Queensland Competition Authority 2021 inflation review

QUEENSLAND TREASURY CORPORATION

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1 Summary

Inflation and the return on equity

- The QCA's objective of targeting a 10-year real return on equity can be improved by using an implied real risk-free rate that is calculated using market estimates of inflation and the observable 10-year indexed Commonwealth Government Security (CGS) yield.
- The QCA's current proxy for the real risk-free rate equals the 10-year nominal CGS yield minus QCA 10-year expected inflation. This results in an implied inflation risk premium (IRP) being reflected in the real risk-free rate, however a true real (ie, inflation-indexed) rate does not include compensation for inflation. As such, the QCA's real risk-free rate proxy is likely to be biased.
- This submission sets out a simple approach for estimating a lower bound for an indexed CGS yield that excludes expected inflation, the IRP and the liquidity premium in the observable indexed CGS yield.
- QTC considers the mid-point between the lower bound indexed CGS yield and the observable indexed CGS yield to be a reasonable estimate of the real risk-free rate that should be reflected in the real return on equity. The deductions for inflation on the equity-funded portion of the regulated asset base (RAB) should be made using the difference between the 10-year nominal CGS yield in the nominal return on equity and the 10-year mid-point indexed CGS yield.
- For consistency, the same estimate of inflation should be used in the dividend discount model and the Wright approach when estimating the market risk premium (MRP).

Inflation and the cost of debt

- It is efficient practice for the benchmark entity to issue nominal debt rather than inflation-indexed debt. The treatment of debt in the QCA's building block model is consistent with the issuance of nominal debt.
- As the cost of servicing nominal debt does not change based on actual inflation, the delivered nominal cost of debt should also be unaffected by actual inflation. This can be achieved by:
  - using an estimate of expected inflation for the term of the regulatory period to make the deductions for inflation on the debt-funded portion of the RAB, and
  - using the same estimate of expected inflation to index the debt-funded portion of the RAB at the end of the regulatory period rather than actual inflation.
- QTC considers this to be a pragmatic way for the delivered and expected nominal cost of debt to be equal in each regulatory year. This is consistent with the contractual nature of nominal debt servicing costs, which must be made on time and in full in each regulatory year regardless of the level of actual inflation.
- If the QCA continues to target a real cost of debt the deductions for inflation on the debt-funded portion of the RAB should equal the amount of inflation that is expected to be added at the end of the regulatory period. This requires estimating expected inflation for the term of the regulatory period.
- This submission sets out two approaches for estimating expected inflation for the term of the regulatory period based on the Reserve Bank of Australia's (RBA) 1–2 year headline inflation forecasts and the implied-forward 1-year zero-coupon inflation swap (ZCIS) rates. QTC considers both approaches to be a reasonable way of making use of market and non-market estimates of inflation.

2 The role of inflation in the regulatory framework

- It is QTC's understanding that the QCA's current objectives are to:
  - determine a real rate of return based on a nominal rate of return minus QCA expected inflation, and
  - deliver the real rate of return plus actual inflation during the regulatory period.
- The nominal return on equity and cost of debt are inputs in the revenue building block model. The inputs are converted to real terms by making deductions for inflation on the RAB using QCA expected inflation. This produces the same revenues as applying a real weighted average cost of capital to the indexed RAB.
- To ensure the equity providers are not compensated for inflation twice, the deductions for inflation on the equity-funded portion of the RAB should equal the amount of inflation compensation in the 10-year nominal CGS yield that is used to determine the nominal return on equity.
- Different considerations apply to the debt-funded portion of the RAB because it is efficient practice for the benchmark entity to issue nominal debt rather than inflation-indexed debt. As such, it is appropriate to deliver a nominal cost of debt that is not affected by actual inflation rather than targeting a real cost of debt. This can be done by using the same estimate of expected inflation to make the deductions for inflation on the debt-funded portion of the RAB and to index the debt-funded portion of the RAB at the end of the regulatory period.

3 Estimating expected inflation

3.1 Current approach

- The QCA estimates 10-year expected inflation using RBA headline Consumer Price Index (CPI) forecasts in years 1–2 and the 2.5 per cent mid-point of the RBA's 2.0–3.0 per cent target band in years 3–10. The approach assumes the RBA mid-point is an anchor for long-term inflation expectations.

