

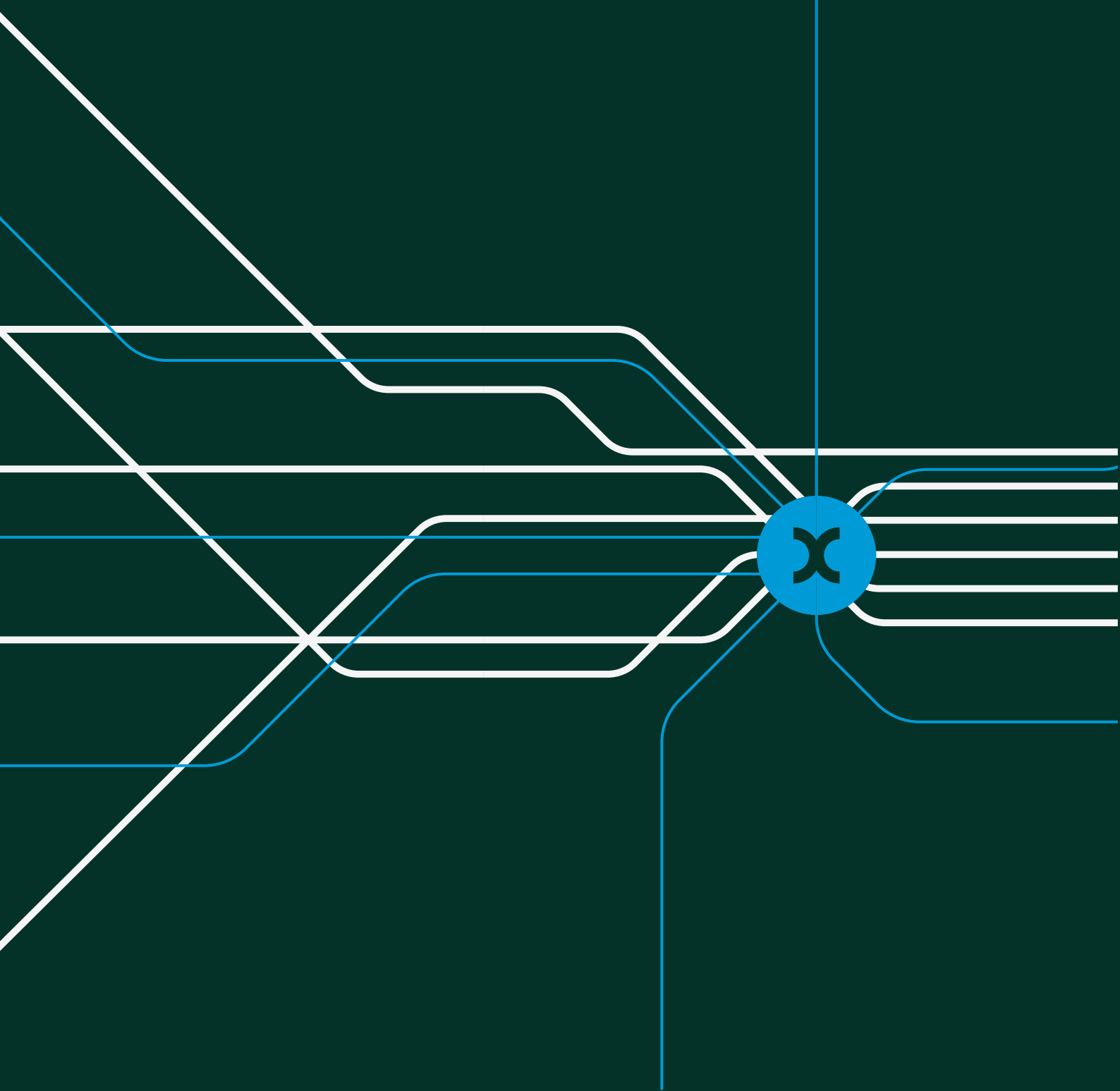
RIIO-3 cost of equity

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Prepared for Energy Networks Association

oxera

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Contents

Executive summary	4
1 Introduction	14
2 CAPM framework	17
2.1 RFR	17
2.2 TMR and ERP	38
2.3 Equity beta	59
2.4 The CAPM CoE estimation	73
3 ARP–DRP as a cross-check to the CAPM	75
3.1 Underpinnings and use case of the ARP–DRP framework	75
3.2 Estimating the ARP–DRP differential	78
3.3 The relationship between ARP, DRP and gearing, and the implications for the appropriate level of ARP and CoE	80
3.1 The results of the ARP–DRP cross-check	82
4 Concluding remarks	85
A1 Calculation of alternative ex post TMR estimators	87
A1.1 Blume (1974) adjusted estimator	87
A1.2 Cooper (1996) estimator	87
A1.3 JKM (2005) unbiased and MSE efficient estimators	88

Figures and Tables

Box 2.1	Ofgem's approach to estimating the risk-free rate	18
Box 2.2	The concept of the convenience premium	21
Figure 2.2	Nominal spreads of AAA-rated bond indices relative to benchmark government bonds	27
Table 2.1	iBoxx AAA characteristics	28
Table 2.2	Convenience premium estimation	29
Table 2.3	20-year forecast approach based on OBR data	31
Figure 2.3	Weekly average of 20-year RPI–CPI spread, based on the difference between RPI 20-year swaps and CPI 20-year swaps	32
Table 2.4	RPI–CPI wedge estimation results	32
Figure 2.4	Historical spread between CPIH and CPI rates of inflation	34
Table 2.5	RPI–CPIH wedge estimation results	35
Table 2.6	RFR estimation	35
Box 2.3	Ofgem's approach to estimating the TMR	40
Table 2.7	The ex post TMR (CPIH-real)	44

Figure 2.5	Alternative ex post TMR estimators (CPIH-real)	46
Figure 2.6	TMR determinations and gilt yields (RPI-real)	54
Box 2.4	Ofgem's approach to estimating the beta	59
Table 3.2	ARP implied by 100% gearing	83
Figure 4.1	The impact of individual methodological choices on Ofgem's and Oxera's CoE estimates (CPIH-real)	86

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Executive summary

Following the publication of the Sector Specific Methodology Consultation (SSMC) for the RII-3 price controls, Energy Networks Association (ENA) has asked Oxera to estimate a reasonable range for the cost of equity (CoE) allowance for RII-3, building on the estimate from the capital asset pricing model (CAPM) parameters. This estimate is to be cross-checked against the observable cost of debt by comparing the asset risk premium (ARP) and debt risk premium (DRP)—i.e. by applying the ARP–DRP framework. The work is to be limited to the CAPM parameters that are applicable to all gas and electricity networks—sector-specific risks are outside the scope of this work, whether or not they affect the CAPM parameters (hereafter, 'baseline estimates').

The capital markets and macroeconomic context in which this work is being undertaken is markedly different to when the RII-2 price controls were being determined. Yields on UK government bonds have increased by 332bps since the publication of the RII-2 final determinations for gas distribution and electricity and gas transmission networks (GD&T).¹ Central banks have stopped quantitative easing and switched to quantitative tightening. Concurrently, the demand for capital to finance investment across a wide range of infrastructure sectors has increased, both in the UK and internationally. Companies need to be able to offer investors returns that are attractive if they are to have reliable access to sufficient capital. It is therefore timely to review the approach for estimating the cost of capital of energy networks.

The ARP–DRP framework that we use as a cross-check to the CoE helps with testing the outcome of the CAPM approach, which is based on the long-term 'through-the-cycle' total market return (TMR) estimate, against more concurrent debt market evidence. Testing the appropriateness of a CAPM-based estimate, with reference to recent capital markets evidence allows for the opportunity cost of equity

¹ Refers to the change in real gilt yields. The cut-off date for the analysis in this report is 20 December 2023. The RII-2 final determination for GD&T network companies was published on 8 December 2020. See Ofgem (2020), 'RII-2 Final Determinations – Core Document', 8 December, <https://www.ofgem.gov.uk/publications/rii-2-final-determinations-transmission-and-gas-distribution-network-companies-and-electricity-system-operator> (last accessed on 9 February 2024).

capital to be reflected in the allowance—this will support the investability of the networks.

We apply the methodology that we consider to be appropriate for RIIO-3 in light of regulatory precedent constraints, developments in capital markets, and academic evidence, and assess its consistency with the UK Regulators Network (UKRN) cost of capital estimation guidance. We do not, however, account for the forward-looking sector-specific risks, which may need to be estimated separately. In addition, we assess the CoE estimate that Ofgem would set in RIIO-3 if it rolled forward the RIIO-2 methodology, accounting for the methodological changes introduced in the RIIO-3 SSMC that do not require regulatory judgement. Importantly, our analysis does not intend to forecast Ofgem's RIIO-3 allowances. To summarise, we estimate a reasonable allowed return for the RIIO-3 CoE by following the two approaches described below.

- **Ofgem's roll-forward approach**, i.e. closely following the methodology that Ofgem applied in the RIIO-2 price controls across the energy networks (gas and electricity transmission and distribution), and following the initial comments that Ofgem made in relation to the expected methodology as part of the SSMC for the RIIO-3 price controls. For this exercise, we 'roll forward' Ofgem's approach while seeking to avoid predicting the outcome of regulatory judgement.
- **Oxera's approach**, i.e. applying the methodology that we consider to be most appropriate in the context of the RIIO-3 price controls, accounting for the constraints created by, and information provided by, the latest regulatory precedent, market developments and academic literature, although not accounting for forward-looking risks not reflected in historical evidence.

The cut-off date for our analysis is 20 December 2023.

In the table below, we summarise the differences in the estimation methodology for the parameters of the CAPM under these two approaches.

Overview of Ofgem's roll-forward and Oxera's approaches to the RIIO-3 CoE estimation

Parameter	Ofgem's approach	Oxera's approach
Risk-free rate (RFR)	<p>Relying on the 20-year index-linked gilt yields.</p> <p>For the wedge between the retail price index (RPI) and the consumer prices index including owner occupiers' housing costs (CPIH), using the '20-year inflation forecast' approach, as per the RIIO-3 SSMC.¹</p>	<p>Relying on the 20-year index-linked gilt yields.</p> <p>Using a historical average of 20-year gilt and AAA-rated corporate bond yields to account for the gilt convenience premium, which increases the RFR estimate.</p> <p>For the RPI–CPIH wedge, using the average of the '20-year inflation forecast' approach and the 'inflation swaps' approach to derive an RPI–CPI wedge. In addition, a historical average of the CPI–CPIH wedge is added to arrive to the total RPI–CPIH wedge. Altogether, this leads to an estimate that is higher than Ofgem's.</p>
Total market return (TMR)	<p>Assuming the same estimate range as in RIIO-2 (i.e. 6.25–6.75%), which Ofgem set based on the historical ex post estimate, and cross-checked with forward-looking evidence.</p> <p>For RIIO-3, Ofgem plans to continue estimating the TMR based on the historical ex post approach and, in addition, to give weight to the historical ex ante approach.</p>	<p>Setting the range around the historical ex post approach (long-term arithmetic mean of one-year returns, using CPIH backcast inflation for 1950–88), while covering the ex ante TMR estimate within that range.</p> <p>Recognising that some increase in the TMR is both a logical consequence of the large increase in interest rates, and required for the risk premium on assets to be sufficient relative to the risk premium on debt.</p>
Asset beta	<p>Assuming the same estimate range as in RIIO-2 (i.e. 0.323–0.373). In RIIO-2 appeals, Ofgem explained that its estimate can be seen as being based on a combination of the ten-year National Grid beta and a 70%/30% mix of evidence from National Grid and UK water networks, which results in a similar estimate based on the latest market data.</p> <p>For RIIO-3, Ofgem plans to consider a range of timeframes and frequencies and apply regulatory judgement to the set the point estimate. Ofgem may reconsider the sample of comparators or the weighting attributed to each.</p>	<p>Keeping Ofgem's estimate unchanged since RIIO-2 for the baseline beta covered in this report,² which is consistent with putting greater weight on the up-to-date long-term beta estimates. Overall, accounting for the beta evidence from National Grid, UK water companies and European energy networks; 2Y, 5Y and 10Y estimation windows; spot estimates; and 2Y, 5Y and 10Y rolling averages and qualitative considerations (see the main body text below this table in the beta section).</p>

Note: ¹ Ofgem (2023), 'RIIO-3 Sector Specific Methodology Consultation-Finance Annex', 13 December, para. 3.40, <https://www.ofgem.gov.uk/sites/default/files/2023-12/RIIO->

We provide more details on our reasoning behind the choice of the methodology by each parameter below.

RFR

The key differences between the Oxera and Ofgem approaches are in the convenience premium and the RPI–CPIH wedge.

- **Convenience premium**—we provided a significant amount of evidence in support of the convenience premium in our previous submissions (detailed in section 2.1). The new developments include new academic evidence and an increasing use of the approach in regulatory precedent, both further strengthening our case.
- **RPI–CPIH wedge**—in addition to the approach to the wedge, suggested by Ofgem in the RIIO-3 SSMC, we account for the information observed in the inflation swaps market, in relation to which Ofgem did not express any criticism in the SSMC, and which is listed as a potential source of evidence in the UKRN guidance. We also account for the difference between CPI and CPIH outturn inflation rates, which was also observed by Ofgem in the SSMC.

Neither deviation from the Ofgem roll-forward approach contradicts the UKRN guidance.

As a result, the Ofgem and Oxera approaches lead to RFR estimates of 1.32% and 1.84% respectively in CPIH-real terms.

TMR

Ofgem's intention for RIIO-3 is to give weight to both historical ex post and historical ex ante approaches, which is also consistent with the UKRN guidance. In our assessment, we consider both of these approaches. Ofgem also intends to follow a stable TMR approach.

Our starting point for the TMR range is the historical ex post arithmetic average of one-year returns, based on the CPIH backcast series for the 1950–88 period, which is 7.00% (CPIH-real). Our reasoning behind the choice of the arithmetic over the geometric average, and one-year

returns over longer-term overlapping and non-overlapping holding periods, has not changed since our previous submissions and is only summarised in this report.

Further, we assess a wide array of ex post TMR estimators. However, in line with the Competition and Markets Authority's (CMA) position that these estimators do not provide information that is additional to the arithmetic average, we do not put weight on them in our final estimate.

As for the historical ex ante approach, despite our previously published considerations that this approach produces TMR estimates that are subjective and prone to hindsight bias, which therefore should not be used for regulatory purposes, in this report we have looked into the details of two ex ante TMR approaches as guided by the UKRN. We have been able to implement one of these approaches, which implies an ex ante TMR estimate of 6.53% (CPIH-real). However, this assessment process has led us to identify further reasons why ex ante TMR approaches might not be considered to be robust, and why this estimate might not be reliable such that we put little weight on this evidence in deriving a reasonable range for the allowed TMR as described below.

Overall, while the one-year arithmetic average is the most robust and reliable technique to estimate the TMR, we acknowledge that there is uncertainty in deriving the true expected TMR, and have therefore added ± 50 bps around the point estimate of 7.00%. The resulting range of **6.50–7.50%** (CPIH-real) encompasses almost all presented ex post and ex ante approaches, and is narrower when compared with the implied confidence interval in the DMS historical data series.

As a result, we put considerably more weight on the historical ex post than the historical ex ante estimate. We consider it appropriate in the context of the UKRN guidance that recommends using primarily these two approaches. The main reason is that market conditions have changed since the guidance was developed (rather than finalised and published)—interest rates have surged. In this context, as noted by the UKRN, it may be reasonable to revise regulatory practice. We therefore consider that, irrespective of the methodological reasoning, the historical ex ante approach produces estimates incompatible with the changed market environment as discussed below.

We have considered what the increase in interest rates implies for the TMR. The UKRN guidance observes that UK regulators have assumed greater stability in the TMR than the ERP, and that continuing with this approach is preferable. Ofgem also emphasises the importance of

maintaining this approach throughout the price controls, to avoid overcompensating networks (on average) in the SSMC. However, the UKRN guidance also states that this 'does not imply that regulators should simply pick the same fixed value for the TMR in each decision for all time, but that the TMR would be relatively less variable than the underlying RFR'.² In this context, we observe that Ofgem did reduce the TMR allowances first in RIIO-ED1 and then in RIIO-2 when gilt yields declined, noting that it was reducing the TMR estimate 'to give greater weight to the influence of current market conditions in relation to the equity market return'.³ Given that the TMR was between 7.0% and 7.25% (RPI-real) before the decline in the gilt yields, a consistent regulatory approach over time would imply an increase in the TMR assumption in RIIO-3 up to 7.00–7.25% (RPI-real), which would be equivalent to a TMR of 8.07–8.32% in CPIH-real terms.⁴

Increasing the TMR assumption by 150bps from the 6.5% adopted in RIIO-2 to the approximately 8.0% adopted before the decline in gilt yields would be 45% of the increase in gilt yields since the publication of the RIIO-2 final determinations for GD&T networks—a change of a comparable magnitude to Ofgem's change of the TMR allowance between RIIO-ED1 and RIIO-GD&T2.⁵ In comparison, an increase of the TMR from 6.25–6.75% in RIIO-2 to 6.5–7.5% in RIIO-3 would be a relatively small change in the context of the observed increase in the UK government gilt yields (i.e. 15% of the increase). Our suggested range is therefore consistent with the UKRN's guidance that 'the TMR would be relatively less variable than the underlying RFR', and the conclusions in one of our previous studies that the TMR is 'relatively stable'.⁶

Moreover, as a final step, we cross-check the CoE estimate and consequently the TMR (and beta) ranges using the ARP–DRP framework, which suggests that only the upper part of our range produces a risk premium on assets that is sufficiently high compared with the risk

² UKRN (2022), 'UKRN guidance for regulators on the methodology for setting the cost of capital', p. 19, https://ukrn.org.uk/app/uploads/2023/03/CoC-guidance_22.03.23.pdf (last accessed on 5 January 2024).

³ Ofgem (2014), 'Decision on our methodology for assessing the equity market return for the purpose of setting RIIO-ED1 price controls', p. 4, https://www.ofgem.gov.uk/sites/default/files/docs/2014/02/decision_on_equity_market_return_methodology_0.pdf (last accessed on 20 February 2024).

⁴ Using a 1% stylised RPI–CPIH wedge for conversion.

⁵ The figure of 45% is estimated as 150bps dividend by 332bps. We estimate the change in TMR between RIIO-ED1 and RIIO-GD&T2 to be 53% of the corresponding change in real gilt yields between the determination dates.

⁶ Oxera (2018), 'The cost of equity for RIIO-2', 28 February, p. 2, https://www.oxera.com/wp-content/uploads/2018/07/ENA-cost-of-equity_2018-02-28.pdf (last accessed on 23 February 2024).

premium on debt. This finding further supports our choice of a TMR range that extends to 7.5%.

For the Ofgem 'roll-forward' approach, we use its RIIO-2 TMR range of 6.25–6.75% as a placeholder, to avoid having to predict the outcome of the regulatory judgement that it will exercise in RIIO-3. The actual Ofgem's RIIO-3 range could be different from the range based on this 'roll-forward' approach.

Beta

We have considered a wide range of evidence in determining the most appropriate asset beta estimate, including evidence from:

- National Grid, UK water companies and European energy networks;
- 2Y, 5Y and 10Y estimation windows;
- spot estimates, as well as 2Y, 5Y and 10Y rolling averages.

We consider that Ofgem's RIIO-2 asset beta range of **0.32–0.37**, with a mid-point of 0.349, is appropriate for a baseline beta that does not yet account for forward-looking RIIO-3 risks.⁷ This is for the following reasons:

- the overall range of beta estimates based on a range of regression windows and rolling averages applied to National Grid, UK water networks and European comparators is wide, and there is a need for judgement to narrow down that range;
- if Ofgem's RIIO-2 methodology is applied to the latest market data, a similar estimate is observed;
- Ofgem, Ofwat and the CMA have all previously expressed a preference for longer-term beta approaches that point to a similar estimate;
- we agree with the reasons behind regulatory support for longer-term beta estimates, before accounting for forward-looking and sector-specific risks, in the specific context of RIIO-3;
- an allowance towards the upper end of the range is consistent with the need to address the low-beta anomaly.

⁷ We use Ofgem's RIIO-2 debt beta of 0.075.

The UKRN guidance leaves significant room for regulatory judgement in the estimation of beta, and our approach is compliant with the guidance.

Overall, our proxy for Ofgem’s estimate of the RIIO-3 CoE allowance leads to a range of **4.75–5.77%** (CPIH-real, at 60% gearing), with a mid-point of 5.26%. This is 71bps higher than the CoE estimate in the RIIO-GD&T2 final determination, where the CoE allowance at 60% gearing was 4.55%.⁸ The increase is driven by an increase in the RFR from -1.58% to 1.32%, the latter as calculated for RIIO-3 in this report. Our RIIO-3 mid-point estimate for Ofgem, 5.26%, is also 3bps higher than the CoE allowance in the RIIO-ED2 final determination, where the CoE was 5.23% and the RFR was 1.23%.⁹

Oxera’s estimation of a CAPM-based CoE range for RIIO-3 is **5.08–6.48%** (CPIH-real, at 60% gearing), with a mid-point of 5.78%—as mentioned above, this does not account for potential impacts of sector-specific forward-looking risks. This is higher than Ofgem’s range due to the differences in the RFR and the TMR.

The table below outlines the CAPM parameters underlying the CoE estimates.

