to plotting the best straight line through the series and then taking the difference between the original series and best fit straight line.

300. It is also necessary to modify the 5-year Treasury rate in order to account for the de-trending of the 10-year Treasury rate. This was done by taking the difference between the original 10-year Treasury rate and the original 5-year Treasury rate, and adding it to the de-trended 10-year Treasury rate. That is, the spread between the 10- and 5-year Treasury rates is assumed to be unaffected by the de-trending process. An alternative approach would be to de-trend the 5-year Treasury rate separately, but this would result in a different slope of the best straight line, leading to two de-trended series that are not comparable.

301. For the CEG Australian, Chairmont, and post-Volcker FRED US datasets, I set the start of the de-trending horizons at 10 years before the first regulatory month analysed, in order to take the initial 10-year trailing average into account. For the CEG Australian and Chairmont datasets, de-trending was carried out across the period from July 1994 to June 2014, and from July 1992 to January 2015 respectively, while the FRED US dataset was de-trended over the period between January 1986 and January 2015. I have also used different starting periods for the de-trending process and found that the resulting final statistics are not materially different.

302. The original and modified 10- and 5-year Treasury/swap rates are shown in Figure 35 and Figure 36, for the US/Australian data.

Figure 35: US FRED dataset; 5- and 10-year Treasury rates; non-detrended and detrended

Source: Federal Reserve Bank of St Louis, CEG analysis

Figure 36: Australian dataset; 5- and 10-year swap rates; non-detrended and de-trended

Source: Bloomberg, CEG analysis

Appendix F Standard deviations over 60 regulatory cycles

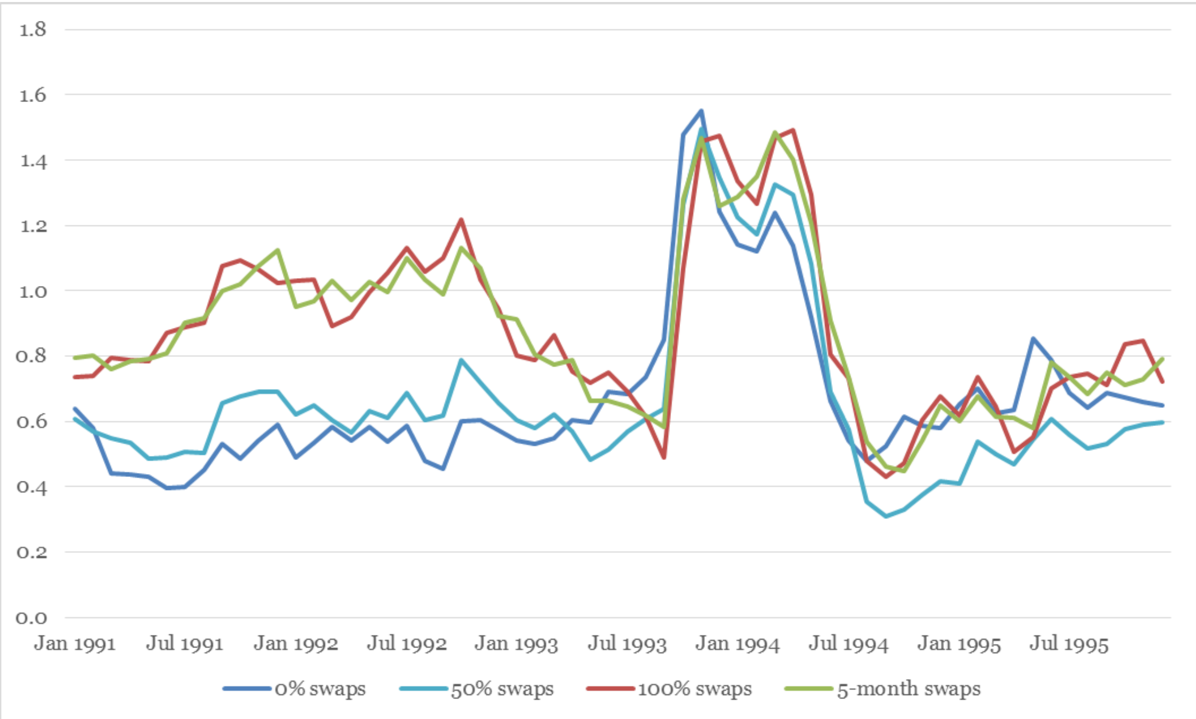
303. Figure 37 shows a plot of the 60 standard deviations obtained from the US post-Volcker dataset while Figure 38 shows the corresponding uncentred standard deviations for the same dataset, with the 60 initial regulatory cycles having starting months ranging from January 1991 to December 1995, as explained in Section 5.1.1.