3.2 Market estimates of inflation

- The two market estimates of inflation are the bond break-even inflation rate (BBIR) and the zero-coupon inflation swap (ZCIS) rate:
  - The BBIR equals the difference between the observable nominal and indexed CGS yields.
  - A ZCIS involves exchanging the difference between a notional cash flow that is indexed by a fixed inflation rate and a notional cash flow that is indexed by the actual change in the headline CPI over the term of the swap.
- Market estimates reflect expected inflation and the inflation risk premium (IRP). The IRP is often viewed as a source of bias that makes market estimates unsuitable for regulatory purposes. However, the real return on equity requires the deductions for inflation on the equity-funded portion of the RAB to equal the amount of inflation compensation in the 10-year nominal CGS yield (ie, expected inflation *and* the IRP).

4 Inflation and the return on equity

- The QCA's objective of targeting a 10-year real return on equity can be improved by using an implied real risk-free rate that is calculated using market estimates of inflation and the observable 10-year indexed CGS yield.
- The QCA's current proxy for the real risk-free rate equals the 10-year nominal CGS yield minus QCA 10-year expected inflation. This results in an implied inflation risk premium (IRP) being reflected in the real risk-free rate, however a true real (ie, inflation-indexed) rate does not include compensation for inflation. As such, the QCA's real risk-free rate proxy is likely to be biased.
- Appendix A sets out a simple approach for estimating a lower bound for an indexed CGS yield that excludes expected inflation, the IRP and the liquidity premium in the observable indexed CGS yield.
- QTC considers the mid-point between the lower bound indexed CGS yield and the observable indexed CGS yield to be a reasonable estimate of the real risk-free rate that should be reflected in the real return on equity. The deductions for inflation on the equity-funded portion of the RAB should be made using the difference between the 10-year nominal CGS yield in the nominal return on equity and the 10-year mid-point indexed CGS yield.
- For consistency, the same estimate of inflation should be used in the dividend discount model and the Wright approach when estimating the market risk premium (MRP).

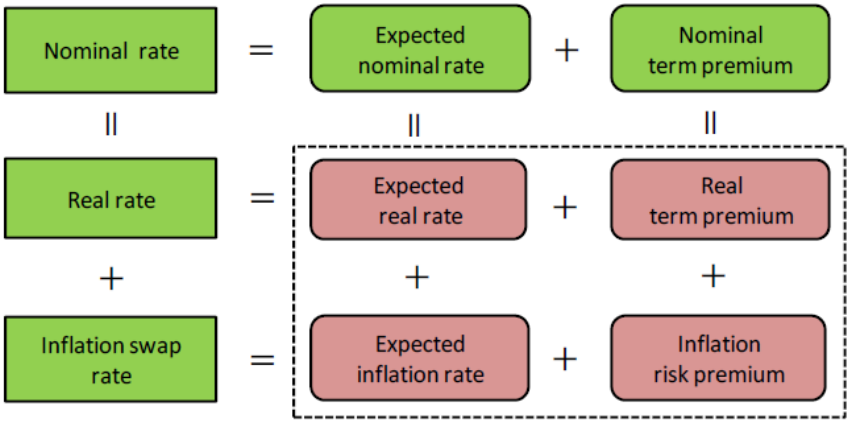
4.1 Applying the CAPM in real terms

- The QCA uses the Capital Asset Pricing Model (CAPM) to calculate the nominal return on equity. Although the nominal return on equity is an input in the revenue building block model, making deductions for inflation on the equity-funded portion of the RAB is equivalent to determining a real return on equity based on QCA expected inflation. As such, the QCA implicitly applies the CAPM in real terms to determine a real return on equity.
- In a 2020 report for the Australian Energy Regulator (AER), Lally advised that[1]:

> *'If the discrete-time CAPM applies, it would then apply in real terms, and the risk-free rate would be that on indexed bonds.'*

- The observable 10-year indexed CGS yield contains a relative liquidity premium, so it is typically not used as a proxy for the real risk-free rate when the CAPM is applied in real terms.
- The QCA's proxy for the real-risk free equals the 10-year nominal CGS yield minus QCA 10-year expected inflation. This is an estimate of the expected 'real' yield on 10-year nominal CGS. It *is not* an estimate of the 10-year indexed CGS yield, which is the required input when the CAPM is applied in real terms.
- As shown in Figure 1 nominal rates include expected inflation and the IRP. By definition, a real rate does not include inflation compensation because the real return on an indexed bond is not affected by actual inflation[2].

FIGURE 1: BOND YIELD DECOMPOSITION



Source: Imakubo & Nakajima, April 2015

- The QCA's current inflation approach does not remove the IRP. Even if the QCA's estimate of expected inflation is accurate the resulting proxy for the real risk-free rate will be biased by the IRP, which can be positive or negative.
- Expected inflation and the IRP cannot be observed individually, however their combined value is approximately equal to the inflation swap rate.