CoE estimation at 60% (before accounting for sector-specific forward-looking risks)

	Formula	Ofgem approach range	Ofgem approach mid-point	Oxera approach range	Oxera approach mid-point
RFR	[A]	1.32%	1.32%	1.84%	1.84%
TMR	[B]	6.25–6.75%	6.50%	6.50–7.50%	7.00%
Re-levered equity beta at 60% gearing	[C]	0.70–0.82	0.76	0.70–0.82	0.76
CAPM CoE	[Ke]=[A]+[C]*([B]-[A])	4.75–5.77%	5.26%	5.08–6.48%	5.78%

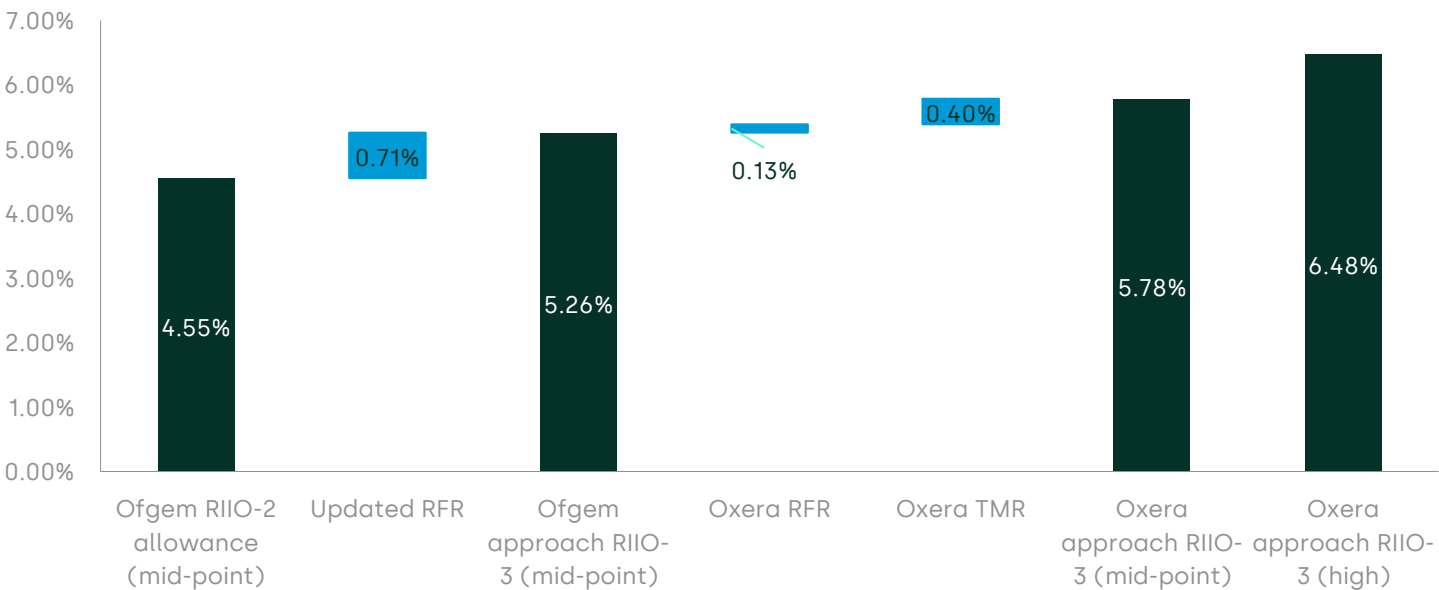
⁸ Ofgem (2021), 'RIIO-2 Final Determinations – Finance Annex (REVISED)', 3 February, p. 24, https://www.ofgem.gov.uk/sites/default/files/docs/2021/02/final_determinations_-_finance_annex_revised_002.pdf (last accessed on 16 January 2024).

⁹ Ofgem (2022), 'RIIO-ED2 Final Determinations Finance Annex', 30 November, p. 33, <https://www.ofgem.gov.uk/sites/default/files/2022-11/RIIO-ED2%20Final%20Determinations%20Finance%20Annex.pdf> (last accessed on 23 January 2024).

Note: The cut-off date for the analysis is 20 December 2023. The debt beta is assumed to be 0.075.
Source: Oxera analysis.

The figure below shows step changes from Ofgem’s RIIO-GD&T2 estimate to the updated estimate following our proxy for Ofgem’s approach, and to the updated estimate following Oxera’s approach (before accounting for changes in the forward-looking risks). The difference between the estimates under Ofgem’s and Oxera’s approaches is explained by a higher RFR and TMR estimate under Oxera’s approach.

The impact of individual methodological choices on Ofgem’s and Oxera’s CoE estimates (CPIH-real)



Note: Ofgem RIIO-2 estimate refers to the CoE allowance at 60% gearing for GD&T networks. The mid-points are calculated as averages of the low and high CoE scenarios, rather than the average of each specific CoE parameter. The quantification of the impact of the change in individual parameters is indicative, as it depends on the sequence in which adjustments of individual parameters are performed. Minor discrepancies may occur due to rounding. The estimates do not separately account for the forward-looking sector-specific risks.
Source: Oxera analysis.

We have undertaken a cross-check on the reasonableness of the estimated CoE range, applying the ARP–DRP framework to use the cost of debt as a benchmark. As explained in our previous submissions, the strength of this cross-check is that it uses market-observed data on debt spreads to test the reasonableness of a CoE that is estimated

using theoretical models such as the CAPM, since the CoE is not observable.

The ARP–DRP framework also helps to test whether the ‘through-the-cycle’ approach to the TMR produces sensible results for the CoE, when tested against the debt market evidence. At the same time, the framework in its latest form smoothens the impact of the short-term volatility in debt markets.

In response to earlier discussions with stakeholders such as the CMA, in relation to the framework, we have developed it further and applied an updated version in this report. For example, the analysis in this report does not rely on historical regulatory precedents as benchmarks, or on the spot estimates for the DRP.

The application of the ARP–DRP framework, taking into account the pricing of debt risk over a five-year horizon, suggests that the appropriate point estimate of the CoE needs to be above the top end of the Ofgem rolled-forward range from RIIO-2, and close to the upper end of the Oxera range. This is consistent with our observation that, based on the historical correlation of Ofgem’s TMR allowances with gilt yields, it would be appropriate for Ofgem to increase the TMR relative to RIIO-2. It is also consistent with the extensively documented finding that the CAPM underpredicts returns for low-beta stocks.

Overall, the weight of evidence suggests that the CoE for RIIO-3 is most likely to be above the middle of the Oxera range based on CAPM parameter estimates.

1 Introduction

In December 2023, Ofgem published its Sector Specific Methodology Consultation (SSMC) for the RIIO-3 price control for gas distribution and gas and electricity transmission (GD&T) networks.¹⁰ In this report, we estimate and discuss a cost of equity (CoE) range for GB energy networks for the RIIO-3 price control period, on behalf of Energy Networks Association (ENA). Our work is limited to the capital asset pricing model (CAPM) parameters that are applicable to all gas and electricity networks, while sector-specific risks are outside of our scope, whether or not they affect the CAPM parameters (hereafter, 'baseline estimates').

In the RIIO-3 SSMC, Ofgem discussed its intended methodology for the CoE estimation, which would largely follow the methodology applied in RIIO-2.¹¹ Therefore, in this report, we also outline the RIIO-2 methodology. In particular, in December 2020, Ofgem published its RIIO-2 final determinations for GD&T networks—with these being updated in February 2021.¹² The final determinations, and specifically the CoE allowance, were appealed to the Competition and Markets Authority (CMA) by multiple energy networks.¹³ Out of 12 grounds of appeal, the CMA upheld five (partially or fully). In several areas, the CMA afforded Ofgem a 'margin of appreciation', whereby the regulator ruled that Ofgem had not made an error, even in areas where the CMA might have acted differently.

Following the CMA appeals, Ofgem published its draft and final determinations for the RIIO-ED2 price controls for electricity distribution (ED) networks.¹⁴ The methodology used to calculate the CoE of ED

¹⁰ Ofgem (2023), 'RIIO-3 Sector Specific Methodology Consultation-Finance Annex', 13 December, <https://www.ofgem.gov.uk/sites/default/files/2023-12/RIIO-3%20SSMC%20Finance%20Annex.pdf> (last accessed on 16 January 2024).

¹¹ Ofgem (2023), 'RIIO-3 Sector Specific Methodology Consultation-Finance Annex', 13 December, para. 1.3, <https://www.ofgem.gov.uk/sites/default/files/2023-12/RIIO-3%20SSMC%20Finance%20Annex.pdf> (last accessed on 16 January 2024).

¹² Ofgem (2021), 'RIIO-2 Final Determinations-Finance Annex', 3 February, https://www.ofgem.gov.uk/sites/default/files/docs/2021/02/final_determinations_-_finance_annex_revised_002.pdf (last accessed on 16 January 2024).

¹³ Competition and Markets Authority (2021), 'Final determination Volume 2A: Joined Grounds: Cost of equity', 28 October, https://assets.publishing.service.gov.uk/media/617fe5468fa8f52980d93209/ELMA_Final_Determination_Vol_2A_publication.pdf (last accessed on 23 January 2024).

¹⁴ Ofgem (2022), 'RIIO-ED2 Draft Determinations', 29 June, <https://www.ofgem.gov.uk/publications/riio-ed2-draft-determinations> (last accessed on 23 January 2024); Ofgem (2022), 'RIIO-ED2 Final Determinations Finance Annex', 30 November, <https://www.ofgem.gov.uk/sites/default/files/2022-11/RIIO-ED2%20Final%20Determinations%20Finance%20Annex.pdf> (last accessed on 23 January 2024).

companies was largely the same as that which had been subject to appeals two years before.¹⁵

Finally, shortly after the RIIO-ED2 final determinations, the UK Regulators Network (UKRN) published guidance for regulators on the methodology for setting the cost of capital.¹⁶ In the RIIO-3 SSMC, Ofgem expressed its intention to stay compliant with the guidance.¹⁷

Consequently, we have considered how the evidence base, including regulatory precedents, has developed since RIIO-2 and the publication of the UKRN guidance, in order to understand the evolution of the reasonable range of the allowed CoE in RIIO-3 relative to the previous Ofgem decisions.

This report summarises the methodology used by Ofgem to calculate the CoE allowance in RIIO-2 and the comments that Ofgem made about the RIIO-3 methodology in the SSMC, along with the resulting estimates corresponding to that methodology—to the extent that the exercise does not require us to predict the outcome of the regulatory judgement that Ofgem will provide. The report also outlines Oxera's assessment of the methodology employed by Ofgem, and carefully considers where adaptation of the approach would better reflect the latest capital market and academic evidence, although taking into account the constraints created by recent regulatory precedent.

The rest of this report is structured as follows.

- **In section 2**, we introduce the overall CAPM framework:
 - in sub-section 2.1, we discuss the risk-free rate (RFR);
 - in sub-section 2.2, we assess the total market return (TMR) and the equity risk premium (ERP);
 - in sub-section 2.3, we discuss the equity beta;
 - in sub-section 2.4, we summarise the CAPM-based estimates under an evolution of Ofgem's approach as well as under Oxera's recommended methodologies.

¹⁵ Ofgem noted that the main change as a result of the CMA appeals was that they removed its expected outperformance adjustment as part of the RIIO-ED2 price control process. See Ofgem (2022), 'RIIO-ED2 Draft Determinations – Finance Annex', 29 June, para. 3.5, <https://www.ofgem.gov.uk/sites/default/files/2022-06/RIIO-ED2%20Draft%20Determinations%20Finance%20Annex.pdf> (last accessed on 23 January 2024).

¹⁶ UKRN (2022), 'UKRN guidance for regulators on the methodology for setting the cost of capital', https://ukrn.org.uk/app/uploads/2023/03/CoC-guidance_22.03.23.pdf (last accessed on 5 January 2024).

¹⁷ Ofgem (2023), 'RIIO-3 Sector Specific Methodology Consultation-Finance Annex', 13 December, para. 2.7, <https://www.ofgem.gov.uk/sites/default/files/2023-12/RIIO-3%20SSMC%20Finance%20Annex.pdf> (last accessed on 16 January 2024).

- **In section 3**, we cross-check the CAPM-based estimates using the asset risk premium relative to debt risk premium (ARP–DRP) framework.
- **In section 4**, we set out our conclusions.

The report focuses on a CAPM-based CoE estimate (i.e. on a baseline basis) that is suitable for all GB energy networks, and does therefore not account for the sector-specific forward-looking risks. The assessment therefore does not consider whether additional premia are required on top of the CoE estimate for the return on equity allowance, for example due to sector-specific reasons.

2 CAPM framework

In the RIIO-2 final determinations and subsequent interactions, Ofgem relied primarily on the CAPM framework to determine the allowed CoE. The CAPM is widely used by regulators to calculate the CoE, in the context of setting the allowed revenues for regulated companies. Other methods—such as comparisons against the cost of debt using the ARP–DRP framework—can be used as cross-checks to outputs obtained through the CAPM framework. The relevant formula for the CAPM is the following:

$$CoE = RFR + equity\ beta * ERP = RFR + equity\ beta * (TMR - RFR)$$

In essence, the CAPM assumes that the CoE of a particular investment is related to its exposure to 'systematic' or non-diversifiable equity market risk. The return required by equity investors consists of the return on a risk-free investment plus a risk premium that reflects how correlated the returns on the particular investment in question are with the market overall. The CAPM assumes that in equilibrium the expected return for bearing non-systematic risk will be zero, since the model assumes that these risks can be diversified away by holding a portfolio of assets.

Exposure to systematic risk is measured by the equity beta. An investment with no systematic risk (i.e. with no correlation with returns on the market) would have an equity beta of zero. An investment in the equity of a company of average market risk would have an equity beta of one—in other words, the premium over the RFR that equity investors expect to earn on such an investment would be the same as the average for the overall market (i.e. it would be equal to the ERP).

We summarise below Ofgem's approach to estimating input parameters for the CAPM formula in the RIIO-2 and RIIO-3 SSMC, and comment on whether we consider the methodology to be appropriate in the context of estimating a revised allowed return on equity for the RIIO-3 period. We further comment on the consistency of our methodology with the UKRN guidance.

2.1 RFR

The RFR measures the expected return on an asset that is free of risk—i.e. where the realised return on the investment will be equal to the expected return. In the CAPM framework, this notional riskless asset is also referred to as a 'zero-beta asset' (i.e. an asset with zero sensitivity to overall market risk). The CAPM assumes that all investors can borrow

and lend an unlimited amount at the RFR. In economies with low sovereign default risk, regulators have typically estimated the RFR with reference to the yield to maturity (YTM) on government-issued bonds (also known as 'gilts' in the UK), at least as a basis to which they add premia, or as one of the instruments on which they rely. These bonds are assumed to be notionally free of default and systematic risk.¹⁸

However, more recently there has been a debate in the UK and elsewhere in Europe as to whether government bonds provide the best estimate of the RFR. It has been observed that private borrowers, even those with very low credit risk, cannot borrow at the same rate as the government—i.e. the yield on the highest-rated corporate bonds (those rated AAA) is usually above the yield on government bonds of the same maturity.¹⁹ It has also been argued that government bond yields are below the return on a zero-beta asset because the bonds have special properties that give rise to a price premium that usually lowers their yields below the RFR—we refer to the spread between the government bond yields and the return on a zero-beta asset (which reflects these special properties of the government bonds) as a 'convenience premium' in this report. As explained in sub-section 2.1.1 below, we consider that it is important to account for the convenience premium when estimating the RFR. Allowing for a convenience premium adjustment in the calculation of the RFR (e.g. by including highly rated corporate bonds in the assessment) is an approach that is increasingly used by other UK and European regulators, as discussed further in this section.

Box 2.1 below summarises Ofgem's approach to estimating the RFR in the RIIO-2 and RIIO-3 SSMC.

Box 2.1 Ofgem's approach to estimating the risk-free rate



In the RIIO-2 price controls, Ofgem relied on the following set of parameters in order to set a point estimate for the allowed RFR. In the RIIO-3 SSMC, it said that it would keep the methodology broadly unchanged. The RFR, like the overall

¹⁸ In the past, UK regulators have typically followed this approach while allowing for a certain amount of additional headroom above traded (spot) yields to allow for interest rate uncertainty.

¹⁹ For example, see Oxera (2020), 'Are sovereign yields the risk-free rate for the CAPM?', prepared for the Energy Networks Association, 20 May, <https://www.oxera.com/wp-content/uploads/2020/08/2020.05.20-RFR-and-gearing-1.pdf> (last accessed on 23 January 2024).

return allowance, is set in consumer prices index including owner occupiers' housing costs (CPIH)-real terms.

- **Benchmark yield:** Ofgem uses 20-year index-linked gilts (ILG) as a benchmark to set the RFR. It does not intend to change its approach to the benchmark yield in RIIO-3.
- **Averaging period and indexation:** to set the allowed RFR, Ofgem uses a one-month average of historical 20-year ILG yields over the month of October. Ofgem updates the RFR allowance on an annual basis in a process known as RFR indexation. To provide a forward-looking view on where the RFR allowance is likely to be during the price control period, Ofgem relies on a spot gilt yield at the selected cut-off date as well as a forward premium. In RIIO-3, Ofgem intends to retain this approach to the averaging period and indexation.
- **Inflation:** the retail price index (RPI)-real RFR estimate, based on RPI-real ILGs, is converted into CPIH-real terms using the RPI-CPIH wedge. For RIIO-2, the wedge was calculated by looking at a single (the fifth) year of RPI and consumer prices index (CPI) inflation forecasts from the Office for Budget Responsibility (OBR). In the RIIO-3 SSMC,¹ Ofgem has proposed to calculate the wedge using (i) official forecasts of CPI and RPI (by the OBR or HM Treasury) up to the point of convergence of the RPI and CPIH rates (assumed to be February 2030); and (ii) a zero wedge for the period ranging from the point of convergence to the maturity of the ILG being used, which we understand to be 20 years.

Source: Ofgem (2022), 'RIIO-ED2 Final Determination Finance Annex', 30 November. ¹ Ofgem (2023), 'RIIO-3 Sector Specific Methodology Consultation-Finance Annex', 13 December, para. 3.40, <https://www.ofgem.gov.uk/sites/default/files/2023-12/RIIO-3%20SSMC%20Finance%20Annex.pdf> (last accessed on 12 January 2024).

The key elements of the RFR estimation where the approach that we consider to be most appropriate deviates from that of Ofgem are the benchmark yield (i.e. the application of the convenience premium) and

the treatment of inflation (and the RPI–CPIH wedge). We discuss these in sub-sections 2.1.1 and 2.1.2 below. We then summarise Ofgem’s and Oxera’s RFR estimates in section 2.1.3 and comment on compliance with the UKRN guidance in section 2.1.4.

2.1.1 Benchmark yield and the convenience premium

In principle, we agree with the use of 20-year ILGs as a starting point for calculating the RFR; this is aligned with the methodology outlined by the CMA in the PR19 water redetermination and is not disputed in the RIIO-2 appeals.²⁰ The CMA observes that ILGs closely match the key requirement of the RFR. The UK government enjoys a strong credit rating of AA/Aa3, and as a sovereign nation the UK has monetary and fiscal levers to support debt repayment that are not available to commercial lenders.²¹

Based on a cut-off date of 20 December 2023, the spot yield on 20-year ILGs is 0.74% (RPI-real), while the expected value over the RIIO-3 price control is 1.00%.²²

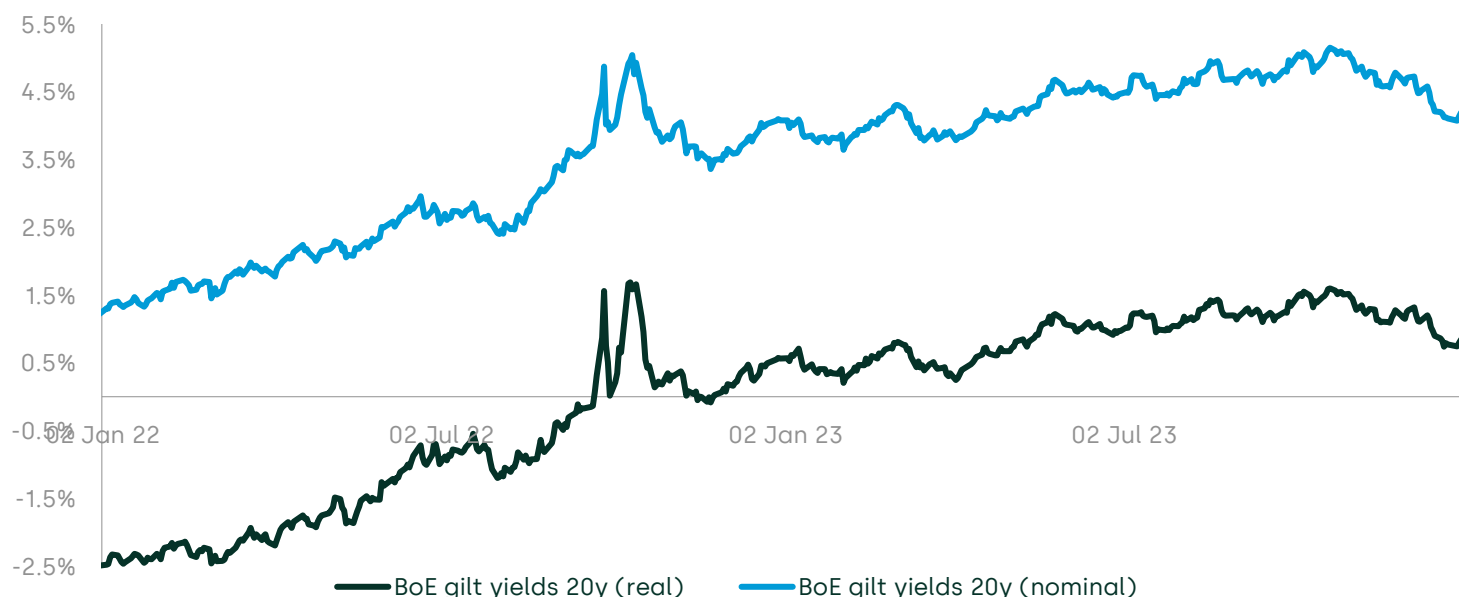
Figure 2.1 below shows the evolution of the yields for UK 20-year nominal gilts and ILGs.

²⁰ CMA (2021), ‘Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations. Final Report’, 17 March, para. 9.241, https://assets.publishing.service.gov.uk/media/60702370e90e076f5589bb8f/Final_Report_---_web_version_-_CMA.pdf (last accessed on 9 February 2024), hereafter ‘CMA PR19 redetermination (2021)’, para. 9.241; Competition and Markets Authority (2022), ‘Final determination Volume 2A: Joined Grounds: Cost of equity’, 28 October.

²¹ CMA PR19 redetermination (2021), para. 9.103.

²² To forecast ILG yields for the RIIO-3 price control period, we have used Ofgem’s modelling where the forward premium is embedded into the RFR forecast.

Figure 2.1 20-year nominal gilt and ILG yield



Source: Oxera analysis based on Bank of England (BoE) data.

However, as recognised by the CMA,²³ and explained below, we consider that the yields on AAA-rated non-government bonds are also a suitable input to estimate the RFR, recognising the convenience premium adjustment. In 2020, Oxera published a report that investigated the relationship between sovereign yields and the CAPM.²⁴ Box 2.2 summarises the intuition behind the concept of the convenience premium.

Box 2.2 The concept of the convenience premium



The CAPM defines the RFR as the rate of return on a zero-beta asset, and assumes that there is a single RFR at which investors can undertake risk-free borrowing and lending. However, this assumption might be violated when considering an estimate of the RFR that is based on yields on government bonds.

²³ CMA PR19 redetermination (2021), para. 9.162.

²⁴ Oxera (2020), 'Are sovereign yields the risk-free rate for the CAPM?', prepared for the Energy Networks Association, 20 May, <https://www.oxera.com/wp-content/uploads/2020/08/2020.05.20-RFR-and-gearing-1.pdf> (last accessed on 23 January 2024).

In the Oxera 2020 report, we investigated the relationship between sovereign yields and the CAPM.¹ We explained that using the yield on government bonds as the RFR in the CAPM model can lead to a violation of the Modigliani–Miller (MM) theorem.² We also explained that this is caused by a convenience premium, which typically pushes yields on government bonds relative to the RFR down.