304. It can be seen from Figure 37 that the 0% interest rate swaps debt management strategy (blue line) has a lower standard deviation than the 100% interest rate swap debt management strategy (red line). The spike in the standard deviations of all strategies associated with regulatory periods beginning in late 1993 to mid-1994 are associated with regulatory cycles that have a regulatory period beginning in late 2008 to mid-2009 (i.e., the middle of the global financial crisis).

305. The same observations can be seen with the uncentred standard deviations in Figure 38, whereby the series for the 0% swap strategy is generally lower than that of the 100% swap strategy for the US post-Volcker dataset.

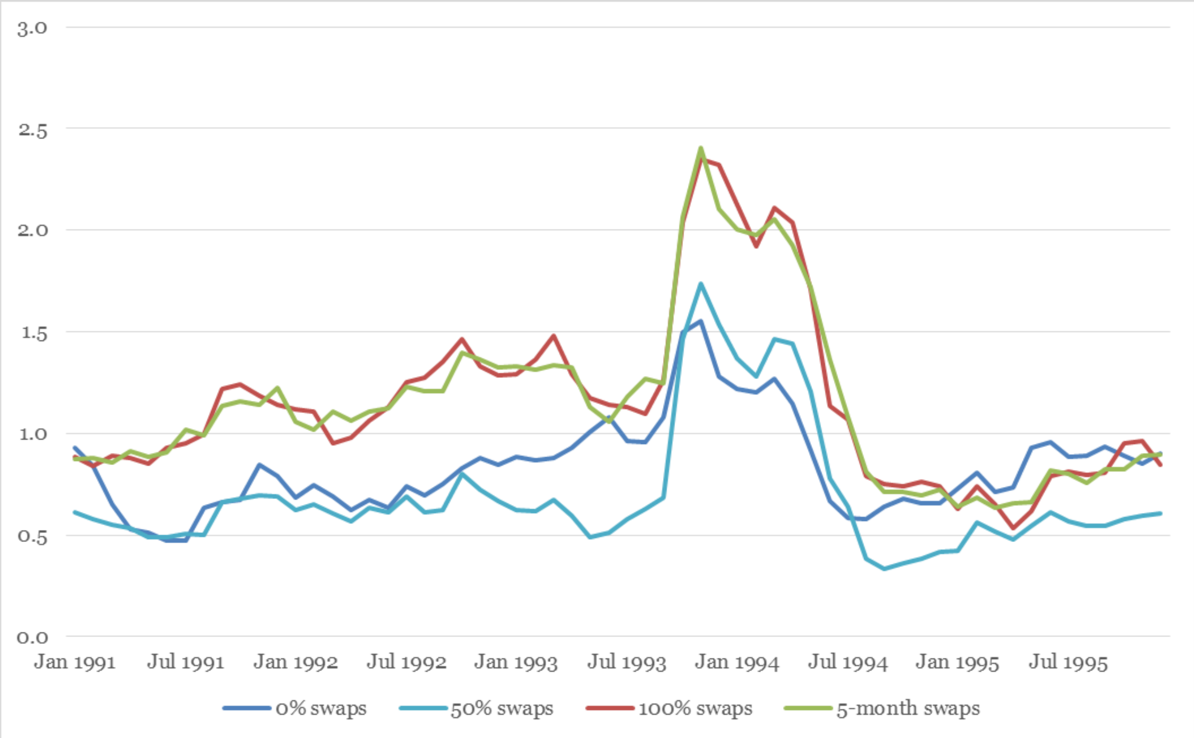
306. Overall, these confirm the results presented in Sections 4.4, 5.2, and 5.3.

Figure 37: Standard deviations – US Post-Volcker dataset



Source: CEG analysis

Figure 38: Uncentred standard deviations – US Post-Volcker dataset



Source: CEG analysis

Appendix G US FRED results using Lally's approach with only March 1968 – March 1986 excluded

307. In Section 4.3.2, I pointed out that inflation rates in the US were high and variable over the 1970s and 1980s, which meant that this period should be excluded from this analysis since expected and actual inflation were clearly not the same during this timeframe.