4.1.1 Example

- For a given estimate of expected inflation there is an 'implied' IRP based on the observable ZCIS rate. For example:
  - If the estimate of expected inflation is 2.3 per cent and the ZCIS rate is 2.0 per cent, the implied IRP is -0.3 per cent. By only making a deduction for expected inflation the implied IRP is reflected in the proxy for real risk-free rate, however a true real rate does not include any inflation compensation. As a consequence, the real risk-free rate is biased downwards in this example.
  - Expressed differently, the amount of inflation compensation in the nominal CGS yield is 2.0 per cent, however the deductions for inflation are made using expected inflation of 2.3 per cent. This means the deductions have been overstated by 0.3 per cent, which biases the real return on equity downwards by 0.3 per cent.
- In this example the real return on equity is biased even if the best estimate of expected inflation is 2.3 per cent.

[1] Martin Lally, July 2020, *Review of the AER's inflation forecasting methodology*, p. 12

[2] Imakubo & Nakajima, April 2015, *Estimating inflation risk premia from nominal and real curves using a shadow-rate model*, p. 23

4.2 Bias in the QCA's real CGS yield proxy

- Appendix A sets out a simple approach for estimating a lower bound for a 10-year indexed CGS yield that excludes expected inflation, the IRP and the liquidity premium in the observable 10-year indexed CGS yield. The lower bound assumes that each observable ZCIS rate is an upper bound for the amount of inflation compensation in the nominal zero coupon CGS yield for the same term to maturity.
- The differences between the QCA real risk-free rates and the lower bound are shown in Figure 2. Because the yields at the lower bound exclude expected inflation, the IRP and the indexed CGS liquidity premium, the differences can be viewed as the implied IRPs in the QCA's proxy for the real risk-free rate.

FIGURE 2: IMPLIED IRP (QCA REAL RISK-FREE RATE MINUS LOWER BOUND)

Source: RBA and Bloomberg. QTC calculations. 20-day averages to 12 May 2021.

- Since 2016 the QCA's real risk-free rates have been below the lower bound. This indicates that a negative implied IRP has been reflected in the QCA's proxy for the real risk-free rate, which means the real return on equity has been biased downwards during this period.
- Historical estimates of the MRP reflect a deduction for the positive average IRP in the historical 10-year CGS yield. If the Ibbotson and Siegel approaches are used to estimate the MRP the net impact of the IRP on the return on equity (assuming a beta of 1.0) equals the implied IRP minus the positive historical average IRP[3]. As such, the downward bias in the return on equity can be material when the implied IRP is negative.
  - This has important implications for the QCA's rate of return review and the weights that are assigned to the different approaches for estimating the MRP.

4.3 An alternative approach

- There are structural reasons for why the ZCIS rates are likely to be higher than the combined value of expected inflation and the IRP[4]. This means the best estimate of the real risk-free rate that should be used when the CAPM is applied in real terms is likely to be:
  - higher than the lower bound, and
  - lower than the observable indexed CGS yield.
- In the absence of any other considerations QTC considers the *mid-point* between the lower bound and the observable indexed CGS yield to be a reasonable estimate of the real risk-free rate that should be reflected in the real return on equity.

[3] There are no long-term estimates of the historical IRP in Australia, however model-based estimates using US Treasury yields show a positive historical average IRP of 0.46 per cent between 1983–2021. More detail has been provided in QTC's submission to the QCA's request for comments on the 2021 rate of return review.

[4] See Appendix A.

- There are two options for producing *internally consistent* estimates of the nominal return on equity and the deductions for inflation on the equity-funded portion of the RAB:
  - The prevailing 10-year nominal CGS yield is used to calculate the nominal return on equity. The inflation rate that is used to make the deductions equals the 10-year nominal CGS yield minus the 10-year mid-point indexed CGS yield.
  - The deductions are made using 10-year expected inflation from the QCA's current approach[5]. This estimate of expected inflation is added to the 10-year mid-point indexed CGS yield to determine the 10-year nominal CGS yield that is used to calculate the nominal return on equity.
- For consistency, the same estimate of inflation should be used in the dividend discount model and the Wright approach when estimating the MRP. QTC's views on the weights that should be assigned to these two approaches have been provided to the QCA's 20201 rate of return review[6].