In essence, the convenience premium is caused by excess demand for highly rated government bonds driven by regulatory requirements and the use of government bonds in hedging strategies—such as interest rate hedging. The convenience premium therefore reflects the money-like safety and liquidity characteristics of government bonds.

The excess demand for government bonds used in hedging strategies was demonstrated by the market turmoil of September 2022, where the BoE had to intervene in the gilt market and provide a new liquidity facility for a subset of gilt market participants (Liability Driven Investment funds) to halt a potential fire sale of long-dated gilts. The Liability Driven Investment market created a leveraged demand for gilts as a hedge against long-dated pension fund liabilities, recognising the money-like safety and liquidity characteristics of government bonds.

Source: ¹ Oxera (2020), 'Are sovereign yields the risk-free rate for the CAPM?', prepared for the Energy Networks Association, 20 May, <https://www.oxera.com/wp-content/uploads/2020/08/2020.05.20-RFR-and-gearing-1.pdf> (last accessed on 23 January 2024). ² Ibid., p. 6.

We have published more work on the convenience premium since our initial report in 2020.²⁵ However, there are two developments that we detail in this report that are new relative to Ofgem's RIIO-ED2 price control review process and the publication of the UKRN guidance. These are additional academic literature and new regulatory precedents,

²⁵ See, for example, Oxera (2022), 'RFR methodology for PR24', prepared for Water UK, 2 September, https://www.ofwat.gov.uk/wp-content/uploads/2022/09/NWG_Risk_Free_Rate_Oxera.pdf (last accessed on 15 January 2024).

which we discuss below. After this, we turn to the quantification of the convenience premium.

Additional academic literature

Academic research published since our initial report about the convenience premium (the Oxera (2020) report mentioned above) has confirmed the existence of a convenience yield in government bonds, including those issued by the UK government. In Oxera (2022), we laid out the ongoing academic developments.²⁶ Van Binsbergen, Diamond and Grotteria (2020) estimate a convenience premium of around 40bps on US government bonds over 2004–18.²⁷ Koijen and Yogo (2020) also find evidence consistent with a significant convenience premium for US Treasuries between 2002 and 2017.²⁸

More recently, Acharya and Laarits (2023) assess the convenience yield of US Treasuries by decomposing the aggregate stock–bond covariance (as a measure of the treasuries' hedging properties) into terms corresponding to the convenience premium, the frictionless RFR, and default risk. They also study how the convenience premium changes depending on the circumstances. The authors find that an increase in the government bonds' hedging properties—i.e. a decrease in the covariance of returns on Treasury bonds and the aggregate stock market—leads to an increase in the convenience premium. The study also points out that an increase in aggregate risk, such as during crises, leads to a higher convenience premium. On the other hand, Acharya and Laarits (2023) show that heightened inflation expectations negatively affect the convenience yield. Specifically, high inflation expectations can erode the positive relationship between the convenience yield and aggregate risk. Overall, the authors demonstrate that the convenience premium is, on average, positive, although it varies significantly over time, and that there are instances where the premium briefly drops to almost zero, or even below zero. While their main analyses focus on US Treasuries, the authors also show the existence and variance of the

²⁶ Oxera (2022), 'RFR methodology for PR24', prepared for Water UK, 2 September, https://www.ofwat.gov.uk/wp-content/uploads/2022/09/NWG_Risk_Free_Rate_Oxera.pdf (last accessed on 15 January 2024).

²⁷ Van Binsbergen, J.H., Diamond, W.F. and Grotteria, M. (2022), 'Risk-free interest rates', *Journal of Financial Economics*, **143**:1, pp. 1–29.

²⁸ Koijen, R.S. and Yogo, M. (2020), 'Exchange rates and asset prices in a global demand system', *NBER Working Paper No. 27342*, June, <https://www.nber.org/papers/w27342> (last accessed on 15 January 2024).

convenience premium in European capital markets via an additional assessment of German government bonds.²⁹

Evidence regarding the existence of the convenience premium in international capital markets is also provided by Diamond and Van Tassel (2023) as they analyse the convenience premium in ten of the G11 currencies, including pounds sterling.³⁰ They find an average convenience premium of 38bps for two-year UK gilts, which is higher than the average 35bps convenience premium on two-year US Treasuries. At the same time, they show for one-year UK gilts that the convenience premium is volatile and that the premium has turned negative multiple times (albeit briefly) since 2005. In addition, they show that a 1% increase in nominal interest rates in a country leads to an increase in the convenience premium by 15bps, and that the premium spikes during financial crises.³¹

Therefore, based on our previous assessments and the recent academic literature that confirms our findings, when estimating the RFR for use as an input in the CAPM from government bond yields, adjustments are required to account for the convenience premium. However, as demand for government bonds varies over time with changes in macroeconomic variables including inflation and interest rates, so does the level of the convenience premium. For this reason, the use of a longer-term estimate might be more appropriate, as we discuss below.

Latest regulatory precedents

Adjusting the RFR for the convenience premium is consistent with approaches that have been taken by regulators in the UK, including the CMA and the UK Civil Aviation Authority (CAA). A more comprehensive list of regulatory decisions that have embedded a convenience premium in the RFR, for example by including the highest-rated corporate bonds

²⁹ Acharya, V. and Laarits, T. (2023), 'When do Treasuries Earn the Convenience Yield? — A Hedging Perspective', *NBER Working Paper No. 31863*, 3 November, <https://www.nber.org/papers/w31863> (last accessed on 10 January 2024).

³⁰ The currencies are the Australian dollar, Canadian dollar, Danish krone, euro, Japanese yen, Norwegian krone, pound sterling, Swedish krona, Swiss franc and US dollar.

³¹ Diamond, W. and Van Tassel, P. (2023), 'Risk-Free Rates and Convenience Yields Around the World', *Jacobs Levy Equity Management Center for Quantitative Financial Research Paper*, 3 February, p. 3, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4048083 (last accessed on 10 January 2024).

in the sample for the estimation of the regulatory allowed RFR, is as follows:³²

- the UK CMA PR19 redetermination in 2021;
- the H7 Final Decision in 2023;
- the NATS final decision issued by the UK CAA in 2023;
- the GD23 price control final determination issued by UREGNI (Northern Irish regulator) in 2022;
- the gas and electricity weighted average cost of capital (WACC) allowance issued by ARERA (Italian regulator) in 2021;
- the determination for the fourth regulatory period for energy networks issued by BNetzA (German regulator) in 2021.

We provide further details of the CMA PR19 redetermination, the CAA H7 final proposals for Heathrow, the NATS final decision by the UK CAA, and the GD23 price control final determination issued by UREGNI, in relation to the inclusion of a convenience premium below.

- In the PR19 redetermination, in adjusting for the inclusion of a convenience premium, the CMA has evaluated whether highly rated, non-government bonds may improve the RFR estimation in the context of price controls. It assessed the iBoxx £ non-gilt AAA 10+ index and the iBoxx £ non-gilt AAA 10–15 index,³³ and concluded that the constituents of these indices are not 'risk-free' in the same way as government bonds denominated in the home country's currency are. This is because investors in these non-government bonds still bear liquidity risks, as well as the additional default risks associated with the issuer. That said, the CMA recognised that the default risks of these high-quality bonds are exceptionally low, and evidence from actual performance suggests that the expected loss is significantly

³² CMA PR19 redetermination (2021); Civil Aviation Authority (2023), 'Economic regulation of Heathrow Airport Limited: H7 Final Decision – Section 3: Financial issues and implementation', <https://publicapps.caa.co.uk/docs/33/H7%20Final%20Decision%20-%20Section%203%20-%20Financial%20issues%20and%20implementation%20CAP2524D.pdf> (last accessed on 5 February 2024); Civil Aviation Authority (2023), 'Economic regulation of NATS (En Route) plc: Final Decision for the NR23 (2023-2027) price control review', October, <https://publicapps.caa.co.uk/docs/33/CAP2597%20NR23%20Final%20Price%20Control%20Decision%20original%20release.pdf> (last accessed on 5 February 2024); UREGNI (2022), 'GD23 – Gas Distribution Price Control 2023-2028 – Final Determination – Main Report', October, <https://www.uregni.gov.uk/files/uregni/documents/2022-10/GD23%20FD%20Main%20Document.pdf> (last accessed on 5 February 2024); ARERA (2021), 'Delibera 23 dicembre 2021 614/2021/R/com'; Bundesnetzagentur (2021), 'BK-4-21-055', 12 October, section 2d, p. 38, https://www.bundesnetzagentur.de/DE/Beschlusskammern/1_GZ/BK4-GZ/2021/BK4-21-0055/BK4-21-0055_Beschluss_download_bf.pdf?__blob=publicationFile&v=5 (last accessed on 31 January 2024).

³³ CMA PR19 redetermination (2021), para. 9.145.

lower than the debt premium.³⁴ As a result, the CMA concluded that the yields on AAA-rated non-government bonds are suitable inputs to the RFR estimation.³⁵

- In line with the CMA's decision, the CAA in its price control decision for Heathrow concluded that it was appropriate to place a 50% weighting on AAA-rated non-government bonds.³⁶ In that decision, it proposed to estimate the convenience premium embedded in gilts by comparing the returns on these indices with the closest nominal gilt in maturity for each of the iBoxx £ non-gilt AAA 10+ and 10–15 indices. However, the CAA took an average of the ILGs with the premium and the ILGs without the premium, meaning that only half of that premium was estimated in the final RFR. This approach is closely aligned with the CMA's approach of placing a 50% weight on ILGs and 50% weight on AAA-rated bonds.
- The CAA, in the NATS final decision, remained of the view that the yields on the ILGs could exhibit factors that do not reflect the properties of the 'true' RFR, including 'convenience yield'. The CAA estimated the convenience yield by taking a one-month average of the difference between the yields of the iBoxx £ non-gilt AAA 10–15 index and nominal gilt yields of similar maturity.³⁷ As for Heathrow, the CAA added this convenience yield only to the top end of the range used to estimate the RFR, i.e. the CAA assigns equal weight to the measure of the RFR with and without the convenience yield.³⁸ However, given that the convenience yield estimate was based on the full difference between the yields of the AAA-rated indices and gilts rather than half of it as per the CMA's approach, the CAA's and the CMA's approaches are closely aligned.
- UREGNI, in the GD23 price control final determination issued in October 2022, based the RFR estimate on the yields of the 20-year ILGs and the AAA-rated non-government bonds of 10–15

³⁴ CMA PR19 redetermination (2021), para. 9.146.

³⁵ CMA PR19 redetermination (2021), para. 9.162.

³⁶ Civil Aviation Authority (2022), 'Economic regulation of Heathrow Airport: H7 Final', June, section 3, paras 9.247–9.250, <https://publicapps.caa.co.uk/docs/33/CAP2365D%20H7%20Proposals%20Section%203-kb.pdf> (last accessed on 5 February 2024).

³⁷ Civil Aviation Authority (2022), 'Economic regulation of NATS (En Route) plc: Appendices to initial proposals for the next price control review ("NR23")', October, p. 15, https://consultations.caa.co.uk/economic-regulation/initial-proposals-nr23/supporting_documents/CAP2394b%20Appendices%20A%20to%20G.pdf (last accessed on 9 February 2024).

³⁸ Civil Aviation Authority (2023), 'Economic regulation of NATS (En Route) plc: Final Decision for the NR23 (2023-2027) price control review', October, pp. 129 and 133, <https://publicapps.caa.co.uk/docs/33/CAP2597%20NR23%20Final%20Price%20Control%20Decision%20original%20release.pdf> (last accessed on 9 February 2024).

and 10+ year maturities, consistent with the CMA and CAA approaches.³⁹

Quantification of the convenience premium

Figure 2.2 below presents the nominal spreads of the iBoxx £ AAA non-gilt 10+ and 10–15 indices, used in regulatory precedents, relative to benchmark gilts. The spreads have generally been positive over the past ten years, although they get close to zero in the recent dates shown in the chart.

Figure 2.2 Nominal spreads of AAA-rated bond indices relative to benchmark government bonds



Note: The spreads are calculated by deducting yields on maturity-matching nominal gilts.

Source: Oxera analysis of IHS Markit and Bank of England data.

³⁹ UREGNI (2022), 'GD23 – Gas Distribution Price Control 2023-2028 – Final Determination – Main Report', October, p. 86, <https://www.uregni.gov.uk/files/uregni/documents/2022-10/GD23%20FD%20Main%20Document.pdf> (last accessed on 5 February 2024).

Table 2.1 below summarises the main characteristics of the iBoxx £ non-gilt AAA 10–15 and iBoxx £ non-gilt AAA 10+ indices.

Table 2.1 iBoxx AAA characteristics

	iBoxx £ non-gilt AAA 10–15	iBoxx £ non-gilt AAA 10+
Number of bonds in the sample	4	12
Average remaining life of the bonds	13 years	30 years
Duration ¹	10 years	13 years

Note: ¹ Duration is the weighted average time to receive all interest and principal payments, expressed in present value terms. It also measures the sensitivity of the bond price to changes in interest rates. The YTM of a bond depends on the average time taken by cash flows to arrive and not on the total time to maturity. We therefore find duration to be more useful as a metric for comparison purposes.
Source: Oxera analysis of IHS Markit and Bloomberg data.

As Table 2.1 shows, the iBoxx £ non-gilt AAA 10–15 index has an average remaining time to maturity of 13 years, while the duration of the index is close to ten years. This is well within the 10–20-year CAPM investment horizon that is common to regulatory determinations.⁴⁰ Combining it with the iBoxx £ non-gilt AAA 10+ index, the average maturity (between 13 and 30 years) and duration (between ten and 13 years) are still within the 10–20-year range.

Our conclusion is that the estimate of the RFR should be based on both the ILGs and the AAA-rated bonds in order to account for the convenience premium. This is also consistent with the methodology applied by the CMA, the CAA and UREGNI.

Following the convenience premium estimation discussed in this section, and in line with academic evidence that the convenience premium is a time-varying number,⁴¹ we have calculated a five-year average convenience premium estimate—the period that matches the length of the price control period. Table 2.2 shows our estimate of the

⁴⁰ UKRN (2022), 'UKRN guidance for regulators on the methodology for setting the cost of capital', p. 14, https://ukrn.org.uk/app/uploads/2023/03/CoC-guidance_22.03.23.pdf (last accessed on 7 February 2024).

⁴¹ For example, it changes as the relative demand for government bonds varies in line with changes in macroeconomic variables over time, as detailed in the academic evidence cited earlier.

convenience premium of c. **0.11%** over the last five years (2018–23).⁴² Given the volatility that we are observing within credit markets at present, and the resultant impact on the convenience premium, it will be important to reassess and update this evidence in line with further capital market movements closer to the final determinations for RIIO-3.

Table 2.2 Convenience premium estimation

	Formula	Oxera estimate
Five-year average of AAA indices, nominal	[A]	2.32%
Five-year average of 20-year gilts, nominal	[B]	2.10%
Average AAA indices, gilts	[C]=avg ([A], [B])	2.21%
Convenience premium estimate (5Y)	[D]=[C]-[B]	0.11%

Note: The cut-off date for the analysis is 20 December 2023. Discrepancies may be due to rounding.

Source: Oxera analysis using Bloomberg data.

2.1.2 Inflation wedge

In November 2020, the Chancellor announced that the UK Statistics Authority could introduce its transition from RPI to CPIH unilaterally from 2030. This planned reform will align the changes in RPI with the changes in CPIH.⁴³ Note that CPIH-linked instruments (e.g. swaps) and CPIH forecasts are not generally available, and when forecasting we therefore use CPI as a proxy for CPIH. We further discuss the spread between CPIH and CPI and its implications later in this sub-section.

Against this background, Ofgem and other UK regulators have considered a number of methodologies for estimating the RPI–CPIH wedge in order to convert RPI-linked ILG yields into CPIH-real RFR estimates. In particular, for RIIO-2, Ofgem considered two methods to

⁴² This is calculated by averaging the nominal yields of the AAA-rated indices (2.32%) with 20-year nominal gilt yields (2.10%), resulting in an overall average figure (2.21%). Subsequently, estimating the difference between this figure (2.21%) and the average 20-year nominal gilt yields (i.e. the basis for the RFR without the convenience premium) leads to our convenience premium estimate of 0.11%.

⁴³ UK Statistics Authority (2020), 'Response to the joint consultation on reforming the methodology of the Retail Prices Index', <https://uksa.statisticsauthority.gov.uk/news/response-to-the-joint-consultation-on-reforming-the-methodology-of-the-retail-prices-index/> (last accessed on 16 January 2024).

estimate the wedge: the 'single year' approach,⁴⁴ and the '20-year inflation forecast' approach, where a 20-year geometric average forecast wedge is calculated by combining five years of OBR forecasts with assumptions for the following 15 years.⁴⁵ However, when determining the final point estimate, Ofgem relied solely on the results of the first approach for both the GD&T and ED price controls of RIIO-2—i.e. the fifth-year OBR forecast. In the RIIO-3 SSMC, Ofgem has proposed to calculate the wedge using official forecasts of CPI and RPI up to the point of convergence of RPI and CPIH rates (which is assumed to be February 2030), and a zero wedge for the period ranging from the point of convergence to the maturity of the ILG being used for the estimation of the RFR, which we understand to be 20 years.⁴⁶ In other words, Ofgem has proposed to follow the '20-year inflation forecast approach' that it considered in RIIO-2 but did not use.

In this section, we have estimated the wedge based on new market data and Ofgem's preferred approach. In addition, we provide an estimation of the wedge based on RPI and CPI swap rates, and use that in addition to Ofgem's '20-year inflation forecast' methodology for Oxera's preferred wedge estimate.

Table 2.3 below shows our update of Ofgem's '20-year inflation forecast' approach, as proposed in the SSMC, which results in an RPI–CPI wedge of **0.32%**. We have used the most recent OBR inflation forecasts up to 2028 (the longest available forecast horizon).⁴⁷ In addition, the period 2029–30 is treated as a transition period, with CPI equal to its long-term target of 2%, and RPI for 2029 equal to the long-term assumption of 3% while RPI for 2030 is estimated as a weighted average of 3% and 2%, reflecting a transition during the year and resulting in an estimate of 2.17% for 2030.⁴⁸ Both inflation rates equal 2% thereafter. By construction, the '20-year inflation forecast' approach

⁴⁴ Ofgem (2022), 'RIIO-ED2 Draft Determination – Finance Annex', 29 July, para. 3.16, <https://www.ofgem.gov.uk/sites/default/files/2022-06/RIIO-ED2%20Draft%20Determinations%20Finance%20Annex.pdf> (last accessed on 5 February 2024).

⁴⁵ Ofgem (2022), 'RIIO-ED2 Draft Determination – Finance Annex', 29 July, para. 3.16, <https://www.ofgem.gov.uk/sites/default/files/2022-06/RIIO-ED2%20Draft%20Determinations%20Finance%20Annex.pdf> (last accessed on 5 February 2024).

⁴⁶ Ofgem (2023), 'RIIO-3 Sector Specific Methodology Consultation-Finance Annex', 13 December, para. 3.40, <https://www.ofgem.gov.uk/sites/default/files/2023-12/RIIO-3%20SSMC%20Finance%20Annex.pdf> (last accessed on 14 January 2024).

⁴⁷ The OBR forecasts were last published in November 2023.

⁴⁸ We treat 2030 as a transition year. In the SSMC, Ofgem mentions that RPI and CPI will converge in February 2030. Given that we use the OBR's forecasts for calendar years, in line with Ofgem, we have calculated a weighted average of the RPI estimate for 2030, with the RPI assumed to be 3% until February 2030, and 2% from March 2030. The exact calculation is as follows: $(3\% \times (2/12) + 2\% \times (10/12)) = 2.17\%$.

assumes that the RPI inflation rate implied by the ILGs will equal the CPI inflation rate with a 100% probability from February 2030 onwards.

Table 2.3 20-year forecast approach based on OBR data

	RPI inflation	CPI inflation	RPI–CPI spread
2024	5.12%	3.61%	1.46%
2025	2.60%	1.78%	0.81%
2026	2.51%	1.45%	1.05%
2027	2.80%	1.73%	1.06%
2028	2.86%	1.96%	0.88%
2029	3.00%	2.00%	0.98%
2030	2.17%	2.00%	0.16%
2031–43	2.00%	2.00%	0.00%
Geometric average			0.32%

Source: Oxera analysis using data from Office for Budget Responsibility (2023), 'Economic and Fiscal outlook – November 2023', November.

As for the inflation swaps approach, Figure 2.3 shows the latest weekly spread implied by RPI and CPI swap rates. On 20 December 2023, the spot estimate was **0.47%**. This approach assumes that investors acting in the ILGs and swaps market have the same information set.

Figure 2.3 Weekly average of 20-year RPI–CPI spread, based on the difference between RPI 20-year swaps and CPI 20-year swaps



Note: Seven-day moving average. The cut-off date for the analysis is 20 December 2023.
Source: Oxera analysis using Bloomberg data.

Table 2.4 below compares the RPI–CPI wedge estimates calculated under the methods presented in this section.

Table 2.4 RPI–CPI wedge estimation results

	Formula	RPI–CPI wedge
‘20-year inflation forecast’ approach: OBR forecast 20-year ahead average	[A]	0.32%
Inflation swaps (RPI 20Y–CPI 20Y)	[B]	0.47%
Average of the 20-year inflation forecast approach and the inflation swaps approach	[C] = avg ([A], [B])	0.39%

Note: The cut-off date for the analysis is 20 December 2023. Discrepancies are due to rounding.
Source: Oxera analysis based on Bloomberg and OBR data.

The inflation swaps approach and the 20-year inflation forecast approach provide a range of estimates from 0.32% to 0.47%.

For the purpose of this report, we present the RFR estimation considering different approaches. In particular, we present the expected Ofgem estimate with the ‘20-year inflation forecast’ approach, while

Oxera estimates are based on the average of the '20-year inflation forecast' approach and the inflation swaps approach, which leads to an estimate of **0.39%**.