308. My subsequent analysis in Sections 4.4 to 5.4 using Lally's FRED dataset proceeded with all data prior to April 1986 excluded. In this Appendix, I carry out the same analysis with a different dataset, whereby only the period from March 1970 to March 1986 is excluded. That is, the dataset consists of two separate periods from April 1953 to February 1970, and then from April 1986 to January 2015. The average standard deviation is then calculated as the average of five standard deviations obtained from five sets of regulatory cycles.

309. With the dataset broken into two separate segments, each of the five sets of regulatory cycles will have two initial regulatory starting months. That is, the first set of regulatory cycles will have two initial starting months in March 1963 and March 1996, both of which involve using the first 10 years of observations in both data segments prior to those dates in order to obtain a 10-year trailing average component. For this first set of regulatory cycles, the standard deviation is calculated with regulatory reset months occurring in March 1963, March 1968[75], March 1996, March 2001, March 2006, and March 2011.

310. The reset months in the second to fifth sets of regulatory cycles sequentially occur one year later. For example, the standard deviation from the second set of regulatory cycles is calculated with reset months in March 1964, March 1969, March 1997, March 2002, March 2006, and March 2012. The resulting five standard deviations are then averaged to obtain the average standard deviation for each of the three debt management strategies investigated by Lally. These results are shown in Table 19, along with that of the full dataset and the post-Volcker dataset.

75 However, only the deviations between cost and allowance in the first two years of this regulatory period are used in the calculation – the later years falling in the excluded 1970s period.

Table 19: Results of Lally's methodology for different US FRED datasets

Firm Policy	Std Dev – Full dataset	Std Dev – Post-Volcker	Std Dev – 70s and 80s excluded
Enter swaps over 1 month	0.87%	0.97%	0.97%
Enter swaps over 5 months	0.82%	0.97%	0.95%
Do not use swaps	1.49%	0.71%	0.75%

Source: Lally (2015); CEG analysis

311. The standard deviations of the first two columns in Table 19 can also be seen in Figure 8 and Figure 12, with the first column replicating Table 4 of Lally (2015) exactly.

312. The standard deviations in the last column, which are obtained by applying Lally's methodology to his US FRED dataset with the 70s and 80s excluded, are very close to the ones obtained from the post-Volcker dataset, which excludes all observations prior to April 1986. This confirms the argument that I put forward in Section 4.3, that Lally's results are purely attributed to the high and unstable inflation observed in the US during the 70s and 80s. Including the period of relatively stable inflation in the 50s and 60s does not lead to substantial changes in the results obtained from the post-Volcker dataset.

Appendix H Combined dataset approach for measuring standard deviations

313. In Section 5.1.2, I criticised Lally's approach of measuring the risk associated with a particular debt management strategy based on the average standard deviation, calculated as the average of the individual standard deviations of each set of regulatory cycles.

314. Instead, I suggested an alternative measure that estimates a single standard deviation from a single combined dataset of all 60 sets of regulatory cycles instead of calculating the average over individual standard deviations.

315. The notation in this Appendix uses lower case letters to denote variables derived from individual sets of regulatory cycles (except raw data taken from the US FRED database), and upper case letters to represent the variables obtained by combining the 60 sets of regulatory cycles.

316. Using this approach, the combined set of allowed rates is obtained by combining the allowed rates calculated from Equation (13) of Lally (2015) for different sets of regulatory cycles with different starting months into a single set:[76, 77]

$$K(ALL) = \begin{bmatrix} k(All_{Mar1958}) \\ k(All_{Apr1958}) \\ \vdots \\ k(All_{Jan1963}) \\ k(All_{Feb1963}) \end{bmatrix} = \begin{bmatrix} R_{f10;\ \mathrm{Mar1958}}^{OTD(1)} + DRP_{10;\ \mathrm{Mar1958}}^{OTD(1)} \\ R_{f10;\ \mathrm{Apr1958}}^{OTD(1)} + DRP_{10;\ \mathrm{Apr1958}}^{OTD(1)} \\ \vdots \\ R_{f10;\ \mathrm{Jan1963}}^{OTD(1)} + DRP_{10;\ \mathrm{Jan1963}}^{OTD(1)} \\ R_{f10;\ \mathrm{Feb1963}}^{OTD(1)} + DRP_{10;\ \mathrm{Feb1963}}^{OTD(1)} \end{bmatrix}$$

317. The combined set of incurred costs under the trailing average approach (0% hedging ratio) would be:

76 The equation below adopts the modifications to Lally's methodology set out in Section 5.1.

77 Note that the month and year in the subscripts of each vector refer to the starting month of each set of regulatory cycles, with the regulatory cycles in each set resetting every five years. They do not refer to 10-year risk-free rates and DRPs in that single month alone.