5 Inflation and the cost of debt

- It is efficient practice for the benchmark entity to issue nominal debt rather than inflation-indexed debt. The treatment of debt in the QCA's building block model is consistent with the issuance of nominal debt.
- The cost of servicing nominal debt does not change based on actual inflation. However, because the QCA targets a real cost of debt, the delivered nominal cost of debt depends on actual inflation. This creates a potential mismatch between the delivered and expected nominal cost of debt in each regulatory year.
- In QTC's view, the delivered nominal cost of debt should not be affected by inflation. A pragmatic way to achieve this outcome is by using the same estimate of expected inflation to make deductions on the debt-funded portion of the RAB and to index the debt-funded portion of the RAB at the end of the regulatory period.
- If the QCA continues to target a real cost of debt, the deductions on the debt-funded portion of the RAB should equal the amount of inflation that is expected to be added at the end of the regulatory period. This requires estimating expected inflation for the term of the regulatory period.

5.1 Treatment of debt in the building block model

- It is QTC's understanding that the QCA's revenue building block model is similar to the AER's post-tax revenue model (PTRM) regarding the treatment of debt for the benchmark entity:
  - The expected nominal cost of debt is an input in the PTRM. This cost is implicitly converted from nominal to real by making deductions for inflation on the debt-funded portion of the RAB.
    - The expected nominal cost of debt equals the real cost of debt plus *expected* inflation.
    - The delivered nominal cost of debt equals the real cost of debt plus *actual* inflation.
  - The benchmark entity maintains constant gearing by borrowing against the annual indexation of the debt-funded portion of the RAB based on actual inflation.
    - This feature of the PTRM makes it clear that the benchmark entity issues nominal debt. If inflation-indexed debt was used the increase in the benchmark debt balance for inflation would occur automatically via indexation of the principal, and there would be no proceeds raised by a new borrowing.
  - The real cost of debt allowance and the proceeds from the new borrowing is the total amount of cash available for the benchmark entity to make its annual nominal debt service payments.
  - Any difference between actual and expected inflation creates a mismatch between the delivered and expected nominal cost of debt, which is effectively a wealth transfer between consumers and the regulated entity.

5.2 Nominal debt costs are not affected by inflation

- The cost of servicing nominal debt does not change based on actual inflation. If the efficient nominal cost of debt is 5.0 per cent this amount must be paid regardless of the level of actual inflation over the term of the loan.

[5] The QCA's current approach could be modified by using the AER's new glide-path to estimate expected inflation in years 1–5, with expected inflation in years 6–10 being equal to 2.50 per cent. This may be a reasonable approach *provided that* the estimate of 10-year expected inflation is added to the 10-year mid-point indexed CGS yield to determine the 10-year nominal CGS yield that is used to calculate the nominal return on equity, and that the same estimate of expected inflation is used in the dividend discount model and the Wright approach.

[6] QTC's proposed weights for calculating the MRP are Ibbotson (25 per cent), Wright (25 per cent) and dividend discount model (50 per cent).

- Debt service payments are contractual obligations that must be made on time and in full. Failing to meet these obligations may have serious negative consequences for the borrower, including the risk of triggering a default. Therefore, it is important for the regulatory cost of debt approach to provide sufficient compensation in each regulatory year rather than (potentially) on average over multiple regulatory periods.
- Targeting a real cost of debt creates mismatches between the delivered and expected nominal cost of debt:
  - If actual inflation is lower than expected inflation there will be insufficient cash for the benchmark entity to make its contractual debt service payments. The shortfall will need to be made up by:
    - reducing operating expenditure, possibly to levels below what is deemed to be efficient by the QCA, or by
    - reducing dividend payments to the equity providers, which results in the real return on equity being lower than the QCA's estimate of the efficient real return on equity.
  - If actual inflation is higher than expected inflation the equity providers will receive a windfall gain because the delivered nominal cost of debt is higher than the efficiently incurred nominal cost of debt. This means that consumers have paid a price that is higher than the efficient price for the regulated service.

5.3 Proposed approach

- A delivered nominal cost of debt that is not affected by actual inflation can be achieved by:
  - using an estimate of expected inflation that matches the length of the regulatory period to make deductions for inflation on the debt-funded portion of the RAB, and
  - using the same estimate of expected inflation to index the debt-funded portion of the RAB at the end of the regulatory period rather than actual inflation.
- Under this approach the delivered and expected nominal cost of debt are equal in each regulatory year.