The CPI–CPIH wedge

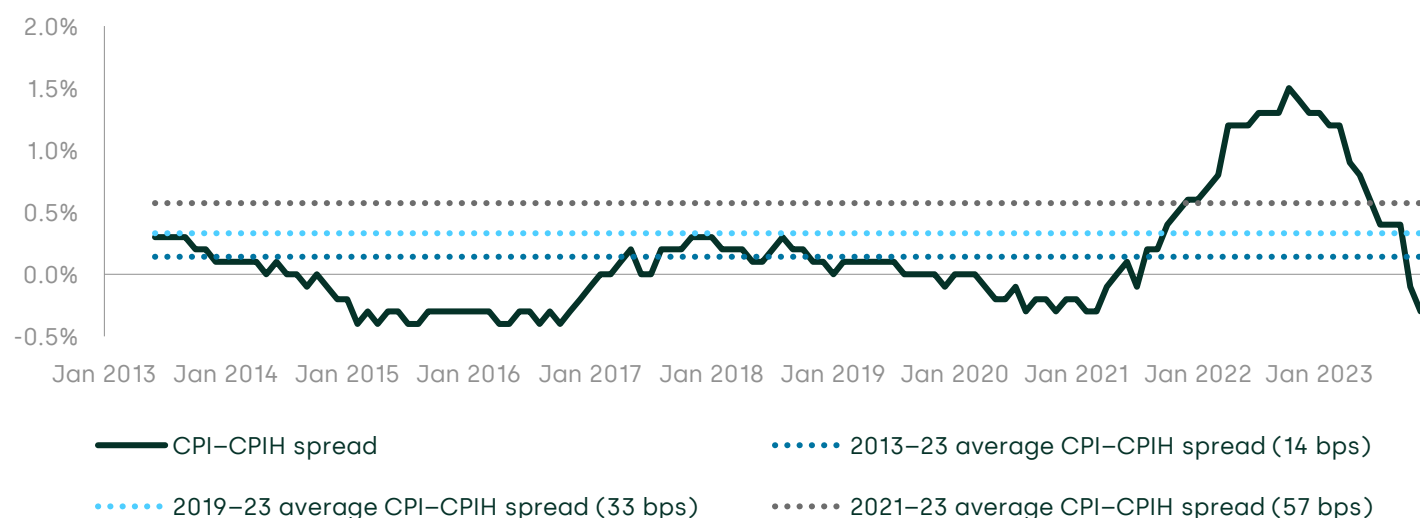
We mention above that we use CPI as a proxy for CPIH. However, there is a difference between these two measures. For example, although Ofgem notes that, historically, CPI and CPIH rates of inflation have been 'very close' on average, it specifies that CPI was, on average, 14bps higher than CPIH between June 2013 and June 2023 (also illustrated in Figure 2.4 below).⁴⁹ We have verified Ofgem's estimate but do not agree that 14bps implies that the rates are 'very close'. If we adjusted our RPI–CPIH wedge estimate by 14bps, the wedge would increase from 39bps to 53bps and the CPIH-real RFR would increase as well. Furthermore, we note that, the difference between CPI and CPIH since 2006 (i.e. since the start of the official CPIH index data),⁵⁰ over the last three years and over the last five years respectively, was significantly higher than 14bps—at 19bps, 57bps and 33bps.⁵¹ However, we also observe that this spread has been volatile and has, for example, switched from positive to negative in recent months.

⁴⁹ Ofgem (2023), 'RIIO-3 Sector Specific Methodology Consultation-Finance Annex', 13 December, para. 3.39, <https://www.ofgem.gov.uk/sites/default/files/2023-12/RIIO-3%20SSMC%20Finance%20Annex.pdf> (last accessed on 14 January 2024).

⁵⁰ The official data for the index starts in 2005, which allows us to calculate the rates from 2006.

⁵¹ Between January 2006 and December 2023, the average spread between CPI and CPIH rates was 19bps. The three-year average spread between CPI and CPIH is estimated as 57bps for the period between January 2021 and December 2023, and the five-year average spread is estimated as 33bps for the period between January 2019 and December 2023. The CPIH inflation measure was introduced in 2013, while the official data series starts in 2005. See ONS (2018), 'Consumer Prices Index including owner occupiers' housing costs (CPIH) historical series: 1988 to 2004', 14 December, section 2, <https://www.ons.gov.uk/economy/inflationandpriceindices/articles/consumerpricesindexincludingowneroccupiershousingcostshistoricalseries/1988to2004> (last accessed on 22 February 2024). An inflation rate for a certain month is estimated as the ratio of the inflation index in that month and the month a year ago. For example, January 2006 CPIH rate is estimated as the ratio of January 2006 CPIH index to January 2005 CPIH index.

Figure 2.4 Historical spread between CPIH and CPI rates of inflation



Note: The chart shows the difference between annual CPI and CPIH inflation rates. A positive spread implies a higher CPI rate relative to CPIH rate. The 2013–23 average (14bps) refers to the difference between the CPI and CPIH annual rates between June 2013 and June 2023. This is to verify Ofgem’s historical CPI–CPIH spread of 14bps. The averaging windows for five-year (2018–23) and three-year (2020–23) CPI–CPIH spreads start in January and end in December.

Source: Oxera analysis based on data from ONS.

In conclusion, historical data from 2006, as well as over the last ten, five and three years consistently indicates that, on average, CPI was higher than CPIH, due to historical downward contribution of owner occupiers’ housing costs.⁵² This implies that Ofgem will be underestimating the RPI–CPIH wedge—and thereby RFR—if no adjustment for the CPI–CPIH wedge is introduced. This is because correcting for the spread between CPI and CPIH would increase the RPI–CPIH wedge and the CPIH-real RFR. There is uncertainty around the exact level of the CPI–CPIH wedge in the future—this evidence can be updated and reassessed closer to the RIIO-3 decision. We have used a five-year average CPI–CPIH wedge of 33bps for our RFR estimate. The five-year period is aligned with the length of the price control.

⁵² The main driver for differences between CPI and CPIH inflation measures is the owner occupiers’ housing costs (i.e. the costs related to purchasing, maintaining and living in one’s own home) component which constitutes 16% of the CPIH. See ONS (2024), ‘Consumer price inflation, UK: December 2023’, 17 January, <https://www.ons.gov.uk/economy/inflationandpriceindices/bulletins/consumerpriceinflation/deceember2023/latest-movements-in-cpih-inflation> (last accessed on 22 February 2024).

Table 2.5 combines the RPI–CPI wedge with the CPI–CPIH wedge to estimate the RPI–CPIH wedge used for the RFR estimation.

Table 2.5 RPI–CPIH wedge estimation results

	Formula	RPI–CPI spread
RPI–CPI wedge ¹	[A]	0.39%
CPI–CPIH wedge ²	[B]	0.33%
RPI–CPIH wedge	[C] = [A] + [B]	0.72%

Note: The cut-off date for the analysis is 20 December 2023. Discrepancies are due to rounding. ¹ See Table 2.4. ² The five-year average of the historical CPI–CPIH wedge—see section 2.1.2 above.

Source: Oxera analysis based on Bloomberg and OBR data.

2.1.3 Overall RFR estimate

Using the results obtained in the above sections, we now compute the RFR. Table 2.6 below summarises the RFR estimation using the Ofgem and Oxera approaches, which result in estimates of **1.32%** and **1.84%** respectively.

Table 2.6 RFR estimation

	Formula	Ofgem estimates	Oxera estimates
20Y ILG yields, including forward premium, RPI-real ¹	[A]	1.00%	1.00%
Convenience premium ²	[B]	n.a.	0.11%
Benchmark RFR estimate, RPI-real	[C]=[A]+[B]	1.00%	1.11%
RPI–CPIH wedge ³	[D]	0.32%	0.72%
RFR, CPIH-real	[G]=(1+[C])*(1+[D])-1	1.32%	1.84%

Note: The cut-off date for the analysis is 20 December 2023. Numbers might not sum due to rounding. ¹ Ofgem estimates the forward premium and therefore the expected ILG yield for each year of the price control and then averages the estimates to a single datapoint. We use Ofgem's modelling. ² See Table 2.2. ³ See Table 2.5.

Source: Oxera analysis.

2.1.4 UKRN guidance

The UKRN guidance provides the following recommendations for the RFR estimation methodology.

- **Benchmark yield:** the UKRN recommends employing 10–20-year (or ‘a maturity which matches the assumed investment horizon for their sector’⁵³) ILG yields. The UKRN guidance does not recommend the use of other benchmarks such as AAA-rated corporate indices, due to concerns about a number of their constituents and the constituents’ time to maturity.⁵⁴ Specifically, the UKRN is concerned that there are currently too few constituents in the AAA-rated corporate bond indices, and that the indices may feature instruments that might be illiquid, with tenors significantly longer than the usual 10–20-year assumed investment horizon.
- **Convenience premium:** the UKRN states that there is a lack of empirical estimates for the convenience premium in the UK for the required maturities, and highlights the divergence in approaches across regulators. As a result, it states that the ‘guidance does not therefore propose alignment to a particular stance’,⁵⁵ and suggests that further work on this topic would be beneficial.
- **Averaging period:** the UKRN guidance recommends that recent yields from no more than one year prior to the cut-off date of the analysis are the most relevant.⁵⁶
- **Inflation:** the UKRN guidance suggests that the ‘inflation swaps or long-run inflation forecasts or assumptions from official sources such as the OBR’ are appropriate to convert RPI-real estimates into CPIH-real terms.⁵⁷ However, the guidance leaves flexibility to regulators in times of high inflation volatility. The guidance also leaves room for regulatory judgement in terms of how to account for the expected convergence of RPI and CPIH in 2030.

We discuss the alignment of the Oxera estimates with the UKRN guidance in the following paragraphs.

Benchmark yield and convenience premium: in principle, we agree with the UKRN guidance on the use of long-term (20-year) ILG yields as a starting point for calculating the RFR. However, we consider that the characteristics of the AAA-rated corporate bond indices are sufficiently

⁵³ UKRN (2022), ‘UKRN guidance for regulators on the methodology for setting the cost of capital’, p. 15, https://ukrn.org.uk/app/uploads/2023/03/CoC-guidance_22.03.23.pdf (last accessed on 5 January 2024).

⁵⁴ Ibid., p. 14.

⁵⁵ Ibid., p. 14.

⁵⁶ Ibid., p. 14.

⁵⁷ Ibid., p. 15.

suitable for the indices to be used as one of the inputs in estimating the RFR.

While one of the indices, the iBoxx £ non-gilt AAA 10+ index, does, indeed, have a longer than 10–20 years average remaining time to maturity (30 years) as the UKRN notes, the duration-weighted exposure of this index is c. 13 years, as of December 2023, which is within a regulatory investment horizon of 10–20 years.⁵⁸ Further investigating the iBoxx £ non-gilt AAA index constituents, as of December 2023, we noted that seven out of the 12 constituents had a remaining time to maturity of close to 20 years.⁵⁹ Out of the remaining five bonds that have a time to maturity of over 30 years, two of the longest-tenor bonds are callable,⁶⁰ which suggests that their remaining time to maturity may be shortened, depending on movements in interest rates and other market conditions.

The average time to maturity and duration of the other index that we use, the iBoxx £ non-gilt AAA 10–15 index, are 13 and ten years respectively.

Given the average time to maturity and the duration of both of the indices, and the fact that a few of the longest-tenor bonds are callable, we consider that the AAA-rated indices are appropriate to account for the convenience premium estimation.

As for the concept of the convenience premium, the UKRN guidance does not prevent regulators from applying it—rather, it suggests looking at additional evidence. In the sub-sections above, we put forward additional evidence based on new academic literature and new regulatory precedents on the concept of the convenience premium, which both show that stakeholders continue using it in their work. We highlight the relevance of a convenience premium adjustment and consider the yields on AAA-rated non-government bonds as a suitable input to estimate the RFR. We therefore base our RFR estimates on an average of 20-year ILG yields and AAA-rated corporate indices.

⁵⁸ Duration is the weighted average time to receive all interest and principal payments, expressed in present value terms. It also measures sensitivity of the bond price to changes in interest rates. The YTM of a bond depends on the average time taken by cash flows to arrive, and not on the total time to maturity. We therefore find that duration is more useful as a metric for comparison purposes.

⁵⁹ Specifically, as of January 2024, seven bonds in the iBoxx £ non-gilt AAA 10+ index had remaining years to maturity of 12.4, 12.5, 13.1, 13.4, 15.2, 16.5 and 20.2 years respectively.

⁶⁰ As of January 2024, two of the longest-tenor bonds in the iBoxx £ non-gilt AAA 10+ index, i.e. the Wellcome Trust Ltd (2118) bond with remaining time to maturity of c. 94 years and the Wellcome Trust Ltd (2071) bond with remaining time to maturity of c. 47.5 years, are both callable.

Averaging period: given that the estimates are used only for forecasting and October average estimates will be used in Ofgem's indexation during the price control period, we consider that the approach to forecasting is irrelevant to the compliance with the UKRN guidance. At the same time, the October averaging is aligned with the guidance to use short-term historical averages.

Inflation: combining two approaches to the RPI–CPIH wedge estimate (i.e. a 20-year inflation forecast, where a 20-year geometric average forecast wedge is calculated by combining five years of OBR forecasts with assumptions for the following 15 years, and an inflation swaps approach) is in line with the UKRN guidance that long-run inflation forecasts, assumptions from official sources such as the OBR, or inflation swaps should be used. The UKRN guidance does not comment on the wedge between CPI and CPIH.

2.2 TMR and ERP

The ERP is a premium above the RFR that investors demand for investing in a market equity portfolio. The ERP is calculated as the difference between the TMR and the RFR. UK regulators and the CMA have tended to follow the view that the expected real TMR is fairly stable over time, and that changes in the real RFR are largely offset by changes in the ERP.⁶¹ While the TMR may indeed be largely stable over time, it is important to consider how the high-interest-rate environment affects investability in RIIO-3. Notwithstanding that the TMR has historically been more stable than the ERP, we observe that regulatory precedent on the TMR has supported higher allowances in high-interest-rate environments and vice versa over time, as further discussed in this section—this has important implications for the appropriate cost of equity allowance in RIIO-3.

Keeping the regulatory precedent in mind, the TMR can be estimated using a range of methodologies. One approach to estimating the TMR is:

- historical ex post: based on the average of observable historical returns. This is the most widely used method and the one that produces the most robust results.

⁶¹ See, for example, Competition and Markets Authority (2021), 'Final determination Volume 2A: Joined Grounds: Cost of equity', 28 October, https://assets.publishing.service.gov.uk/media/617fe5468fa8f52980d93209/ELMA_Final_Determination_Vol_2A_publication.pdf (last accessed on 5 February 2024).

The other two approaches are:

- historical ex ante: based on the average of adjusted historical returns, where the adjustment accounts for 'unexpected' events that generated a return that was lower or higher than expected;
- forward-looking: based on investors' expectations of future returns. Various methodologies can be used to estimate this, from survey evidence to dividend discount models.

For context, Box 2.3 below summarises Ofgem's approach to setting the TMR.



In the RIIO-2 final determinations for transmission and gas distribution networks and subsequent interactions (i.e. the ED2 draft and final determinations), Ofgem used the following approach for TMR estimation. Its final TMR range was from 6.25% to 6.75% (CPIH-real).

- 1 **Approaches:** Ofgem derived a range for the TMR using primarily the ex post approach—estimated as the geometric average of historic returns subjectively uplifted by a 1–2% premium, to bring it closer to the arithmetic average and to adjust for serial correlation. Ofgem also mentions the evidence from outturn world TMR data, professional forecasts, and other cross-checks.¹ It is not clear from Ofgem's decision how much weight was placed on each of the TMR methodologies considered.
- 2 **Treatment of inflation:** for RIIO-GD&T2, Ofgem used a CPI backcast for the 1949–88 period. In the RIIO-ED2 price control review process, once the new ONS CPIH back series spanning 1950 to 1988 was published, Ofgem set out that the new backcast was likely to be a more suitable inflation series to deflate historical equity returns than the historical RPI series and the CPI backcast.² However, Ofgem did not quantitatively take into account the ONS CPIH backcast series in the RIIO-ED2 decision and continued using the RIIO-GD&T2 estimates, which were based on the older CPI backcast. Ofgem stated that it was not persuaded to adjust the TMR estimate, because it does not 'place sole reliance on any one estimation approach because there is no perfect single source of information on TMR', including no perfect single estimate of historical inflation.³

In the RIIO-3 SSMC, Ofgem proposes to continue estimating the TMR based on the historical ex post approach and, in addition, to give weight to the historical ex ante approach, considering a range of 'appropriate timeframes, averaging methodologies and potential adjustments'.⁴ Ofgem has confirmed that the CPIH backcast is considered superior to the historical RPI series and the CPI backcast. It is not planning to place significant weight on forward-looking estimates.

Note: ² The CPIH data from 1988 is assumed to be outturn. However, the official CPIH data starts only in 2005. For the period from 1988 to 2004, the ONS models the historical series from 1988 to 2004 for CPIH by 'taking the existing estimates for the CPI for 1988 to 1996 and adding in indices for rates or Council Tax and rental equivalence'.

Source: Ofgem (2022), 'RIIO-ED2 Final Determination Finance Annex', 30 November. Ofgem (2023), 'Consultation - RIIO-3 Sector Specific Methodology Consultation – Finance Annex', 13 December, paras 3.49–3.59.

¹ For example, the use of Dividend Growth Models is outlined in Ofgem (2018), 'RIIO-2 Sector Specific Methodology Annex: Finance', 18 December, paras 3.72–3.76. ² ONS (2024), Consumer Prices Index including owner occupiers' housing costs (CPIH) historical series: (1988 to 2004), 14 December, <https://www.ons.gov.uk/economy/inflationandpriceindices/articles/consumerpricesindexincludingowneroccupiershousingcostshistoricalseries/1988to2004> (last accessed on 19 February 2024) ³ Ofgem (2022), 'RIIO-ED2 Final Determination Finance Annex', 30 November, para. 3.42. ⁴ Ofgem (2023), 'Consultation - RIIO-3 Sector Specific Methodology Consultation – Finance Annex', 13 December, para. 3.52.

As outlined above, Ofgem is planning to place some weight on both historical ex post and historical ex ante approaches for RIIO-3 allowances. In the rest of this section, we discuss which specification of the historical ex post approach we consider to be most appropriate (sections 2.2.1 and 2.2.2) and why we consider that only limited, if any, weight can be placed on the historical ex ante estimation method (section 2.2.3). We then assess how Ofgem has historically responded to changes in the interest rate environment (section 2.2.4), before concluding on the TMR range that we consider to be most appropriate (section 2.2.5). Finally, we assess compliance with the UKRN guidance (section 2.2.6).

2.2.1 The historical ex post TMR

The historical ex post (or just 'ex post') TMR approach is based on the assumption that the average historical return provides a reliable indicator of expected future returns.

This approach is adopted by many regulators in the UK. For instance, Ofgem, Ofcom, Ofwat (PR19) and the CAA used this methodology as the primary source of evidence to estimate the TMR in their most recent regulatory reviews.

To estimate the TMR using the ex post approach, one needs to average a series of historical returns. The Dimson, Marsh and Staunton (DMS) dataset provides a useful starting point to calculate this historical

average.⁶² However, as regulators in the UK are interested in real returns, it is necessary to combine the DMS data with a reliable measure of inflation to estimate the real historical returns. In addition, one needs to make a choice about which averaging method to use (i.e. geometric or arithmetic).

In the following sub-sections, we explain how we deflate the nominal return series and how we average the real returns to obtain a reliable measure of the TMR.

Treatment of inflation

As explained in a previous Oxera report in response to the UKRN consultation on the methodology for estimating the cost of capital for regulated companies,⁶³ we consider it most appropriate to deflate nominal historical returns using the CED series (for the period 1900–49) and the new backcast series for the CPIH (for the period 1950–88) if a backcast is used. The new backcast CPIH series addresses the most concerning errors found in the previously existing CPI backcast. The new CPIH backcast should therefore be used instead of the old CPI backcast when estimating historical returns in CPIH-real terms. For the period 1988–2022, the ONS has published reliable estimations of the CPIH inflation levels. Note that Ofgem did not quantitatively rely on the new CPIH backcast series in its latest determination in the RIIO-ED2 price control.⁶⁴ However, other regulators such as Ofwat have already incorporated the new series into their TMR estimation.

Averaging historical returns

As explained in our previous publication in response to the UKRN consultation,⁶⁵ there are two options to estimate the average TMR: by calculating the geometric mean, and by calculating the arithmetic mean. The geometric mean of any set of numbers is always lower than

⁶² Dimson, E., Marsh, P. and Staunton, M. (2023), 'Credit Suisse Global Investment Returns Yearbook 2023'.

⁶³ Oxera (2022), 'A review of the methodology used to estimate the allowed cost of equity for regulated companies', November, p. 19, <https://www.oxera.com/wp-content/uploads/2023/07/A-review-of-the-methodology-used-to-estimate.pdf> (last accessed on 24 January 2024).

⁶⁴ Ofgem stated that it was not persuaded to adjust the TMR estimate, because it does not 'place sole reliance on any one estimation approach because there is no perfect single source of information on TMR', including no perfect single estimate of historical inflation. Ofgem (2022), 'RIIO-ED2 Final Determination Finance Annex', 30 November, para. 3.42, <https://www.ofgem.gov.uk/sites/default/files/2022-11/RIIO-ED2%20Final%20Determinations%20Finance%20Annex.pdf> (last accessed on 22 February 2024).

⁶⁵ Oxera (2022), 'A review of the methodology used to estimate the allowed cost of equity for regulated companies', November, p. 22, <https://www.oxera.com/wp-content/uploads/2023/07/A-review-of-the-methodology-used-to-estimate.pdf> (last accessed on 5 February 2024).

the arithmetic mean unless all the numbers are equal (in which case the means are the same). For a series of returns, equality between the geometric and arithmetic means would occur only if there is no volatility at all (i.e. if returns are constant). While there is debate about which is the more appropriate averaging method in any given context, the academic literature is broadly supportive of adopting the arithmetic average for estimating the ERP to use when computing required equity returns for valuation and capital budgeting purposes.⁶⁶

This conclusion is consistent with the CMA decision in the PR19 redetermination, where the CMA stated that:⁶⁷

[...] in the absence of clear modelling of the regulator's decision, the most appropriate estimate to use is the arithmetic mean. [...]
On balance, we consider that using the arithmetic mean is preferable due to its simplicity and transparency, and also given that at the current time, there is no reason to conclude that one perspective, either that of the capital budgeter or of the portfolio investor, is 'correct'.

Finally, in order to determine a TMR estimate we rely on non-overlapping annual holding periods over the entire DMS series. Using non-overlapping holding periods relative to overlapping ones ensures no serial correlations in the returns. In our previous publication in response to the UKRN consultation,⁶⁸ we applied the Ljung-Box test to the DMS series assuming different non-overlapping holding periods.⁶⁹ The results show that, for each non-overlapping holding period (i.e. one-year, five-year, ten-year and 20-year), we do not find statistically significant serial correlation in the returns. In addition, with respect to the considered holding periods, using non-overlapping holding periods spanning multiple years comes with the disadvantage of significantly reducing the available datapoints leading to those estimates being susceptible to outliers.⁷⁰ This was the reason why Ofwat rejected the use of non-overlapping ten- and 20-year estimators in the PR24 Final Methodology.⁷¹

⁶⁶ Berk, J. and DeMarzo, P. (2024), *Corporate Finance*, Pearson, Global Edition, 6th edition, January, p. 310.

⁶⁷ CMA PR19 redetermination (2021), paras 9.326–9.328.

⁶⁸ Oxera (2022), 'A review of the methodology used to estimate the allowed cost of equity for regulated companies', November, p. 22, <https://www.oxera.com/wp-content/uploads/2023/07/A-review-of-the-methodology-used-to-estimate.pdf> (last accessed on 5 February 2024).