$$K(PAID) = \begin{bmatrix} k(Paid_{Mar1958}) \\ k(Paid_{Apr1958}) \\ \vdots \\ k(Paid_{Jan1963}) \\ k(Paid_{Feb1963}) \end{bmatrix} = \begin{bmatrix} R^{TA}_{f10;\ \text{Mar1958}} + DRP^{TA}_{10;\ \text{Mar1958}} \\ R^{TA}_{f10;\ \text{Apr1958}} + DRP^{TA}_{10;\ \text{Apr1958}} \\ \vdots \\ R^{TA}_{f10;\ \text{Jan1963}} + DRP^{TA}_{10;\ \text{Jan1963}} \\ R^{TA}_{f10;\ \text{Feb1963}} + DRP^{TA}_{10;\ \text{Feb1963}} \end{bmatrix}$$

318. The combined set of incurred costs under a hybrid approach (100% hedging ratio) with swaps being undertaken in the same month as the regulatory reset date is:

$$K(PAID) = \begin{bmatrix} k(Paid_{Mar1958}) \\ k(Paid_{Apr1958}) \\ \vdots \\ k(Paid_{Jan1963}) \\ k(Paid_{Feb1963}) \end{bmatrix} = \begin{bmatrix} R^{OTD}_{f5;\ \text{Mar1958}} + DRP^{TA}_{10;\ \text{Mar1958}} \\ R^{OTD}_{f5;\ \text{Apr1958}} + DRP^{TA}_{10;\ \text{Apr1958}} \\ \vdots \\ R^{OTD}_{f5;\ \text{Jan1963}} + DRP^{TA}_{10;\ \text{Jan1963}} \\ R^{OTD}_{f5;\ \text{Feb1963}} + DRP^{TA}_{10;\ \text{Feb1963}} \end{bmatrix}$$

319. Finally, the reported standard deviation is the standard deviation of the difference between the regulatory allowed rates and incurred costs of debt for the combined dataset. For a particular hedging ratio, x, the standard deviation would be:

$$SD(ALL - PAID) = SD\left\{ \begin{bmatrix} k(All_{Mar1958}) \\ k(All_{Apr1958}) \\ \vdots \\ k(All_{Jan1963}) \\ k(All_{Feb1963}) \end{bmatrix} - \begin{bmatrix} k(Paid_{Mar1958}) \\ k(Paid_{Apr1958}) \\ \vdots \\ k(Paid_{Jan1963}) \\ k(Paid_{Feb1963}) \end{bmatrix} \right\}$$

$$= SD\left\{ \begin{pmatrix} R^{OTD(1)}_{f10;\text{Mar1958}} + DRP^{OTD(1)}_{10;\text{Mar1958}} - xR^{TA}_{f10;\text{Mar1958}} - (1-x)R^{OTD}_{f5;\text{Mar1958}} - DRP^{TA}_{10;\text{Mar1958}} \\ R^{OTD(1)}_{f10;\text{Apr1958}} + DRP^{OTD(1)}_{10;\text{Apr1958}} - xR^{TA}_{f10;\text{Apr1958}} - (1-x)R^{OTD}_{f5;\text{Apr1958}} - DRP^{TA}_{10;\text{Apr1958}} \\ \vdots \\ R^{OTD(1)}_{f10;\text{Apr1958}} + DRP^{OTD(1)}_{10;\text{Apr1958}} - xR^{TA}_{f10;\text{Apr1958}} - (1-x)R^{OTD}_{f5;\text{Apr1958}} - DRP^{TA}_{10;\text{Apr1958}} \\ R^{OTD(1)}_{f10;\text{Apr1958}} + DRP^{OTD(1)}_{10;\text{Apr1958}} - xR^{TA}_{f10;\text{Apr1958}} - (1-x)R^{OTD}_{f5;\text{Apr1958}} - DRP^{TA}_{10;\text{Apr1958}} \end{pmatrix} \right\}$$

320. In contrast to Lally's approach, which calculates one standard deviation for each set of regulatory cycles with different starting months and then calculates the average, the combined approach instead generates only a single standard deviation that is computed across all the sets of regulatory cycles.

321. In doing so, this approach has the advantage of:

i. Correctly referencing a single mean that is calculated across all of the sets of regulatory cycles;

ii. Implicitly incorporating correlations among all the sets of regulatory cycles; and

iii. Assigning the correct weight to regulatory cycles of different lengths.