5.4 Targeting a real cost of debt

- As explained in Section 5.1, part of the benchmark entity's nominal cost of debt is paid using the proceeds from borrowing against the indexation of the debt-funded portion of the RAB. The size of the borrowing is based on the actual inflation during the regulatory period.
- If the QCA continues to target a real cost of debt, an estimate of expected inflation for the term of regulatory period should be used because it reflects the amount of inflation that is expected to be added to the RAB during the regulatory period. This is consistent with the new inflation approach adopted by the AER in December 2020[7].
- Although a shorter-term estimate of expected inflation is an improvement on the current approach, it is still likely that actual inflation will differ from expected inflation in most regulatory years, thereby resulting in mismatches between the delivered and expected nominal cost of debt.
- In our view, the best approach is to deliver a nominal cost of debt that is not affected by actual inflation using the approach in Section 5.3. This is consistent with the issuance of nominal debt being efficient practice for the benchmark entity and the treatment of debt in the QCA's revenue building block model.

5.5 Estimating shorter-term expected inflation

- There are several approaches for estimating expected inflation for the term of the regulatory period (eg, 5 years). These approaches can be used if the QCA targets a real cost of debt or a delivered nominal cost of debt that is not affected by actual inflation:
  - The AER's new glide-path approach, which uses RBA headline CPI forecasts in years 1–2 and a linear glide-path from the year 2 forecast to the 2.5 per cent mid-point of the RBA target band in year 5.
  - A glide path with the implied forward 1-year ZCIS rate in year 5 rather than the 2.5 per cent RBA mid-point.
  - RBA headline CPI forecasts in years 1–2 and the implied-forward 1-year ZCIS rates in years 3–5.

5.5.1 Indicative inflation estimates

- Table 1 shows the indicative inflation estimates based on the three approaches above and the QCA's current 10-year approach. The RBA forecasts for years 1–2 are the headline CPI forecasts for FY22 and FY23 from the May 2021 Statement on Monetary Policy:

[7] AER, December 2020, *Final position – Regulatory treatment of inflation*, p. 6

TABLE 1: INDICATIVE INFLATION ESTIMATES {TO BE UPDATED}

Estimation approach	Year 1	Year 2	Year 3	Year 4	Year 5	Average
AER glide path (2.5 per cent in year 5)	1.25	2.00	2.17	2.33	2.50	**2.05**
AER glide path (implied-forward ZCIS in year 5)	1.25	2.00	2.13	2.25	2.38	**2.00**
RBA forecasts in years 1–2 and implied-forward ZCIS in years 3–5	1.25	2.00	2.17	2.29	2.38	**2.02**
Current QCA 10-year estimate						**2.32**

Source: RBA, Bloomberg. 20-day averages to 12 May 2021 for ZCIS rates.

- There should be some non-overlapping information in the market and non-market estimates of inflation. As such, QTC considers the second and third approaches in Table 1 to both be reasonable approaches. Giving meaningful weight to non-market estimates may also reduce the impact of the IRP in the implied-forward ZCIS rates on the estimate of inflation that applies to the debt-funded portion of the RAB.

6 Responses to questions in the issues paper

Should we maintain our existing approach to estimating expected inflation?

- It is appropriate for the QCA to change its approach for estimating expected inflation:
  - The current approach produces biased estimates of the real return on equity because an implied IRP is reflected in the QCA's proxy for the real risk-free rate.
  - The current approach delivers a nominal cost of debt that is affected by actual inflation, however the nominal debt servicing costs for the benchmark entity are the same regardless of the level of actual inflation.

Over what term should we forecast the inflationary gain deduction we use to derive the 'return on capital' component of allowable revenues?

- The deduction for inflation on the equity-funded portion of the RAB should equal the amount of inflation compensation (ie, expected inflation and the IRP) in the 10-year nominal CGS yield that is used to calculate the nominal return on equity. QTC's proposed approach for doing this is set out in Appendix A.
- If the QCA continues to target a real cost of debt, the deduction for inflation on the debt-funded portion of the RAB should equal the amount of inflation that is expected to be added at the end of the regulatory period. This requires expected inflation to be estimated for the term of the regulatory period rather than the current 10-year term.
- If the QCA decides to deliver a nominal cost of debt that is not affected by actual inflation, the same estimate of expected inflation should be used to make the deductions for inflation on the debt-funded portion of the RAB and to index the debt-funded portion of the RAB at the end of the regulatory period.

If we continue to use short-term RBA forecasts in our forecasting methodology, should we consider using a multi-year transition path to our estimate of long-term inflation expectations?

- This question is addressed in Sections 4.3 and 5.5.

Should we consider the use of market-based measures of inflation expectations as either the primary estimation method or to derive long-term inflationary expectations?

- The ZCIS curve can be used to determine a lower bound for the real risk-free rate in the real return on equity. The deductions for inflation on the equity-funded portion of the RAB should be made using the difference between the 10-year nominal CGS yield in the return on equity and the 10-year mid-point indexed CGS yield based on the approach in Appendix A.
- The implied-forward ZCIS rates can be combined with the RBA's 1–2 year headline CPI forecasts to produce an estimate of inflation for making the deductions for inflation on the debt-funded portion of the RAB.