⁶⁹ The Ljung-Box test is a quantitative method that tests for autocorrelation at multiple lags jointly. Ljung, G.M. and Box, G.E.P. (1978), 'On a Measure of a Lack of Fit in Time Series Models', *Biometrika*, **65**:2, pp. 297–303.

⁷⁰ CMA PR19 redetermination (2021), para. 9.333.

⁷¹ Ofwat (2022), 'Final Methodology for PR24: Appendix 11 - Allowed Return on Capital', December, p. 26, https://www.ofwat.gov.uk/wp-content/uploads/2022/12/PR24_final_methodology_Appendix_11_Allowed_return.pdf (last accessed on 5 February 2024).

Hence, in the absence of serial correlation, using a non-overlapping one-year arithmetic average remains a more robust estimation methodology than using the geometric average as a basis and adjusting it upwards for the potential impact of serial correlation.⁷²

For comparison, in Table 2.7 below we show our ex post TMR estimate (i.e. the non-overlapping one-year arithmetic average) and Ofgem’s RIIO-2 TMR (which was derived primarily with reference to the geometric average of historical returns and the outdated CPI backcast series).⁷³

Table 2.7 The ex post TMR (CPIH-real)

Ofgem’s RIIO-2 range	6.25–6.75% (a mid-point of 6.50%)
1900–2022 arithmetic average real equity returns assuming a one-year holding period and using CPIH backcast inflation series for 1950–88	7.00%

Note: The update from the ONS affects only the data points between 1950 and 1988. To cover the pre-1950 period, we use Consumption Expenditure Deflator (CED) data published by the Bank of England in its Millennium database (Version 3.1). However, we note that this is an imperfect method as the CED is theoretically and empirically a closer proxy for RPI than CPI.
Source: Oxera analysis based on ONS, DMS and Bank of England data. Ofgem (2022), ‘RIIO-ED2 Final Determination Finance Annex’, 30 November, Table 13.

As Table 2.7 shows, from the above analysis, we have identified a point estimate for the TMR of **7.00%** (i.e. an arithmetic average of real equity returns assuming a one-year holding period and using CED data for the pre-1950 period, CPIH backcast inflation series for 1950–88 and ONS CPIH estimates for 1988 onwards).

⁷² If the geometric average is used as a starting point, this estimate needs to be uplifted to adjust for the impact of arithmetic averaging. While this impact can be quantified as half the variance of log returns, UK regulators have set this uplift between 1% and 2%, which, in addition to uplifting the geometric average to the arithmetic one, accounts for the assumed impact of serial correlation. We have not assessed the most appropriate way to adjust for serial correlation, given that we do not find it statistically significant in our analysis. See UKRN (2022), ‘UKRN guidance for regulators on the methodology for setting the cost of capital’, p. 18, https://ukrn.org.uk/app/uploads/2023/03/CoC-guidance_22.03.23.pdf (last accessed on 30 January 2024).
⁷³ In setting its TMR range, Ofgem considered a range of evidence such as the ex ante, the ex post and the data for World and World excluding US regions, and professional forecasts. It is not clear from Ofgem’s publications how much weight was placed on each of the TMR methodologies considered. Ofgem (2019), ‘RIIO-2 Sector Specific Methodology Decision – Finance’, Decision, 24 May, https://www.ofgem.gov.uk/sites/default/files/docs/2019/05/riio-2_sector_specific_methodology_decision_-_finance.pdf (last accessed on 5 February 2024); Ofgem (2020), ‘RIIO-2 Draft Determinations – Finance Annex’, Consultation, 9 July, https://www.ofgem.gov.uk/sites/default/files/docs/2020/07/draft_determinations_-_finance.pdf (last accessed on 5 February 2024).

2.2.2 Alternative historical ex post TMR estimators

There are a number of alternative ex post historical approaches to estimating the TMR aside from the simple, but robust, arithmetic average return.

The most commonly considered alternatives are the Blume estimator,⁷⁴ the Cooper estimator,⁷⁵ the Jacquier, Kane and Marcus (JKM) unbiased estimator, and the minimum mean squared error (MSE) estimator.⁷⁶ The Blume, JKM and MSE estimators apply a downward adjustment to the arithmetic average, which increases with longer holding periods. In contrast, the Cooper estimator adds an upward adjustment to the arithmetic average. The methodologies of each estimator are outlined in Appendix A1.

In the RIIO-3 SSMC, Ofgem additionally indicates that it will consider evidence on the following ex post TMR estimation methodologies:⁷⁷

- the arithmetic average of real returns over one-year and overlapping ten- and 20-year holding periods (AM);
- the arithmetic average of real returns over non-overlapping ten- and 20-year holding periods (non-overlapping AM);
- the geometric average of real returns assuming a one-year holding period with a geometric-to-arithmetic mean uplift (GM + uplift);⁷⁸
- the geometric average of real returns assuming a one-year holding period with a geometric-to-arithmetic mean uplift and an adjustment for serial correlation (GM + uplift + sc adj).

We apply all of these named ex post historical TMR estimation methodologies, and additionally include the arithmetic average over

⁷⁴ Blume, M.E. (1974), 'Unbiased Estimators of Long-Run Expected Rates of Return', *Journal of the American Statistical Association*, **69**:347, September, pp. 634–638.

⁷⁵ Cooper, I. (1996), 'Arithmetic versus geometric mean estimators: Setting discount rates for capital budgeting', *European Financial Management*, **2**:2, pp. 157–167. However, Ofgem does not consider the Cooper estimator in its RIIO-3 Sector Specific Methodology Consultation.

⁷⁶ Jacquier, E., Kane, A. and Marcus, A. (2005), 'Optimal estimation of the risk premium for the Long Run and Asset Allocation: A case of compounded estimation risk', *The Journal of Financial Econometrics*, **3**, December, pp. 37–55.

⁷⁷ Ofgem (2023), 'RIIO-3 Sector Specific Methodology Consultation-Finance Annex', 13 December, paras 3.55–3.56, <https://www.ofgem.gov.uk/sites/default/files/2023-12/RIIO-3%20SSMC%20Finance%20Annex.pdf> (last accessed on 16 January 2024).

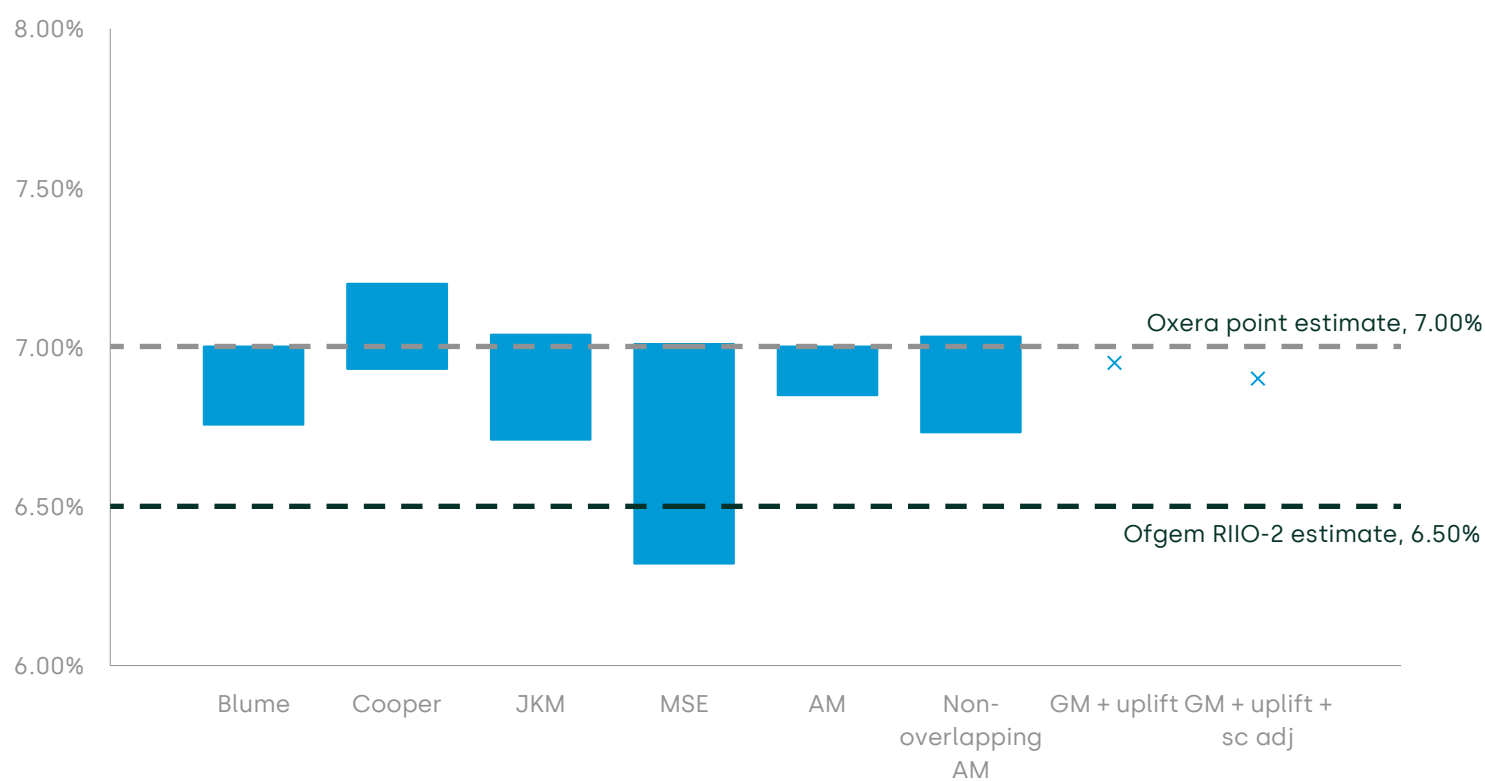
⁷⁸ Ofgem does not specify how it intends to calculate the uplift. We calculate this uplift as half the variance of log returns following the UKRN guidance. See UKRN (2022), 'UKRN guidance for regulators on the methodology for setting the cost of capital', p. 18, https://ukrn.org.uk/app/uploads/2023/03/CoC-guidance_22.03.23.pdf (last accessed on 30 January 2024).

overlapping five years. We then assess whether it is appropriate to put any weight on these estimates.

We note that we do not find a statistically significant serial correlation (see section 2.2.2 above) and therefore have not assessed the most appropriate way of adjusting for it. Nevertheless, one could calculate such an adjustment following the methodology that Ofwat used in its PR24 Final Methodology.⁷⁹ Doing so, we estimate this serial correlation adjustment to be 5bps.

The results are summarised in Figure 2.5, where the ranges of the Blume, Cooper, JKM and MSE estimators, as well as those of the arithmetic average and the non-overlapping arithmetic average, reflect the calculation of these estimators over a range of holding periods. All of the individual values are presented in Table 2.8.

Figure 2.5 Alternative ex post TMR estimators (CPIH-real)



⁷⁹ Ofwat calculates the serial correlation adjustment by deducting the difference between the one-year arithmetic average and the 20-year arithmetic average on overlapping samples. We point out that we do not assess the methodology used to calculate this adjustment in detail, as we deem the adjustment to be inapplicable based on our evidence. Ofwat (2022), 'Final Methodology for PR24: Appendix 11 - Allowed Return on Capital', December, p. 31, https://www.ofwat.gov.uk/wp-content/uploads/2022/12/PR24_final_methodology_Appendix_11_Allowed_return.pdf (last accessed on 5 February 2024).

Note: The methodologies for the Blume estimator, the Cooper estimator, the JKM estimator and the MSE estimator are detailed in Appendix A1. AM refers to the arithmetic mean over overlapping one-year, five-year, ten-year and 20-year holding periods. Non-overlapping AM refers to the arithmetic mean over non-overlapping ten- and 20-year periods. GM + uplift is the geometric mean assuming a one-year holding period with a geometric-to-arithmetic mean uplift of half the variance of log returns. GM + uplift + sc adj equals GM + uplift minus the serial correlation adjustment, estimated as the difference of one-year and 20-year holding period arithmetic returns. The ranges shown in the chart pertain to the ranges of TMR estimates for each estimator across one-, five-, ten- and 20-year holding periods, with the exception of the non-overlapping arithmetic mean, where only estimates for holding periods of ten and 20 years are included. Source: Oxera analysis based on data for the period 1900–2022 from Dimson, E., Marsh, P. and Staunton, M. (2023), 'Credit Suisse Global Investment Returns Yearbook 2023'.

Table 2.8 **Alternative ex post TMR estimators**

Holding period	One-year	Five-year	Ten-year	20-year
Blume Estimator	7.00%	6.82%	6.76%	6.77%
Cooper Estimator	7.03%	6.93%	6.98%	7.20%
JKM Estimator	7.04%	6.86%	6.72%	6.71%
MSE Estimator	7.01%	6.74%	6.51%	6.32%
AM ¹	7.00%	6.86%	6.85%	6.95%
Non-overlapping AM ²	n.a.	n.a.	6.73%	7.03%
GM + uplift ³	6.95%	n.a.	n.a.	n.a.
GM + uplift + sc adj ⁴	6.90%	n.a.	n.a.	n.a.

Note: The methodologies for the Blume estimator, the Cooper estimator, the JKM estimator and the MSE estimator are detailed in Appendix A1. ¹ AM is the arithmetic mean over overlapping holding periods. ² Non-overlapping AM refers to the arithmetic mean over non-overlapping periods. ³ GM + uplift is the geometric mean assuming a one-year holding period with a geometric-to-arithmetic mean uplift of half the variance of log returns. ⁴ GM + uplift + sc adj equals GM + uplift minus the serial correlation adjustment, estimated as the difference of one-year and 20-year holding period arithmetic returns. ³ Non-overlapping AM refers to the arithmetic mean over non-overlapping periods. Source: Oxera analysis based on data from Dimson, E., Marsh, P. and Staunton, M. (2023), 'Credit Suisse Global Investment Returns Yearbook 2023'.

As discussed in section 2.2.1, we deem neither the arithmetic average with longer than one-year holding periods nor the geometric average to be more appropriate than the one-year arithmetic average.

With regard to the Blume, Cooper and JKM estimators, the CMA noted in its final decision on the RIIO-2 appeals that it had considered and

rejected the use of all of them, also in favour of the simple arithmetic average:⁸⁰

[...] Considering a broader range of estimates, which the regulator has no particular reason to believe are more accurate than the arithmetic average and which fall either side of the arithmetic average, does not provide material additional information.

In conclusion, we have assessed a wide array of ex post TMR averaging techniques. However, as they do not add substantial informational content beyond the arithmetic mean, we retain our point estimate of 7.00%.

2.2.3 The historical ex ante TMR

While Ofgem is planning to place weight on the ex ante approach for its TMR range in RIIO-3 (see Box 2.3), as per our previous submissions,⁸¹ we do not consider the ex ante approach to be very informative, due to its subjective nature. We therefore account for this approach only in a limited capacity.

In general, ex ante approaches aim to separate the TMR into multiple components. However, given that decomposing the TMR (and the ERP) can involve many variables and result in many forms, it is a subjective exercise that requires one to choose which elements to include in the decomposition, and which to classify as 'unlikely to be repeatable'. Materially, there is no guarantee that a variable that exhibits 'unrepeatable' behaviour when included in the decomposition with another variable would exhibit the same behaviour in conjunction with a third and different variable.⁸²

Nevertheless, Ofgem proposes to employ two methodologies for an ex ante TMR estimate, which we discuss in this sub-section.⁸³

⁸⁰ Competition and Markets Authority (2021), 'Final determination Volume 2A: Joined Grounds: Cost of equity', 28 October, para. 5.266, https://assets.publishing.service.gov.uk/media/617fe5468fa8f52980d93209/ELMA_Final_Determination_Vol_2A_publication.pdf (last accessed on 24 January 2024).

⁸¹ Oxera (2022), 'A review of the methodology used to estimate the allowed cost of equity for regulated companies', November, <https://www.oxera.com/wp-content/uploads/2023/07/A-review-of-the-methodology-used-to-estimate.pdf> (last accessed on 31 January 2024).

⁸² See also Oxera (2022), 'A review of the methodology used to estimate the allowed cost of equity for regulated companies', November, p. 24, <https://www.oxera.com/wp-content/uploads/2023/07/A-review-of-the-methodology-used-to-estimate.pdf> (last accessed on 31 January 2024).

⁸³ Ofgem (2023), 'Consultation - RIIO-3 Sector Specific Methodology Consultation – Finance Annex', 13 December, para. 3.57, <https://www.ofgem.gov.uk/sites/default/files/2023-12/RIIO-3%20SSMC%20Finance%20Annex.pdf> (last accessed on 5 February 2024).

- the DMS decompositional approach;
- the Fama and French dividend growth model.

DMS decompositional approach

The DMS decompositional approach attempts to identify investors' reasonable expectations of returns by making adjustments to the historical series of returns. These adjustments try to identify one-off outcomes of good or bad 'luck', i.e. those that investors might not expect to be repeated in the future.

This approach (based on the DMS analysis) involves decomposing the ERP into the mean dividend yield, the growth rate of real dividends, the expansion of the price–dividend ratio, and the change in real exchange rate.

The adjustment to the derived TMR then arises from subjective adjustments to the average value of one or more of these components.

It is necessary to clarify the use of the term 'ex ante approach'. An estimate of the TMR today, i.e. the expected future return obtained using the simple historical mean return, can be described as 'ex ante' in the sense that the estimate applies to future return expectations. This should be clearly differentiated from the DMS decompositional methods, which instead try to assess whether the returns that investors were expecting in the past are well approximated by the historical mean.

In effect, the DMS decompositional approach attempts to substitute actual returns with predicted returns. While it is therefore applied to inform a forward-looking estimate, the sensitivity of input assumptions and degree of subjectivity involved make it less reliable than the historical average of actual returns.

We thus consider that this ex ante (decompositional) approach would be more appropriately labelled as an 'adjusted ex post approach', since it uses an adjusted historical data series to estimate the TMR. This should be contrasted against an actual ex ante approach, which would attempt to predict an event before it occurs.

In addition, it is worth noting that the DMS decompositional approach relies on the geometric mean dividend yield as a starting point,⁸⁴ which requires an uplift in order to convert it into an arithmetic average. As the level of this uplift is a point of debate, the approach would benefit from starting off directly with an arithmetic average. However, the necessary data to estimate the arithmetic average of the dividend yield is not provided by DMS. The lack of data availability is an additional limitation of the approach.

Despite our criticism of the DMS decompositional approach, we follow it in order to provide an ex ante TMR estimate. This approach is also consistent with regulatory precedent—it has been applied by the CMA in the PR19 water redetermination and by Ofwat in its PR24 Final Methodology.⁸⁵ While we use Ofwat's approach in its PR24 Final Methodology as a starting point, we critically assess it and apply the following adjustments.

- **Geometric-to-arithmetic mean conversion.** The CMA—and, building on its work, Ofwat—have used an uplift of 150bps to convert the geometric mean to an arithmetic mean. While this adjustment has been used in the DMS 2019 yearbook, it was originally estimated by DMS in 2007 and is, therefore, arguably dated.⁸⁶ Recalculating the uplift following the UKRN guidance as half the variance of log returns, as we do for some ex post historical TMR methodologies, leads to an updated geometric-to-arithmetic mean conversion of 166bps.⁸⁷
- **Serial correlation adjustment.** As we do not find statistically significant serial correlation in the returns, we drop the respective adjustment (see section 2.2.1 above). In addition, this approach aims to incorporate only expected elements of the ERP. It is disputable whether serial correlation is an expected element of the TMR and, hence, whether an adjustment for serial correlation would be appropriate even if there were statistically significant evidence for serial correlation.

⁸⁴ We describe the full methodology below.

⁸⁵ CMA PR19 redetermination (2021), para. 9.351; Ofwat (2022), 'Final Methodology for PR24: Appendix 11 - Allowed Return on Capital', December, p. 35, https://www.ofwat.gov.uk/wp-content/uploads/2022/12/PR24_final_methodology_Appendix_11_Allowed_return.pdf (last accessed on 5 February 2024)

⁸⁶ Dimson, E., Marsh, P. and Staunton, M. (2019), 'Credit Suisse Global Investment Returns Yearbook 2019', p. 37; Dimson, E., Marsh, P. and Staunton, M. (2007), 'The worldwide equity premium: a smaller puzzle', Chapter 11 of R. Mehra (ed.), *The Handbook of the Equity Risk Premium*.

⁸⁷ UKRN (2022), 'UKRN guidance for regulators on the methodology for setting the cost of capital', p. 18, https://ukrn.org.uk/app/uploads/2023/03/CoC-guidance_22.03.23.pdf (last accessed on 30 January 2024).

Table 2.9 shows all the steps that we took to calculate our ex ante TMR estimate of **6.53%** based on the DMS decompositional approach.

Table 2.9 Ex ante TMR, based on the DMS decompositional approach

	Formula	Value
Geometric mean dividend yield ¹	[A]	4.56%
Growth rate of real dividends ²	[B]	0.66%
Unadjusted ex ante TMR (geometric average)	[C] = [A] + [B]	5.22%
Geometric-to-arithmetic mean conversion ³	[D]	1.66%
Unadjusted ex ante TMR (arithmetic average)	[E] = [C] + [D]	6.88%
COLI–CED adjustment ⁴	[F]	-0.35%
Adjusted ex ante TMR (arithmetic average), CPIH-real	[G] = [E] + [F]	6.53%

Note: ¹ The geometric mean of the dividend yield is taken over the period 1900–2022.

³ The geometric-to-arithmetic mean conversion is calculated as half the variance of log returns based on the latest DMS data. ⁴ Pre-1947, DMS inflation figures are based on the Cost of Living Index (COLI) rather than the preferable Consumption Expenditure Deflator (CED). From 1947 onwards, DMS employ a composite CPI series.

Source: The table is based on Ofwat (2022), 'Final Methodology for PR24: Appendix 11 - Allowed Return on Capital', December, p. 35. ^{1,2,3} Dimson, E., Marsh, P. and Staunton, M. (2023), 'Credit Suisse Global Investment Returns Yearbook 2023'. CMA PR19 redetermination (2021), para. 9.358.

Fama and French dividend growth model

Similarly to the DMS decompositional approach, Fama and French argue that the average stock return can be split into the average dividend yield and the average rate of capital gain.⁸⁸ According to the authors, when assuming a stable price–dividend ratio, the compound rate of dividend growth approaches the compound rate of capital gain in long sample periods. They then define the expected stock return as the average dividend yield plus the average growth rate of dividends.

Hence, the Fama and French dividend growth model is conceptually similar to the DMS decompositional approach, which is why we consider that this approach can be more accurately described as an 'adjusted ex

⁸⁸ Fama, E.F. and French, K.R. (2002), 'The Equity Premium', *Journal of Finance*, **57**:2, April.

post' rather than a true 'ex ante' approach. Previously, the model has been calibrated using Barclays Equity Gilt Study data, for example by the CMA in the PR19 water redetermination and by Ofwat in the PR24 Final Methodology.⁸⁹ However, the Barclays Equity Gilt Study is available only to Barclays' clients and hence may not be available even for a purchase. Moreover, its applicability is subject to scrutiny in academia.⁹⁰ This lack of public and undisputed data is a barrier for verification and adds to our concern about whether ex ante TMR approaches are robustly estimated and tested. Finally, similar to the DMS compositional approach, the Fama and French dividend growth model relies on the geometric average of the dividend yield as a starting point, requiring an uplift to approximate it to the arithmetic average rather than using the arithmetic average directly.

Conclusion on ex ante TMR methodologies

Given the subjective nature of the adjustments made to derive the adjusted ex post TMR estimate and the limitations in verifying the results due to private datasets, we conclude that only limited weight, if any, should be placed on either of the ex ante approaches discussed in estimating the TMR. While their aim is to be forward-looking, the sensitivity of input assumptions and degree of subjectivity involved make them less reliable than the historical average of actual returns. Nevertheless, we apply an adjusted version of the DMS compositional approach to arrive at our ex ante TMR estimation of **6.53%**.

2.2.4 TMR determinations and gilt yields

In this sub-section, we consider what the increase in interest rates implies for the TMR. The UKRN guidance observes that UK regulators have assumed greater stability in the TMR than the ERP and that continuing with this approach is preferable.⁹¹ Ofgem also emphasises the importance of maintaining this approach throughout the price controls, to avoid overcompensating networks on average in the SSMC.⁹² The UKRN guidance also states that this 'does not imply that

⁸⁹ CMA PR19 redetermination (2021), para. 9.351; Ofwat (2022), 'Final Methodology for PR24: Appendix 11 - Allowed Return on Capital', December, p. 35, https://www.ofwat.gov.uk/wp-content/uploads/2022/12/PR24_final_methodology_Appendix_11_Allowed_return.pdf (last accessed on 5 February 2024).

⁹⁰ Gregory, A. (2023), 'The Expected Cost of Equity in the UK Revisited', 25 July, pp. 4–5, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4516096 (last accessed on 9 February 2024).

⁹¹ UKRN (2022), 'UKRN guidance for regulators on the methodology for setting the cost of capital', p.19, https://ukrn.org.uk/app/uploads/2023/03/CoC-guidance_22.03.23.pdf (last accessed on 5 January 2024).

⁹² Ofgem (2023), 'RIIO-3 Sector Specific Methodology Consultation-Finance Annex', 13 December, paras 3.47 and 3.84, <https://www.ofgem.gov.uk/sites/default/files/2023-12/RIIO-3%20SSMC%20Finance%20Annex.pdf> (last accessed on 9 February 2024).

regulators should simply pick the same fixed value for the TMR in each decision for all time, but that the TMR would be relatively less variable than the underlying RFR.⁹³ In 2018, we assessed a range of evidence and concluded that 'the RFR and ERP are negatively correlated, with the result that the total market return (TMR) is more stable than the ERP alone'.⁹⁴

In this context, we examine a time series of Ofgem's determinations of the TMR and the development of gilt yields, to see how stable the TMR allowance was across the determinations. Figure 2.6 shows the TMR in RPI-real terms, which are based on the determinations of the ERP and RFR, and 20-year gilt yields in nominal and real terms since 2005.

It is apparent from the figure that Ofgem responded to the decline in gilt yields in the period 2010–21 by reducing the TMR allowance (in RPI-real terms) from 7.25% in 2012 to 6.45% in 2014 and 5.45% in 2020.⁹⁵ We note an acknowledgment in RIIO-ED1 from Ofgem, that it reduced the cost of equity and TMR due to the changes in the market conditions:⁹⁶

[...] we are changing our methodology to give greater weight to the influence of current market conditions in relation to the equity market return, [...]

Since early 2022, the long-term gilt yields have sharply increased, reaching levels last seen during 2005–11. Given that the TMR was between 7.0% and 7.25% (RPI-real) during that period, a consistent regulatory approach over time implies an increase in the TMR assumption in RIIO-3, to take account of the higher interest rate

⁹³ UKRN (2022), 'UKRN guidance for regulators on the methodology for setting the cost of capital', p.19, https://ukrn.org.uk/app/uploads/2023/03/CoC-guidance_22.03.23.pdf (last accessed on 5 January 2024).

⁹⁴ Oxera (2018), 'The cost of equity for RIIO-2', 28 February, p. 2, https://www.oxera.com/wp-content/uploads/2018/07/ENA-cost-of-equity_2018-02-28.pdf.pdf (last accessed on 23 February 2024).

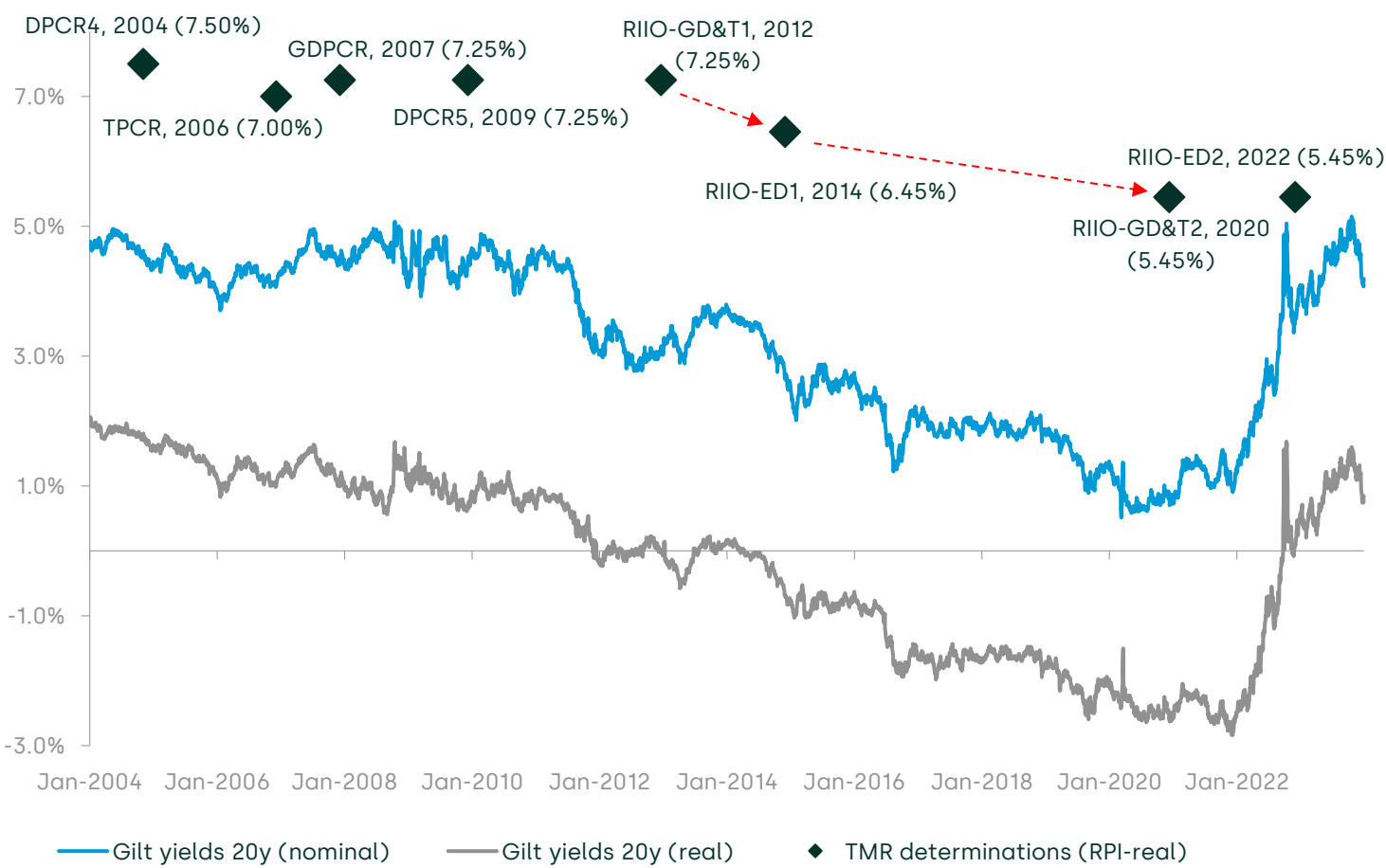
⁹⁵ We convert the RIIO-2 determinations that are originally in CPIH-real terms to RPI-real terms with a stylised RPI–CPIH wedge of 1%.

In the context of RIIO-ED1, Ofgem specifically states that they reduced the central reference cost of equity by 0.3% to 6.0% due to the low interest rate environment. See Ofgem (2014), 'Decision on our methodology for assessing the equity market return for the purpose of setting RIIO-ED1 price controls', p. 4, https://www.ofgem.gov.uk/sites/default/files/docs/2014/02/decision_on_equity_market_return_methodology_0.pdf (last accessed on 20 February 2024).

⁹⁶ Ofgem (2014), 'Decision on our methodology for assessing the equity market return for the purpose of setting RIIO-ED1 price controls', p. 4, https://www.ofgem.gov.uk/sites/default/files/docs/2014/02/decision_on_equity_market_return_methodology_0.pdf (last accessed on 20 February 2024).

environment. 7.0% and 7.25% RPI-real estimates would be equivalent to a TMR between 8.07% and 8.32% in CPIH-real terms.⁹⁷

Figure 2.6 TMR determinations and gilt yields (RPI-real)



Note: Where a TMR allowance is not specified in the determinations, it is based on the sum of RFR and ERP allowances. We convert the RIIO-2 determinations that are originally in CPIH-real terms to RPI-real terms with a stylised RPI–CPIH wedge of 1%.

Source: Oxera analysis based on BoE data and Ofgem determinations: Ofgem (2022), 'RIIO-ED2 Final Determinations Finance Annex', 30 November, pp. 38 and 48; Ofgem (2021), 'RIIO-2 Final Determinations – Finance Annex, 3 February, p. 49; Ofgem (2014), 'Final determinations for the slow-track electricity distribution companies Overview', 28 November, p. 40; Ofgem (2013), 'Strategy decision for the RIIO-ED1 electricity distribution price control Financial issues', 4 March, p. 15; Ofgem (2012), 'RIIO-GD1: Final Proposals Finance and uncertainty supporting document', 17 December, p. 22; Ofgem (2011), 'Decision on strategy for the next transmission and gas distribution price controls - RIIO-T1 and GD1 Financial issues', 31 March, p. 35; Ofgem (2006), 'Transmission Price Control Review: Final Proposals', 4 December, p. 55; Ofgem (2006), 'Transmission Price Control Review: Initial Proposals', 26 June, p. 42.

⁹⁷ Using a 1% stylised RPI–CPIH wedge.

Increasing the TMR assumption by 150bps from the 6.5% (CPIH-real) adopted in RIIO-2 to the approximately 8% (CPIH-real) adopted before the decline in gilt yields, would be 45% of the increase in gilt yields since the publication of RIIO-2 final determinations for GD&T networks.⁹⁸ In comparison, an increase of the TMR from 6.25–6.75% (CPIH-real) in RIIO-2 to the historical ex post estimate of 7.0% (CPIH-real) in RIIO-3, would be a relatively small change in the context of the observed increase in the UK government gilt yields (i.e. 15% of the increase). It would be a less significant change in the TMR compared with Ofgem's response to such changes in interest rates in the past,⁹⁹ while also being consistent with the view that the TMR is broadly stable.

2.2.5 Overall TMR estimate

Having discussed a significant number of approaches to estimate the TMR, we still deem the simple arithmetic average based on a one-year holding period of **7.00%** to be the most appropriate TMR estimate.

We do not put weight on longer holding periods due to the significant loss of data points. Moreover, we consider that an adjustment for serial correlation is inapplicable, as we do not find statistically significant evidence for its existence in the data, as explained in our previous work. In addition, using the geometric average as a starting point would require the potentially subjective exercise of calculating an uplift to bring it closer to the arithmetic average.

As for the discussed alternative ex post TMR estimators, in line with the CMA's position that they do not add information to the arithmetic average, we do not put weight on any of them.

Further, as we consistently reported in our previous work and added to in this report, the historical ex ante TMR approaches lack reliability, for instance due to their subjective nature and lack of public and undisputed data availability. Nevertheless, applying the DMS compositional approach leads to an ex ante TMR estimate of **6.53%**.

⁹⁸ The number 45% is estimated as 150bps dividend by 332bps, where the latter is an increase in real gilt yields from 8 December 2020, the date of the publication of the RIIO-GD&T2 final determinations, to 20 December 2023, the cut-off date for the analysis in this report. See Ofgem (2020), 'RIIO-2 Final Determinations – Core Document', 8 December, <https://www.ofgem.gov.uk/publications/riio-2-final-determinations-transmission-and-gas-distribution-network-companies-and-electricity-system-operator> (last accessed on 9 February 2024).

⁹⁹ For example, the change in TMR between RIIO-ED1 (6.45% RPI-real) and RIIO-GD&T2 (5.45% RPI-real) corresponded to 53% of the change in ILGs.

Lastly, examining a time series of Ofgem's determinations of the TMR and the development of gilt yields, we observe that Ofgem reduced the TMR allowance when gilt yields declined in the period of 2010–21. The level of the TMR allowance that corresponds to the level used by Ofgem at the time when gilt yields were comparable to the current market conditions is **8.0%**. Notwithstanding that Ofgem's stated intent is to maintain a stable TMR (e.g. this is how the ERP is estimated), we observe that in light of the significant increase in gilt yields since the RIIO-GD&T2 final determination, it would be consistent with Ofgem's previous practice of effectively varying the TMR through the cycle to set the TMR allowance higher than Ofgem's RIIO-2 range of 6.25–6.75%.

Overall, the historical evidence points towards an estimate of 7.0% as based on the one-year arithmetic average, which we consider to be the most robust and reliable technique to estimate the TMR. This estimate is also above Ofgem's RIIO-2 range, which would be consistent with Ofgem's historical practice of varying the TMR with changes in gilt yields. However, we acknowledge that there is uncertainty in deriving the true expected TMR. We therefore consider that it would be appropriate to add ± 50 bps around the estimate of 7.00%. The resulting range of **6.50–7.50%** encompasses almost all presented ex post approaches with the sole exception of the MSE estimator based on a 20-year holding period (6.32%). In addition, the range covers the ex ante TMR estimate (6.53%). We therefore consider the ± 50 bps range to be a pragmatic choice that balances the need to make a decision on a point estimate for the CoE against the underlying uncertainty around the estimate of the TMR—even with a dataset of 123 years, the 95% confidence interval is substantial at approximately 3%.

An increase of the TMR from Ofgem's 6.25–6.75% in RIIO-2 to our recommended range of 6.5–7.5% in RIIO-3 would be only a small change in the context of the observed increase in the UK government gilt yields as this would reflect only 15% of the increase in gilt yields since the RIIO-GD&T2 final determinations. It would also be significantly lower than c. 8.0% that Ofgem allowed in the past when gilt yields were at a similar level as they are now. Overall, our suggested range would be consistent with the UKRN's view that the TMR is 'less variable than the underlying RFR'.

As a final step, we cross-check the CoE estimate and consequently the TMR (and beta) ranges using the ARP–DRP framework in section 3. This analysis suggests that only the upper part of our TMR range produces a risk premium on assets that is sufficiently high compared with the risk premium observed in the bond market. Therefore, this cross-check further corroborates that the TMR needs to extend to 7.5%.

Using these results, we present the TMR range under the Ofgem and Oxera approaches in Table 2.10. We retain the Ofgem range as presented in its final determinations for all RIIO-2 price controls, to avoid having to predict the outcome of the judgement that Ofgem will exercise.

Table 2.10 Summary TMR estimation

	Ofgem low	Ofgem high	Oxera low	Oxera high
TMR estimation	6.25%	6.75%	6.5%	7.5%

Note: The cut-off date for the analysis is 1 September 2023.
Source: Oxera analysis. Ofgem (2022), 'RIIO-ED2 Final Determination Finance Annex', 30 November.

2.2.6 UKRN guidance

The UKRN guidance provides the following recommendations for the TMR estimation methodology.

- **Stability of TMR and ERP:** the guidance recommends estimating the ERP from the TMR and RFR (i.e. a stable TMR approach). However, the guidance highlights that the TMR does change over time, that ‘the TMR would be relatively less variable than the underlying RFR’, and that keeping the TMR unchanged is likely to overestimate the CoE at times of low interest rates and underestimate it at times of high interest rates.¹⁰⁰
- **Approaches:** the guidance recommends using primarily historical ex post and historical ex ante approaches. Historical ex post estimates are to be based on equity returns, and a few recommended methodological choices are described below. The UKRN does not provide specific guidance on how to apply the historical ex ante approach, or how much weight to put on each of the approaches, leaving it to the discretion of regulators.¹⁰¹
- **Inflation for the historical ex post approach:** the UKRN notes that no inflation measure is perfect. It recommends using the CED for 1900–47, CPI or CPIH backcast rather than RPI for 1947–88, and actual data for the periods from 1988.¹⁰²
- **Averaging for the historical ex post approach:** the UKRN allows significant flexibility in the implementation of averaging for the

¹⁰⁰ UKRN (2022), ‘UKRN guidance for regulators on the methodology for setting the cost of capital’, pp. 19–20, https://ukrn.org.uk/app/uploads/2023/03/CoC-guidance_22.03.23.pdf (last accessed on 9 January 2024).
¹⁰¹ Ibid., pp. 20–21.
¹⁰² Ibid., p. 20.

historical ex post approach. In particular, it allows for either an arithmetic average with overlapping or non-overlapping returns, or a geometric average with an uplift.¹⁰³

- **Range of estimates:** the UKRN comments on the recommended way to choose the TMR range based on the evidence, saying that the range should not be too wide. However, in the end, the UKRN leaves significant discretion to regulators in relation to this topic.¹⁰⁴

Our alignment with the UKRN guidance is described below.

Stability of the TMR and ERP: we follow the UKRN guidance in implying the ERP from the TMR and RFR. However, we also agree with the UKRN's understanding that keeping the TMR unchanged in a volatile interest rate environment may result in overestimating the CoE at times of low interest rates and underestimating it at times of high interest rates. While not suggesting to increase the TMR all the way up to the level of Ofgem's allowances it applied when market rates were at similar levels, we consider that an increase from the RIIO-2 level at least up to the level supported by the historical ex post evidence would be appropriate. This would be consistent with the principle, outlined in the UKRN guidance, that the TMR is expected to be less variable than the underlying RFR.

Approaches: as recommended by the UKRN, we provide the TMR estimates based on both historical ex post and ex ante TMR approaches. However, consistently with our previous submissions, we do not consider the historical ex ante approach to be reliable. Therefore, our final range is centred around the historical ex post approach.

Moreover, we note that the increase in interest rates is a significant change since the UKRN guidance was developed (rather than finalised and published), and the guidance, rationally, acknowledges that changes in market conditions constitute a case for revising regulatory practice.¹⁰⁵ Given this context, we consider that the change in market conditions is supportive of putting less, if any, weight on the historical ex ante TMR, which corresponds to a lower TMR estimate.

Inflation for the historical ex ante approach: we follow the UKRN recommendation to use the CED for 1900–47, CPI or CPIH backcast

¹⁰³ Ibid., p. 20.

¹⁰⁴ Ibid., p. 21.

¹⁰⁵ Ibid., p. 5.

rather than RPI for 1947–88, and actual data for the periods from 1988 to estimate our TMR range.

Averaging for the historical ex post approach: we use an arithmetic average of one-year non-overlapping returns, as it ensures no serial correlations in the returns. This approach is in line with the UKRN guidance.

2.3 Equity beta

The equity beta in the CAPM is a measure of how risky an equity investment is compared with the average market portfolio. An equity beta of one means that the stock return on average moves in line with the average market return. An equity beta between zero and one means that it tends to move in the same direction as the market return, but to a lesser magnitude (or greater magnitude, for a beta above one).

The beta is a measure of systematic risk in the CAPM. Although it is a forward-looking concept, in practice its estimation requires the interpretation of historical market data. This may lead to betas not capturing some risks that companies expect to face in the future and that may not yet have started affecting share prices, even for those estimates based on the shortest regression windows.

For a company listed on the stock market, estimating the equity beta using regression analysis is fairly straightforward because market data is publicly available.¹⁰⁶ For companies that are not listed, listed comparator companies that can be used as a proxy need to be identified. Observable equity betas for these comparators need to be adjusted to the level of gearing for which the CoE is being estimated, in order for them to be comparable (i.e. de-levering and re-levering needs to be undertaken consistently with reference to the target capital structure). This is how the beta allowance is calculated in Ofgem's price control.

Box 2.4 below summarises Ofgem's approach to estimating the equity beta component of the regulatory allowed CoE.

Box 2.4 Ofgem's approach to estimating the beta

¹⁰⁶ Since the market portfolio is unobservable, it is standard practice to proxy it using an equity index such as the FTSE All Share.



Ofgem uses the following set of assumptions to calculate the equity beta.

1. **Listed comparator set:** in RIIO-2, Ofgem placed weight on National Grid as well as GB water companies (Pennon Group, Severn Trent and United Utilities). Ofgem excluded SSE from the sample of comparator companies due to its proportion of non-regulated business activities. In RIIO-3, Ofgem expects to use a similar sample of comparators. However, it recognises that energy networks might face different systematic risks on a forward-looking basis, and is open to attributing different weights to RIIO-2 comparators and/or considering additional comparators.
2. **Frequency of data:** in RIIO-2, Ofgem estimated the beta with reference to daily returns. In the RIIO-3 SSMC, Ofgem mentions that it may consider a range of frequencies.
3. **Estimation period:** in RIIO-2, Ofgem used 2Y, 5Y and 10Y estimation windows to calculate the raw equity betas for comparator companies. In addition to looking at spot figures, Ofgem presented 2Y, 5Y and 10Y averages of the rolling beta estimates.¹ For RIIO-3, Ofgem intends to consider a range of timeframes for beta estimation.
4. **Gearing and debt beta:** in RIIO-2, Ofgem used the enterprise value of gearing as the working definition of gearing for de-levering raw betas,² using the Harris–Pringle formula. It used a debt beta estimate of 0.075. Ofgem intends to use the same formula for de-levering in RIIO-3, but does not comment on the intended approach to the assessment, or on the level of the debt beta.
5. It is not clear how Ofgem derives its **range and point estimate** with reference to its preferred comparator sample as part of the RIIO-2 decision. As part of the CMA RIIO-T2 appeals, it was explained that Ofgem's range was derived with reference to:⁴
 - a. National Grid's 10Y beta estimates; and
 - b. an estimation based on 70% weight on the pool of National Grid's betas and 30% weight on the pool of water betas.