If we continue to use RBA forecasts in our estimation methodology, are there certain circumstances where the RBA's trimmed mean forecast should be used?

- Trimmed mean CPI forecasts may be appropriate when very large headline CPI outcomes are expected to reverse in the short-term. For example, as explained by RBA Assistant Governor Luci Ellis:[8]

  > *'Temporary factors are driving large movements in inflation in the June and September quarters. Headline CPI declined by 2 per cent in the June quarter. This decline is entirely accounted for by two factors: the fall in petrol prices and the decision to make child care (and some preschool) free.*
  >
  > *Most of the decline in headline CPI will reverse in the September quarter. Petrol prices increased a little in recent months, and fees for child care and preschool are being progressively reintroduced. So there will be some further volatility in the headline inflation figures. This volatility will be less evident in the various underlying measures.'*

- The Government actions referred to in the above quote were highly unusual, so for the majority of the time it will be appropriate to use the RBA's headline CPI forecasts.

[8] RBA, August 2020, *The Economic Outlook*, p. 9. Q220 headline CPI fell 1.9 per cent, which was largely reversed by a 1.6 per cent rise in Q320.

Appendix A: An improved estimate of the 10-year real CGS yield

A.1: Background

- Christensen & Gillian 2012 use nominal and inflation-linked zero-coupon US Treasury (UST) yields, and fixed zero-coupon inflation swap (ZCIS) rates to derive an upper bound for the liquidity premium in the observable inflation-linked UST yields. The authors define liquidity very broadly as measure that captures any 'friction' that drives a wedge between the observable yield and the yield that would prevail in a frictionless market[9]:

> *'Implicit in the usage of the word "premium" (or penalty) is the notion that a clean, unobserved price would prevail if only some, not necessarily well-identified, market microstructure frictions did not bias the prices actually observed. We define the absolute liquidity premium as the price difference between the observed and the unobservable "frictionless" market outcome of a given asset ... In this sense the liquidity premiums we derive represent the total cost of all frictions to trade (wider bid-ask spreads, lower trading volume, etc.) of the less liquid asset beyond those of the more liquid asset against which it is being compared.'*

- The upper bound for the inflation-linked liquidity premium is based on the following assumptions:
  - there is no liquidity premium in the observable nominal UST yield
  - inflation-indexed UST bonds are no more liquid than nominal UST bonds, and
  - ZCIS are no more liquid than nominal UST bonds.
- If the assumptions hold the authors show that the difference between the observed ZCIS rate and the BBIR equals the sum of the liquidity premiums (ie, frictions) in the ZCIS rate and the inflation-linked UST yield. The same logic can be applied to the CGS market using the terminology and descriptions in Table 2:

TABLE 2: PARAMETERS AND DEFINITIONS

Parameter	Definition
CGS[n]	Observable nominal CGS zero coupon yield
CGS[r]	Observable indexed CGS zero coupon yield
ZCIS	Observable zero-coupon inflation swap rate
BBIR	Bond break-even inflation rate: CGS[n] - CGS[r]
R	**Frictionless indexed CGS yield**
S	Frictionless Zero coupon inflation swap rate
EI	Expected inflation
IRP	Inflation risk premium
L[r]	Indexed CGS liquidity premium (≥ 0)
L[s]	ZCIS liquidity premium (≥ 0)

- As explained in Section 4.1 the correct risk-free rate when the CAPM is applied in real terms is the yield on a risk-free indexed bond. As the QCA implicitly delivers a real return on equity, the objective is to determine the best estimate of R (ie, the frictionless indexed CGS yield).

[9] Christensen & Gillian, June 2012, *Could the U.S. Treasury Benefit from Issuing More TIPS?*, p. 7

A.2: Approach

- The lower and upper bound for R is derived as follows:

CGS[n]	= R + EI + IRP
CGS[r]	= R + L[r]
BBIR	= CGS[n] - CGS[r]
	= R + EI + IRP - (R + L[r])
	= EI + IRP - L[r]

S	= EI + IRP
ZCIS	= EI + IRP + L[s]
ZCIS - BBIR	= EI + IRP + L[s] - (EI + IRP - L[r])
	= L[s] + L[r]

- As L[s] and L[r] are non-negative the maximum value for L[r] is ZCIS - BBIR (ie, when L[s] = 0). Therefore:
  - the lower bound for R = CGS[r] - (ZCIS - BBIR), and
  - the upper bound for R = CGS[r].
- As (ZCIS - BBIR) = (ZCIS - CGS[n] + CGS[r]) it can be shown that the lower bound can also be expressed as:
  - **R = CGS[n] - ZCIS**.