For RIIO-3, Ofgem may change this approach, and even allow for the possibility of setting different betas for different sectors.

Note: ¹ Ofgem did not present 10Y averages of 10Y rolling betas. ² The enterprise value of gearing is computed as net debt divided by market capitalisation plus net debt. Ofgem presents both the book value of debt and the market value of debt in its tables.

Source: ³ Competition and Markets Authority (2022), 'Final determination Volume 2A: Joined Grounds: Cost of equity', 28 October, pp. 176–179.

⁴ Competition and Markets Authority (2022), 'Final determination Volume 2A: Joined Grounds: Cost of equity', 28 October, para. 5.338. ⁵ Ofgem (2023), 'RIIO-3 Sector Specific Methodology Consultation – Finance Annex', 13 December, paras 3.73–3.75.

In the next sub-sections, we explore the practical issues involved in beta estimation to develop an estimated range for RIIO-3. These include:

- comparator selection;
- data frequency and the timeframe of analysis;
- de- and re-gearing of betas;
- the level of the debt beta.

We set out a methodological discussion in relation to these issues in sub-sections 2.3.1 and 2.3.2, and then present beta estimates in sub-section 2.3.3. We outline the alignment of our preferred approach with the UKRN guidance in sub-section 2.3.4.

2.3.1 Comparator selection

As outlined in Box 2.4, Ofgem calculates raw equity betas starting from a sample of four companies: National Grid, Pennon, Severn Trent and United Utilities. The only 'pure-play' energy company in the sample is National Grid, which makes it a good comparator for the notional energy company that Ofgem is trying to regulate. However, even with the National Grid beta, it is not possible to observe a disaggregated pure-play beta for a UK regulated energy network, given that a large proportion of National Grid's business over the period of analysis has originated outside the UK, including US operations.¹⁰⁷

¹⁰⁷ For example, based on data from Bloomberg, National Grid recorded approximately 55% of revenues in the USA in FY2022.

In previous submissions,¹⁰⁸ we explained that, given the lack of listed pure-play energy network comparators in the UK, it would be appropriate to include other European comparators to generate an adequately sized representative sample. We further noted that the goal of an asset beta is to capture asset risk, and it is not entirely clear why the asset risk between UK and other European energy networks would be seen as less similar than the risk of two different industries in the same country, such as UK water and energy networks. We compared these risks in another submission.¹⁰⁹

Consistent with previous submissions, we add five listed European energy network comparators to the sample: Enagas, Italgas, Red Eléctrica, Snam and Terna. This sample is the result of a filtering process that excludes companies based on a range of factors, such as those relating to the percentage of regulated activities, data availability, and liquidity.¹¹⁰

The comparator sample is detailed in the table below.

Table 2.11 Betas comparator sample

Company name	Sector	Country
Ofgem's sample		

¹⁰⁸ Oxera (2020), 'The cost of equity for RIIO-2–Q3 2020 update', <https://www.northerngasnetworks.co.uk/wp-content/uploads/2020/09/CoE-Oxera.pdf> (last accessed on 16 January 2024).

¹⁰⁹ Oxera (2022), 'Assessing the risks of GB energy networks', 22 March, <https://ssenfuture.co.uk/wp-content/uploads/2022/08/Finance-Annex-K-Assessing-the-risks-of-GB-energy-networks-by-OXERA.pdf> (last accessed on 16 January 2024). We also observed in our previous submissions that Ofgem is disproportionately reliant on water companies to estimate the beta of energy networks. The risks associated with the regulatory regime of the water sector in the UK differ from those affecting energy networks. Notwithstanding that there are similarities in the models of economic regulation and regimes for the two sectors, one important difference is that, in the water sector, there is a process for redeterminations (by the CMA) rather than an appellate regime, which we assessed as leading to lower risk for the water networks. In addition, we previously found that the evidence from yield spreads suggested that UK water networks have lower asset risk than energy networks. See Oxera (2022), 'Cost of equity in RIIO-ED2 Draft Determinations', 25 August, section 4.1, <https://www.ofgem.gov.uk/publications/riio-ed2-draft-determinations> (last accessed on 16 January 2024), and associated Response Documents contained therein.

¹¹⁰ Note that REN and Elia have been the subject of concerns as regards their level of liquidity, when considering the sample for RIIO-2. In the Oxera CoE ED2 report (2022), we explained that Oxera's methodology was specifically designed to screen out illiquid firms because illiquidity creates estimation problems when calculating the beta. In addition, we show that regimes under which Elia and REN operated were associated with lower risk than RIIO-2, and hence those companies should be excluded from the comparator sample. For more information, see Oxera (2022), 'Cost of equity in RIIO-ED2 Draft Determinations', 25 August, <https://www.ofgem.gov.uk/publications/riio-ed2-draft-determinations> (last accessed on 16 January 2024), and associated Response Documents contained therein.

Company name	Sector	Country
National Grid	Energy	UK
United Utilities	Water	UK
Severn Trent	Water	UK
Pennon	Water	UK

Oxera's additions

Enagas	Energy	Spain
Red Eléctrica	Energy	Spain
Italgas	Energy	Italy
Snam	Energy	Italy
Terna	Energy	Italy

Source: Oxera.

2.3.2 Data frequency, timeframe and index selection

Equity betas can be estimated using daily, weekly or monthly observations. In the RIIO-2 decision, Ofgem estimated the raw equity betas using daily stock returns, although in the RIIO-3 SSMC it mentioned that it could consider a range of frequencies in RIIO-3.

Ofgem uses a 2Y, 5Y and 10Y estimation window to run the regressions. If equal weight is placed on the estimates of different timeframes, recent observations are accounted for multiple times within the overall beta estimate. However, many UK regulators, including Ofgem and the CMA, use this approach.¹¹¹ In this report, we also account for evidence from all these estimation windows.

¹¹¹ In the PR19 redetermination, the CMA employed two-, five-, and ten-year windows to estimate the equity beta. However, in its final determinations for RIIO-2 appeals, it cautioned against giving equal weight to these periods since recent data would be included in all three periods, stating that it did not consider that using a mix of two- and five-year timeframes was better than using a ten-year timeframe. Ofgem uses a wide range of estimation windows in RIIO-2, but states that it places more weight on the ten-year estimation window or the ten-year averages of the smaller windows. Ofwat, in its PR24 Final Methodology, states that it will use a range of estimation windows, including one-, two-, five- and ten-year periods, but that it prefers, and places more weight on, betas with longer estimation windows and longer averaging periods. See Competition and Markets Authority (2021), 'Final determination Volume 2A: Joined Grounds: Cost of equity', 28 October, para. 5.489, https://assets.publishing.service.gov.uk/media/617fe5468fa8f52980d93209/ELMA_Final_Determination_Vol_2A_publication.pdf (last accessed on 5 February 2024); Ofgem (2021), 'RIIO-2 Final

Ofgem also presents, and ultimately relies on when deriving its range, averages of rolling estimations. By doing this, Ofgem accounts for a longer period of data than relying only on spot beta estimates. The key effect of relying on rolling averages of betas is to place greater weight on data within the middle of the estimation period. Therefore, if beta estimates are not stable, the estimation will be biased downwards or upwards, indicating that the use of spot estimates would be more reliable in seeking to examine data relating to a specific period—for example, a two-year spot estimate would use data from only the preceding two years. However, rolling averages are also often used by UK regulators, including Ofgem and the CMA.¹¹² In this report, we present the evidence of the rolling averages of betas.

Another consideration when estimating the equity beta is whether to use a domestic, regional or global market benchmark index. This decision depends on how well the individual capital markets are assumed to be integrated, and what the relevant market portfolio for the marginal investor in the stock is—i.e. the equity market index that an investor will typically use to benchmark the performance of an investment in a given company. Assuming that investors will diversify their portfolios within the relevant currency zone, the use of a currency-specific index that matches the currency in which each company's shares are traded is preferred. Therefore, we have calculated the raw equity betas by regressing each company's returns on the largest available local-currency index—for example, for the UK we use the FTSE All-Share, and for Europe, we use the Euro Stoxx Total Market Index. Ofgem also uses the FTSE All-Share for the UK comparators (and does not estimate betas for other European comparators).¹¹³

2.3.3 Overall asset beta estimate

Table 2.12 below summarises the estimated asset betas for the sample of companies in our peer group, based on the methodology outlined in the sections above. Consistent with Ofgem's debt beta point estimate in

Determinations – Finance Annex (Revised)', 3 February, para. 3.74, https://www.ofgem.gov.uk/sites/default/files/docs/2021/02/final_determinations_-_finance_annex_revised_002.pdf (last accessed on 5 February 2024); Ofwat (2022), 'Final Methodology for PR24: Appendix 11 - Allowed Return on Capital', December, p. 9, https://www.ofwat.gov.uk/wp-content/uploads/2022/12/PR24_final_methodology_Appendix_11_Allowed_return.pdf (last accessed on 5 February 2024).

¹¹² In the RIIO-2 appeals and the PR19 redetermination, the CMA concluded that it supported the use of rolling averages, since this approach is a standard tool in regulatory analysis and provides insight into how betas have changed over time. See Competition and Markets Authority (2021), 'Final determination Volume 2A: Joined Grounds: Cost of equity', 28 October, para. 5.518; CMA PR19 redetermination (2021), para. 9.473.

¹¹³ Ofgem (2018), 'RIIO-2 Sector Specific Methodology Annex: Finance', para. 3.87, https://www.ofgem.gov.uk/sites/default/files/docs/2018/12/riio-2_finance_annex.pdf (last accessed on 8 February 2024).

RIIO-2,¹¹⁴ we use a debt beta of 0.075 to de-lever the raw equity betas. We also use the book value of debt for simplicity. Note that in this report we focus on the evidence suggested by comparators' betas, as commenting on forward-looking sector-specific risks is outside of our scope.

Table 2.12 Summary of asset betas for the comparator sample

Regression window	Averaging period	National Grid	Average water UK	Average Europe 70% National Grid + 30% Water
2-year	Spot	0.29	0.32	0.28
	2 years	0.29	0.30	0.28
	5 years	0.34	0.31	0.35
	10 years	0.37	0.35	0.38
5-year	Spot	0.33	0.32	0.35
	2 years	0.35	0.31	0.35
	5 years	0.37	0.33	0.39
	10 years	0.36	0.34	0.39
10-year	Spot	0.36	0.34	0.38
	2 years	0.37	0.34	0.38
	5 years	0.36	0.33	0.39

Note: Gearing is calculated using the book value of debt. The cut-off date is 20 December 2023.

Source: Oxera analysis based on Bloomberg data.

We recognise that there is a degree of discretion in selecting a range and a point estimate based on the comparators' betas. We observe that there is a large range of two-, five- and ten-year estimates when looking at the averages for National Grid, UK water and European energy comparators, as shown in the table above—i.e. from 0.28 to 0.39. The wider range that is observed in the market data is driven by the significant volatility in betas for utilities during the COVID-19 pandemic period and following the Ukraine crisis. Although this range is formed based on our overall sample, we note that Ofgem has not included the

¹¹⁴ Ofgem (2022), 'RIIO-ED2 Final Determination Finance Annex', 30 November, Table 12, <https://www.ofgem.gov.uk/sites/default/files/2022-11/RIIO-ED2%20Final%20Determinations%20Finance%20Annex.pdf> (last accessed on 5 February 2024).

European network betas in its sample that underpinned the RIIO-2 estimate. Therefore, although we continue to consider the betas of European energy networks as informative and relevant, we also report the range without them, which is from 0.29 to 0.37—i.e. marginally narrower but still wide.

We also observe that there is a statistical anomaly as regards the estimation of betas for a sample with below-market-average risk (i.e. betas that are less than one). As we have discussed in our previous reports, empirical observations indicate that the difference in realised returns between low- and high-beta stocks is lower than anticipated by CAPM predictions, and regression results from a sample of low-beta stocks will exhibit downward bias.¹¹⁵ Since the comparator companies used to determine the asset beta of regulated companies in the UK typically have equity betas lower than one, adopting an asset beta estimate in the top half of the estimated asset beta range would provide some offset to this downward bias. This is discussed further towards the end of this section.

For all the RIIO-2 price controls (i.e. RIIO-GD2&T2 and subsequently RIIO-ED2), Ofgem adopted an asset beta point estimate of 0.349.¹¹⁶ Specifically, it did not update its estimate between the RIIO-GD&T2 controls and the RIIO-ED2 control, as it considered that there had not been material differences in the risks of GD&T relative to ED networks, or material changes in market data between the two price control decisions.¹¹⁷

In terms of the changes in risks since RIIO-2, there is no reason to expect that the risk of energy networks will have decreased in RIIO-3, either in absolute terms or relative to the wider economy. In fact, with reference to Ofgem's acknowledgement of the 'macro developments' underpinning the industry in the lead-up to RIIO-3 and beyond, it is more reasonable to expect that risks have increased and are expected to increase further on a forward-looking basis: for electricity networks, largely due to their expected expansion; while for gas networks, due to the uncertainty on the future of gas and the asset stranding risk.

¹¹⁵ Oxera (2022), 'A review of the methodology used to estimate the allowed cost of equity for regulated companies — Response to the UKRN consultation', November, p. 14, <https://www.oxera.com/wp-content/uploads/2023/07/A-review-of-the-methodology-used-to-estimate.pdf> (last accessed on 9 February 2024).

¹¹⁶ Ofgem (2021), 'RIIO-2 Final Determinations – Finance Annex (REVISED)', p. 24, https://www.ofgem.gov.uk/sites/default/files/docs/2021/02/final_determinations_-_finance_annex_revised_002.pdf (last accessed on 16 January 2024)

¹¹⁷ Ofgem (2022), 'Consultation - RIIO-ED2 Draft Determinations – Finance Annex', 29 June, para. 3.41, <https://www.ofgem.gov.uk/sites/default/files/2022-06/RIIO-ED2%20Draft%20Determinations%20Finance%20Annex.pdf> (last accessed on 15 January 2024).

Specifically, Ofgem has acknowledged some increasing risks and uncertainties in its RIIO-3 SSMC. For example, Ofgem notes that network companies need to manage increasing risks and proactively improve resilience due to climate change and more extreme and frequent severe weather events,¹¹⁸ the increased threat of cyber-attacks on their network and information systems,¹¹⁹ and asset stranding risks.¹²⁰ Accordingly, strong evidence would be needed for Ofgem to assume a lower beta in RIIO-3 than in the RIIO-2 price controls from the point of view of risk evolution. However, detailed considerations of forward-looking risks and quantitative implications of those are outside of the scope of our work.

As for the market data development, Ofgem's RIIO-2 estimation method leads to a very similar result based on the latest data. As presented in Box 2.4, Ofgem's RIIO-2 range was derived with reference to all three of NG's 10Y beta estimates and all the '70% National Grid + 30% Water' estimates across the estimation and the rolling average windows. The average of all the '70% National Grid + 30% Water' beta estimates is 0.339, while the average of NG's 10Y asset betas is 0.365. The average of 0.339 and 0.365 is, in turn, 0.352, which is similar to the mid-point (0.349) of Ofgem's RIIO-2 asset beta range (0.323–0.373).

As a result—and consistent with Ofgem's own considerations from the ED2 price control—there appears to be no reason to reduce the RIIO-2 asset beta estimate and, if anything, there may be reasons to increase the regulatory allowed beta due to increasing risks of energy networks, which should be considered separately. We note that Ofgem's RIIO-2 range (0.323–0.373) is within our wider range of evidence (0.28–0.39).¹²¹

We also observe that, empirically, choosing a point estimate or narrowing the range closer to its upper bound would have the same effect as putting more weight on longer-term estimates (e.g. 10Y betas), as Ofgem did in RIIO-2, since the longer-term estimates inform the upper bound of the overall range. As we pointed out in previous reports, betas covering long-term historical data, such as ten-year betas, have a disadvantage in terms of including old data points that may not be as representative of current business activities and thus type of risk

¹¹⁸ Ofgem (2023), 'RIIO-3 Sector Specific Methodology Consultation - Overview Document', 13 December, paras 2.21–2.22 and 6.152–6.153, <https://www.ofgem.gov.uk/sites/default/files/2023-12/RIIO-3%20SSMC%20Overview%20Document.pdf> (last accessed on 5 February 2024).

¹¹⁹ Ibid., para. 2.24.

¹²⁰ Ibid., para. 2.38.

¹²¹ Although arithmetically the mid-point between 0.323 and 0.373 is 0.348, Ofgem's point estimate in RIIO-2 was 0.349. We assume that the discrepancy arises due to rounding, and consider 0.349 to be a more accurate estimate.

exposure of the companies.¹²² However, longer-term estimation windows also offer some advantages in the context of the beta estimation exercise for the RIIO-3 period specifically. The CMA notes in its final decision on the RIIO-2 appeals that:

- considering all timeframes (i.e. 2Y, 5Y and 10Y) equally would place unequal weight on the short-term data that would be included in all three time periods;¹²³
- taking a longer estimation window ensures that large fluctuations in the beta can be avoided;¹²⁴
- a longer estimation window for the beta of National Grid includes Cadent's gas activities as well as National Grid's ongoing business activities.¹²⁵

In relation to the first point, putting more weight on ten-year betas indeed has an advantage of potentially counterbalancing a disproportionate weight on the short-term data due to the multiple overlapping regression windows.

As for the second point, we agree that there may be value in reducing estimation noise and improving stability of the estimates between price controls when using longer-term betas.

Finally, the third observation has gained more prominence for RIIO-3. National Grid has gradually divested some of its gas assets, with the sale of its stakes in Cadent taking place in 2017 and 2019 and National Gas Transmission (NGT) in 2023.¹²⁶ By our cut-off date of 20 December 2023, only 10Y betas materially capture National Grid returns data with Cadent. By the time of the RIIO-3 final determinations, which will be in December 2025, two-year betas will also have dropped the observations reflecting a time when National Grid had a greater share in the NGT

¹²² Oxera (2018), 'The cost of equity for RIIO-2', 28 February, pp. 39–40, https://www.oxera.com/wp-content/uploads/2018/07/ENA-cost-of-equity_2018-02-28.pdf.pdf (last accessed on 15 January 2015).

¹²³ Competition and Markets Authority (2021), 'Final determination Volume 2A: Joined Grounds: Cost of equity', 28 October, para. 5.489, https://assets.publishing.service.gov.uk/media/617fe5468fa8f52980d93209/ELMA_Final_Determination_Vol_2A_publication.pdf (last accessed on 5 February 2024).

¹²⁴ Ibid., para. 5.491.

¹²⁵ Ibid., para. 5.491.

¹²⁶ National Grid (2016), 'Sale of majority interest in National Grid Gas Distribution Proposed one-off £4 billion return of capital to shareholders', 8 December, <https://www.nationalgrid.com/document/138686/download> (last accessed on 16 January 2024); National Grid (2019), 'Completion of the sale of remaining 39% interest in Cadent', 28 June, <https://www.nationalgrid.com/document/137521/download> (last accessed on 16 January 2024); National Grid (2023), 'Completion of sale of majority interest in NGGT and Metering', 31 January, <https://www.nationalgrid.com/completion-sale-nggt-and-metering> (last accessed on 16 January 2024).

assets' ownership. Therefore, longer-term estimates of National Grid's beta would better represent both gas and electricity asset risk.¹²⁷

Overall, these considerations lend more weight to 10Y betas relative to shorter-term ones, such as two-year betas. The same reasons apply to giving weight to the rolling averages, even though they have their drawbacks. Importantly, both would be in line with recent regulatory practice and CMA decisions, as discussed above.

In addition to placing greater weight on ten-year estimates, there can be other statistical reasons to set an estimate closer to the upper end of the evidence range. There has been a debate about whether the single-factor CAPM, which relies solely on the market beta, presents challenges in accurately predicting market returns for stocks, especially for low-beta stocks such as regulated utilities. This criticism, which is referred to as 'low-beta anomaly', provides evidence that low-beta stocks consistently outperform CAPM-estimated market returns. This was explored, for example, by Haugen et al. in 1972, and was further investigated in a 2013 study by Asness et al. on the US stock market.¹²⁸ Further research on this subject offers different explanations for the low-beta anomaly, such as non-linearity of factor premia, exposure to other factors such as size, value and profitability, micro and macro components such as country and industry risk, and borrowing/leverage constraints.¹²⁹ These studies find that, by controlling for these factors, the low-beta anomaly can be explained. However, considering that Ofgem's methodology uses a single-factor CAPM, we see the need to address the anomaly as another reason, consistent with our previous

¹²⁷ The gas risk information within the long-term National Grid beta is historical. Therefore, recent trends need to be assessed separately, and they are not covered by the 'baseline' beta estimated in this report.

¹²⁸ Haugen, R.A. and Heins, A.J. (1972), 'On the Evidence Supporting the Existence of Risk Premiums in the Capital Market', 1 December, p. 30, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1783797 (last accessed on 2 February 2024); Asness, C., Moskowitz, T.J. and Pedersen, L.H. (2013), 'Value and momentum everywhere', June, <https://pages.stern.nyu.edu/~lpedersen/papers/ValMomEverywhere.pdf> (last accessed on 2 February 2024).

¹²⁹ Fama, E.F. and French, K.R. (2016), 'Dissecting anomalies with a five-factor model', August, p. 23, <https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=99cee66ee68a65aeb67f97c1e224103cff0df208> (last accessed on 8 February 2024); Wright, S., Burns, P., Mason, R. and Pickford, D. (2018), 'Estimating the cost of capital for implementation of price controls by UK Regulators', p. 102, <https://ukrn.org.uk/app/uploads/2018/06/2018-CoE-Study.pdf> (last accessed on 2 February 2024); Baker, M., Bradley, B. and Taliaferro, R. (2014), 'The low-risk anomaly: A decomposition into micro and macro effects', pp. 9–24, https://dash.harvard.edu/bitstream/handle/1/11130436/bakerm%2cbradley%2ctaliaferro_low-beta_FINAL-Decomposition-of-Low%20-Risk.pdf?sequence=1&isAllowed=y (last accessed on 2 February 2024); Frazzini, A. and Pedersen, L.H. (2014), 'Betting against beta', p. 20, <http://docs.lhpedersen.com/BettingAgainstBeta.pdf> (last accessed on 8 February 2024).

recommendations,¹³⁰ to use betas towards the higher end of the proposed range.

To summarise, we consider that Ofgem's RIIO-2 beta range is appropriate for baseline beta, before accounting for forward-looking RIIO-3 risks, for the following reasons:

- an overall range of beta estimates based on a range of regression windows and rolling averages applied to National Grid, UK water networks and other European comparators will be wide, and there will be a need for judgement to narrow down that range;
- if Ofgem's RIIO-2 methodology is applied to the latest market data, a similar estimate is observed;
- Ofgem, Ofwat and the CMA have all previously expressed a preference for longer-term beta approaches that point to a similar estimate;
- we agree with the reasons behind regulatory support for longer-term beta estimates, before accounting for the forward-looking level of risk, in the specific context of RIIO-3;
- an allowance towards the upper end of the range is consistent with the need to address the low-beta anomaly.