TABLE 3: LOWER AND UPPER BOUND FOR THE FRICTIONLESS INDEXED CGS YIELD

Parameter	Lower bound	Upper bound
R	**CGS[n] - ZCIS**	**CGS[r]**

A.3: Practical application

- The equations in Christensen & Gillian are based on continuously compounded zero coupon yields. However, inflation-linked and nominal CGS pay regular coupons, so estimates made using CGS yields are not an exact replication of the Christensen & Gillian's estimates.
- A more accurate estimate of the lower bound for R can be determined as follows[10]:
  - Use the 1–10 year ZCIS rates to convert the 1–10 year nominal zero coupon CGS yields into real CGS yields[11].
  - Use the 1–10 year real CGS yields to calculate the 1–10 year real discount factors.
  - Solve for the coupon rate that, when applied to a real principal of $100, produces real cash flows from 1–10 years (including the real principal at maturity) with a present value equal to $100 using the 1–10 year real discount factors.
- The coupon does not include expected inflation or the IRP because both amounts net out when the zero coupon CGS yields are converted from nominal to real, which is consistent with the lower bound calculation in Table 3.
- The coupon does not include the liquidity premium in the observable indexed CGS yield because the underlying cash flows are based on the nominal zero coupon CGS yields.

A.4: L[r] and L[s] are likely to be positive

- Given that indexed CGS are relatively less liquid than nominal CGS, it is reasonable to assume that L[r] is positive.
- There are sound reasons for why L[s] should also be positive. The Australian inflation swap market is one-sided, with most investors wanting to pay fixed inflation and receive actual inflation. Because there are few natural payers of actual inflation, the swap counterparty will usually require a premium to take the other side of the more popular

[10] The spreadsheet that accompanies this submission provides a hypothetical example of the lower bound calculation.

[11] The RBA produces daily estimates of nominal CGS zero coupon yield curve, which are usually published on its website within 2–3 business days after the end of the month.

trade. This results in the fixed ZCIS mid-market rate being higher than the frictionless swap rate (S), which means L[s] is positive. This is consistent with the US-based conclusions in To & Tran (2019) that: [12]

> *'… both TIPS [Treasury Inflation Protected Securities] and inflation swaps appear mispriced, and more significantly so for longer tenors: TIPS appear consistently under-priced and inflation swaps consistently overpriced (to fixed rate payors) for contracts of 10 years or longer maturities.'*

- An under-pricing in TIPS means the real yield is biased upwards (ie, L[r]>0) whereas over-pricing in inflation swaps means the fixed rate is biased upwards (ie, L[s]>0). Therefore, the best estimate of R is likely to be:
  - higher than the lower bound (as calculated in Section A.3), and
  - lower than the observable 10-year indexed CGS yield[13].
- In the absence of any other considerations QTC considers the mid-point between the lower bound and the observable 10-year indexed CGS yield to be a reasonable estimate of R.

A.5: Perceived biases in ZCIS rates

- In its 2017 and 2020 inflation reviews the AER cited several perceived biases in ZCIS rates. The AER's assessment of these biases, are summarised in Table 3:

TABLE 4: AER ASSESSMENT OF POTENTIAL BIASES IN ZCIS RATES

Potential bias	AER's assessment in 2017 and 2020
Hedging costs	*'The ACCC/AER working paper #11 found that* ***academic literature suggests that hedging costs may be minor****, but there are not many studies to support drawing robust conclusions.'*
Inflation indexation lag	*'****This bias is potentially small*** *due to the short lag on indexed CGS and is not likely to be time-varying.'*
Counterparty default risk	*'… the effect of counterparty default risk on zero coupon inflation swap rates* ***may not be significant****. This premia could result in overestimates of expected inflation and is not likely to be time-varying.'*
Liquidity premia	*'****A-priori liquidity premia may be near zero*** *since swaps can be created as required and there is no supply limitation. Observations of Australian data suggest that this* ***liquidity premia may be negligible.****'* *'… the liquidity premium is likely to be greater during periods of uncertainty when investors' appreciation of liquidity risk may have changed.'*
Inflation risk premium	The inflation risk premium (based on the covariance between inflation and the expected return on the market portfolio) was not cited as a bias in the 2017 inflation review. What the AER described as 'inflation risk' is actually risk arising from cash flow mismatches when an inflation swap is hedged with nominal and real CGS (ie, an imperfect hedge).

Source: AER Draft Position Paper, October 2020, Table H.1, p. 133–134

- According to the AER's assessment the perceived biases may be 'minor, potentially small, near zero or negligible'. As explained in the following section, even if some or all of the biases were material, it is unlikely for the biases to be reflected in the published mid-market ZCIS rates, which are the rates used to estimate the lower bound for the frictionless 10-year indexed CGS yield.

[12] To & Tran, April 2019, *Cheap TIPS or Expensive Inflation Swaps? Mispricing in Real Asset Markets*, p.2

[13] The average difference between the observable 10-year real CGS yield and the lower bound between 2013–2021 is 0.29 per cent.

6.1.2 Perceived biases unlikely to be reflected in ZCIS mid-market rates

- ZCIS rates are the market price of inflation as they reflect the base rates for converting nominal cash flows to real cash flows and vice-versa. The published ZCIS rates are mid-market rates – they do not reflect the total inflation swap rates on actual transactions.
- This is important because *even if* margins for hedging costs, transaction costs, cash flow mismatches due to imperfect hedges and counterparty risk exist, they will be reflected in the dealt ZCIS rates, not the mid-market rates.
- Inflation swaps are marked-to-market using closing ZCIS mid-market rates. By reflecting cost/risk margins in the dealt rate, the NPV of the swap will be positive at inception for the market-maker. Part of the positive NPV will be offset by the initial hedging costs with the remainder acting as a buffer against future adverse outcomes from imperfect hedges and counterparty defaults. These cost offsets and buffers would not exist because the NPV of the swap would be zero at inception if the cost/risk margins were reflected in the ZCIS mid-market rates.
- Another reason why certain cost/risk margins are not reflected in the closing ZCIS mid-market rates is because they are not the same for all counterparties and all transaction types. For example:
  - There is no single margin for counterparty default risk because different counterparties have different levels of credit worthiness. Different spreads will apply to transactions involving counterparties with different credit ratings, but this does not change the base market price of inflation (ie, the mid-market rate).
  - The impact of a counterparty risk margin on the dealt rate will also depend on whether the counterparty is paying fixed (ie, the margin increases the dealt rate) or receiving fixed (ie, the margin decreases the dealt rate), so it is not possible for this margin be expressed in the ZCIS mid-market rates.
  - Hedging mismatches for a standard ZCIS transaction will be smaller than the mismatches for a bespoke cash flow profile for a long-term infrastructure project. All else equal, the difference between the dealt and mid-market rate is likely to be higher for the second type of transaction. However, the higher spread does not change the market price of inflation.
- If ZCIS rates are used for regulatory purposes it is the closing mid-market rates that will be used. Even if margins for hedging costs, transaction costs, cash flow mismatches due to imperfect hedges and counterparty risk exist, they will not be reflected in the closing ZCIS mid-market rates.
- The only bias that may be reflected in the mid-market rates is the premium described in Section A.4, which reflects a structural feature of the market. This causes the ZCIS mid-market rates to be higher than the combined value of expected inflation and the IRP (ie, $L[s] > 0$). This means that receiving fixed and paying actual inflation has a positive expected value over the term of the swap.
- ZCIS mid-market rates may be temporarily affected by relatively large transactions. These liquidity effects can be reduced by using a 20–40-day average of the closing ZCIS mid-market rates as suggested in Moore (2016)[14].

6.1.3 A real-world example

- In 2010 QTC executed an inflation swap transaction based on a bespoke series of nominal cash flows and a non-standard indexation lag. The process for setting the fixed inflation rate for the transaction was as follows:
  - The inter-bank ZCIS bid/offer rates for a standard size market transaction were used to calculate a blended base inflation rate based on the present value of the nominal cash flow profile.
  - A separate margin was determined prior to transacting to compensate the swap counterparty for execution risk, hedging mismatches and the non-standard indexation lag requested by QTC. The total rate for the transaction was equal to the blended base rate plus the margin.
  - The transaction was priced using the closing ZCIS curve. The NPV of the inflation swap was positive (negative) for the counterparty (QTC) when it was first marked-to-market.

[14] Moore, December 2016, *Measures of Inflation Expectations in Australia*, p. 29.

Liquidity effects due to relatively large transactions tend to reverse over short periods of time. For example, if a large pay fixed ZCIS transaction causes the ZCIS rate in the market to increase, it will become more attractive for other market participants who are interested in receiving fixed. As a result, liquidity-driven movements in ZCIS rates are likely to reverse over the short-term. A 20–40-day average of the closing mid-rates is an effective way of smoothing out these movements.