Having considered the reasons outlined above, we conclude that Ofgem's asset beta range for RIIO-2, which is also consistent with putting more weight on longer-term betas, is an appropriate indicator for narrowing our wider asset beta range from 0.28–0.39 to 0.323–0.373, with a mid-point of 0.349, for the beta that does not separately account for forward-looking risks. We assume the same range for both the Ofgem and Oxera asset beta estimates for RIIO-3.¹³¹

Table 2.13 below summarises the range of estimates.

Table 2.13 Summary of the asset beta estimates (before accounting for forward-looking risks)

	Ofgem low	Ofgem high	Oxera low	Oxera high
Asset beta	0.323	0.373	0.323	0.373

¹³⁰ Oxera (2022), 'A review of the methodology used to estimate the allowed cost of equity for regulated companies – Response to the UKRN consultation', November, p. 14, <https://www.oxera.com/wp-content/uploads/2023/07/A-review-of-the-methodology-used-to-estimate.pdf> (last accessed on 2 February 2024).

¹³¹ Although arithmetically the mid-point between 0.323 and 0.373 is 0.348, Ofgem's point estimate in RIIO-2 was 0.349. We assume that the discrepancy arises due to rounding, and consider 0.349 to be a more accurate estimate.

Note: The cut-off date for the analysis is 20 December 2023. The asset betas are calculated using a 0.075 debt beta assumption. The betas do not separately account for forward-looking risks.
Source: Oxera analysis.

We have re-levered the asset beta numbers identified above based on a notional level of gearing of 60% and the debt beta of 0.075, using the following Harris–Pringle formula.¹³²

$$\beta_{equity\ re-levered} = \frac{\beta_{asset} - \beta_{debt} * g_{notional}}{1 - g_{notional}}$$

The table below summarises the results of the re-levering process.

Table 2.14 Summary of the re-levered equity betas at 60% notional gearing and 0.075 debt beta (before accounting for forward-looking risks)

	Ofgem low	Ofgem high	Oxera low	Oxera high
Re-levered equity beta	0.70	0.82	0.70	0.82

Note: The cut-off date for the analysis is 20 December 2023. The betas do not separately account for forward-looking risks.
Source: Oxera analysis.

2.3.4 UKRN guidance

The UKRN guidance provides the following recommendations for the beta estimation.

- **Overall approach:** the UKRN recommends ordinary least squares (OLS) as the standard regression technique, using the most diversified index in a single currency rather than the world index.¹³³
- **Comparator set:** the guidance leaves the choice of the comparator set to regulatory discretion, given that the guidance is cross-sectoral. The most relevant UK comparator companies

¹³² We use the same level of debt beta as that identified by Ofgem in the RIIO-2 final determinations. Ofgem (2022), 'RIIO-ED2 Draft Determination – Finance Annex', 29 July, Table 11, <https://www.ofgem.gov.uk/sites/default/files/2022-06/RIIO-ED2%20Draft%20Determinations%20Finance%20Annex.pdf> (last accessed on 5 February 2024).
¹³³ UKRN (2022), 'UKRN guidance for regulators on the methodology for setting the cost of capital', pp. 23 and 25, https://ukrn.org.uk/app/uploads/2023/03/CoC-guidance_22.03.23.pdf (last accessed on 9 January 2024).

mentioned by the UKRN are 'Severn Trent, United Utilities, National Grid, BT Group and, going forward, Pennon'. Expanding the comparator set to other sectors and geographies is possible. The guidance highlights the room for judgement and adjustments to account for the characteristics of the services provided by comparators.¹³⁴

- **Frequency of data:** the use of daily data is considered to be reasonable, although discretion is left to the regulator.¹³⁵
- **Estimation period:** the UKRN guidance recommends considering a range of estimation windows (e.g. 2Y, 5Y and 10Y) to sufficiently 'balance the dual objectives of minimising unrepresentative noise from small samples of data and recent data relevant to a forecast'. Flexibility is left to the regulator, including on whether to use rolling averages.¹³⁶
- **Gearing and de-/re-levering:** the guidance leaves the choice between the market and book values of net debt for gearing estimation to the regulator. The Harris–Pringle formula is mentioned as being appropriate for de- and re-levering, although the UKRN does not explicitly discourage other approaches.¹³⁷
- **Debt beta:** the UKRN notes a range of approaches that could be used to derive the debt beta estimates (i.e. direct, indirect, structural and decomposition approaches). The UKRN does not recommend that a single approach should be either discounted entirely or relied on exclusively, and that the weight placed on each approach should depend on the regulatory context and specific details of the estimation exercise. It therefore leaves regulatory judgement to the regulator.¹³⁸

Given that the UKRN leaves significant discretion to regulators in their estimation of allowed betas, our methodology comfortably aligns with the UKRN guidance on all elements of the approach, such as using daily data, a range of estimation periods, and a wide but single-currency index, as further outlined below.

Comparator set: we use the comparator set suggested by the UKRN as the basis for our estimation, and extend it with five listed European energy network comparators, as also allowed for in the guidance. Our sample includes Pennon group, which the UKRN states should be

¹³⁴ Ibid., pp. 22–23.

¹³⁵ Ibid., p. 23.

¹³⁶ Ibid., p. 23.

¹³⁷ Ibid., p. 24.

¹³⁸ Ibid., p. 24.

included only going forward. However, having Pennon group in the sample has been Ofgem’s standard practice, and we validated the appropriateness of its inclusion in our work in the context of Ofwat’s PR24 methodology.¹³⁹

Estimation period: we align with the UKRN’s understanding that short-term beta estimates (e.g. 2Y) can point to different values than long-term estimates (e.g. 10Y), and regulatory judgement could affect the final estimate significantly. We therefore consider a range of estimation windows, including two-year, five-year and ten-year windows for our beta range, as well as the rolling averages.

Gearing and de-/re-levering: our approach is consistent with the UKRN guidance. We use the book value of net debt and the Harris–Pringle formula for de- and re-levering of betas.

Debt beta: we use a debt beta of 0.075 in our analysis, based on Ofgem’s RIIO-2 estimate. Given that this estimate is ultimately based on regulatory judgement, we expect it to be compliant with the guidance.

2.4 The CAPM CoE estimation

Using the results obtained in the sections above, we now calculate the CoE under Ofgem and Oxera’s approaches, as applicable to GB energy networks, before potentially separately accounting for forward-looking risks. Table 2.15 below outlines the CAPM parameters underlying the CoE estimates.

Table 2.15 CoE estimation at 60% gearing (before accounting for sector-specific forward-looking risks)

	Formula	Ofgem approach range	Ofgem approach mid-point	Oxera approach range	Oxera approach mid-point
RFR	[A]	1.32%	1.32%	1.84%	1.84%
TMR	[B]	6.25–6.75%	6.50%	6.50–7.5%	7.00%
Re-levered equity beta at 60% gearing	[C]	0.70–0.82	0.76	0.70–0.82	0.76

¹³⁹ Oxera (2023), ‘Cost of capital for PR24’, 25 August, section 2.3.1, https://www.yorkshirewater.com/media/2j4jrgsa/yky58_wacc-assessment-appendix_redacted.pdf (last accessed on 15 January 2024).

	Formula	Ofgem approach range	Ofgem approach mid-point	Oxera approach range	Oxera approach mid-point
CAPM CoE	$[K_e]=[A]+[C]*([B]-[A])$	4.75–5.77%	5.26%	5.08–6.48%	5.78%

Note: The cut-off date for the analysis is 20 December 2023. The debt beta is assumed to be 0.075.
Source: Oxera analysis.

3 ARP–DRP as a cross-check to the CAPM

Regulators and economists in the UK have used multiple approaches to cross-check the results of the CAPM.¹⁴⁰

In its 2023 guidance paper, the UKRN recommended that regulators sense-check the point estimate of the CAPM using alternative methodologies. Specifically, the UKRN paper suggests using market benchmarks as a cross-check. However, the paper notes that there should be a high evidence bar to deviate from the mid-point of the CAPM-based CoE.¹⁴¹

In this section, we explain how the cost of debt can be used as a benchmark for CoE estimates. We implement this by comparing a measure of the ARP (asset risk premium) with the DRP (debt risk premium). This is a reliable cross-check of whether the allowed CoE is appropriately calibrated, because it is derived from market data on observed debt yields rather than built up from a theoretical asset pricing model. Additionally, we address comments on the framework made in previous regulatory publications, and present the improvements that we have introduced since then.

Based on the updated methodology, the ARP (which is a measure implied from the CoE) should be approximately at the level of the DRP re-levered to the 100% gearing. The observed debt market evidence suggests that the ARP should be close to 2.15%, which implies a CoE towards the top end of the Oxera estimation range, i.e. 6.48% (CPIH-real, at 60% gearing).

3.1 Underpinnings and use case of the ARP–DRP framework

In March 2019, as part of ENA's response to Ofgem's RIIO-2 SSMC, Oxera submitted evidence to Ofgem on how calculations of the CoE of regulated companies compared with their risk in the debt markets ('the first Oxera ARP–DRP report').¹⁴² We explained that the differential

¹⁴⁰ See, for example, UK Regulators Network (2023), 'UKRN guidance for regulators on the methodology for setting the cost of capital', p. 26, https://ukrn.org.uk/app/uploads/2023/03/CoC-guidance_22.03.23.pdf (last accessed on 19 January 2024).

¹⁴¹ UK Regulators Network (2023), 'UKRN guidance for regulators on the methodology for setting the cost of capital', p. 26, https://ukrn.org.uk/app/uploads/2023/03/CoC-guidance_22.03.23.pdf (last accessed on 19 January 2024).

¹⁴² Oxera (2019), 'Risk premium on assets relative to debt', 25 March, <https://www.northerngasnetworks.co.uk/wp-content/uploads/2020/09/Oxera-2019-%E2%80%98Risk-premium-on-assets-relative-to-debt%E2%80%99-25-March.-1.pdf> (last accessed on 19 January 2024).

between the ARP and DRP can be used as a cross-check to the estimation of the allowed CoE.¹⁴³

The ARP–DRP framework is founded on the fundamental principle of risk aversion in finance, where holders of capital assets with higher risk demand a higher return. As debt-holders have priority claims ahead of equity investors over a company's assets, equity investors are subject to greater risks and demand a higher return. Where this principle is breached by CoE estimates being too low relative to the market pricing of debt, this suggests an error in the application of the CoE estimation.

The ARP reflects the excess return that is required by investors in exchange for providing capital to risky assets compared with the RFR, while the DRP reflects the excess return that is required by investors in exchange for acquiring risky debt. As an asset (debt) becomes more risky, the ARP (DRP) also increases.

There are several advantages inherent within the ARP–DRP framework, which are altogether beneficial to improving the robustness of cost of capital estimates. The first is that the ARP–DRP framework can be employed to correct bias in estimates of the WACC, as its specification mitigates the attenuation bias that is apparent in the CAPM beta arising from measurement errors in the independent variable (i.e. market returns).¹⁴⁴ By constructing the ARP–DRP delta, any measurement errors embedded within each of the asset and debt beta estimates will tend to offset each other, thus providing a more reliable estimate of the difference between the asset and debt risk premiums.

Second, the ARP–DRP framework provides a method for the evaluation of financeability in a way that is neutral to the method chosen by the regulator to treat inflation in the price control. In other words, the differential derived from nominal parameter values will be the same as that derived from RPI-real or CPIH-real parameter values.

Following the first Oxera report from March 2019, our evidence and methodology was updated in a later submission to Ofgem in September

¹⁴³ For a summary of the ARP–DRP intuition, see also Oxera (2023), 'What does the cost of debt tell us about the cost of equity?', *Agenda*, May, <https://www.oxera.com/insights/agenda/articles/what-does-the-cost-of-debt-tell-us-about-the-cost-of-equity/> (last accessed on 19 January 2024).

¹⁴⁴ Regression attenuation, also known as regression dilution, is the biasing of the linear regression slope towards zero, caused by measurement errors in the independent variable.

2020 ('the second Oxera ARP–DRP report'),¹⁴⁵ where we set out further support for the ARP–DRP framework being given greater weight and consideration in assessing the allowed CoE.

Since the introduction of this framework, several regulators have shared their feedback, the key points from which might be assumed to be summarised in the UKRN guidance issued in March 2023.¹⁴⁶ Following this, the CMA has further assessed the framework as part of the Heathrow H7 appeal. We discuss the key concerns and how we address them in the following sub-section.

3.1.1 Addressing methodological concerns

In its cost of capital guidance, the UKRN reiterated the theoretical principle of equity bearing more risk than debt and hence requiring a higher return, but expressed issues with the application of the ARP–DRP methodology.¹⁴⁷ In particular, the UKRN considered that it was inappropriate to use historical relationships between the two premia as a cross-check, as the CoE is based on a longer-run 'through-the-cycle' TMR while the cost of debt is based on recent data. The UKRN therefore argued that it is difficult to benchmark the optimal level of the ARP–DRP differential using historical regulatory determinations.

There are three responses to this concern. First, the increase in interest rates increases the relevance of the ARP–DRP differential derived from past regulatory determinations made when interest rates were at levels similar to today. Second, we have developed an additional approach that does not rely on regulatory precedents. We explain below how an estimate of the DRP that is re-levered to an assumed 100% gearing could be used as a benchmark for the ARP. Finally, it is precisely the purpose of the framework to test whether the 'through-the-cycle' approach to the TMR produces a risk premium on equity that is appropriate for the forthcoming price control when compared with the observed risk premium on debt.

¹⁴⁵ Oxera (2020), 'Asset risk premium relative to debt risk premium', 4 September, <https://www.northerngasnetworks.co.uk/wp-content/uploads/2020/09/ARP-DRP-Oxera.pdf> (last accessed on 19 January 2024).

¹⁴⁶ UKRN (2023), 'Appendix A: Guidance Consultation Issues and Taskforce Response', 22 March. p. 12.

¹⁴⁷ UKRN (2023), 'Appendix A: Guidance Consultation Issues and Taskforce Response', 22 March. p. 12.

More recently, the ARP–DRP methodology was considered as part of the Heathrow H7 CMA appeals. Several considerations were raised as part of the CMA analysis.¹⁴⁸

First, the CMA has noted that there is no one widely accepted methodology for estimating the DRP, which implies uncertainty and the need for judgement. We consider that it is common regulatory practice to estimate parameters that are not directly observable in the market, and to exercise judgement in setting the methodology for their estimation. For example, there are many valid alternative assumptions to be made when estimating the CoE, such as the preferred estimation windows for equity beta or the method for estimating the debt beta. The need to make such assumptions, as well as the availability of other accepted approaches for estimating the CoE, does not make the regulator's CoE methodology inherently inappropriate.

Second, the CMA was concerned about the need to convert the real TMR allowance into nominal terms to calculate the ARP. However, that need is not in fact present—the ARP can be estimated directly based on the CAPM parameters set by the regulator, by using a real TMR and a real RFR.¹⁴⁹ This is what we refer to as the inflation neutrality property of the ARP–DRP framework.

Third, the CMA has highlighted that the ARP–DRP calculation may be overexposed to spot market volatility. We have recognised this concern and have now moved towards using a longer-term estimate of the DRP. Specifically, in this report we use a five-year median value of the DRP—aligned with the length of a price control period. We use a median value instead of a mean, as short-term shocks that are inherent in the credit market dynamics (and that affect credit spreads) may lead to an upward bias in the mean estimation.

Fourth, a criticism has been raised about the assumption on the DRP level at zero gearing. We discuss this issue in detail in section 3.3.

3.2 Estimating the ARP–DRP differential

Based on the above principles and underpinnings, we have calculated the ARP–DRP differential for two Oxera scenarios (identified through the

¹⁴⁸ Competition and Markets Authority (2023), 'H7 Heathrow Airport licence modification appeals. Final Determination', 17 October, pp. 212–218.

¹⁴⁹ The ARP is estimated as $\text{asset beta} * (\text{TMR} - \text{RFR})$.

range in the TMR and equity beta) as well as the roll-forward range that we have identified for Ofgem's RIIO-3 price control.

The relevant formulae for calculating the ARP–DRP differential are as follows.

$$ARP = \text{asset beta} * (TMR - RFR)$$

$$DRP = CoND - RFR - \text{expected loss}$$

Where, in the DRP formula, the CoND is the cost of new debt and the 'expected loss' parameter represents the annualised probability of default multiplied by the losses that a debt investor will suffer if a borrower defaults. We have estimated this parameter to be equal to 0.30%.¹⁵⁰

The CoND is estimated daily based on the yields of the iBoxx £ Utilities 10+ index. To stay neutral to the treatment of inflation, we estimate the RFR used in the DRP calculation based on nominal gilt yields of maturity matching the modified duration of the iBoxx index.¹⁵¹ To minimise the impact of debt market volatility, we take a five-year median of the DRP. We choose a five-year median window to align with the length of the regulatory price control period.

To achieve the neutral treatment of inflation for ARP, we estimate the ARP starting from CPIH-real TMR and RFR numbers, used in the CoE estimate without any modifications.

A negative ARP–DRP differential would violate the fundamental principle of risk aversion in finance, where the holders of capital assets with higher risk demand a higher return. A positive ARP–DRP differential is a necessary but not sufficient condition to cross-check the calibration of the return on capital. Therefore, in the following sub-section, we give

¹⁵⁰ For the full methodology behind the 0.30% point estimate, see Oxera (2019), 'Risk premium on assets relative to debt', 25 March, p. 11, <https://www.northerngasnetworks.co.uk/wp-content/uploads/2020/09/Oxera-2019-%E2%80%98Risk-premium-on-assets-relative-to-debt%E2%80%99-25-March-1.pdf> (last accessed on 19 January 2024). Our expected loss calculation uses annualised default rates based on Feldhütter and Schaefer (2018) that are higher than those reported by Moody's. Using Moody's reported default rates would produce a lower expected loss assumption, i.e. a higher DRP estimate. See Feldhütter, P. and Schaefer, S.M. (2018), 'The myth of the credit spread puzzle', *The Review of Financial Studies*, **31**:8, pp. 2897–2942; Moody's (2023), 'Annual default study: Corporate default rate will rise in 2023 and peak in early 2024', 13 March, Exhibit 36.

¹⁵¹ The DRP estimate is calculated on a daily basis and then takes a five-year median.

additional consideration to the appropriate sufficient lower bound of this benchmark.

3.3 The relationship between ARP, DRP and gearing, and the implications for the appropriate level of ARP and CoE

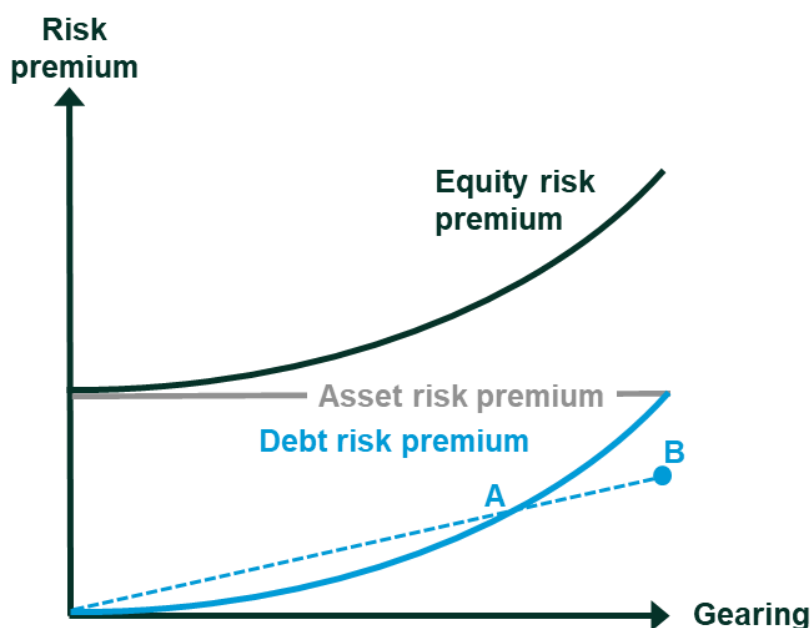
The principle that the ARP–DRP differential should always be greater than zero can be further corroborated by considering the relationship between risk premia and gearing.

Specifically, the DRP should increase with gearing. This increase in the DRP is driven by the greater likelihood and cost of financial distress, which are positively correlated with gearing. At 100% gearing, the DRP must equal the ARP, as the company is now financed entirely by debt. On this basis, the ARP–DRP differential should strictly be greater than zero at less than 100% gearing.

By the same logic, the benchmark level of the ARP–DRP differential can also be further deduced using the relationship between the risk premia and gearing. These relationships are illustrated in Figure 3.1 below.

The DRP is associated with the company's level of gearing, and is depicted by point A in the figure. The figure also shows the relationship between the DRP and gearing—the DRP should be close to zero when gearing is close to zero, and should increase with gearing. The risk profile of debt will resemble the risk profile of the assets as gearing approaches 100% of the enterprise value and the risk premium of debt therefore converges to the risk premium of the assets.

Figure 3.1 The relationship between risk premia and gearing



Source: Oxera.

The cost of debt and, by implication, the DRP are usually assumed to be a convex function of gearing,¹⁵² and estimating this function is not straightforward. However, extrapolating the line connecting the origin and point A is likely to provide a conservative estimate of the DRP at 100% gearing (point B). The slope of the line is given by dividing the observed DRP by the observed gearing (point A). Multiplying the slope by 100% gearing provides the DRP at point B. For example, if a DRP of 100bps is observed at 50% gearing (point A), the slope is 2 and a DRP of 200bps is predicted at point B. A linear extrapolation to 100% gearing will underestimate the ARP if debt risk is a convex function of gearing. In this case, the risk premium on unlevered equity (i.e. the ARP) should be strictly greater than the risk premium on debt (i.e. the DRP) linearly extrapolated to 100% gearing.

In the Heathrow CMA appeal process, one of the parties raised a concern over the assumption that the DRP curve starts at the origin.¹⁵³ The suggested impact of the true function not starting at the origin is that the linear extrapolation from the origin overestimates the DRP at 100% gearing (point B). Irrespective of whether this criticism has

¹⁵² For example, see Berk, J. and DeMarzo, P. (2019), *Corporate Finance*, Pearson, fifth edition, p. 536.

¹⁵³ Competition and Markets Authority (2023), 'H7 Heathrow Airport licence modification appeals. Final Determination', 17 October, p. 216.

theoretical merit, it is unlikely to have a significant impact on the conclusions that we draw from our quantification of the lower bound for ARP. This is because the likely underestimation of the 'true' DRP caused by the use of linear extrapolation (i.e. the spread between the DRP function and point B) would compensate for the effect that accounting for any marginal risk faced on the first tranche of debt may cause. On balance, the point B estimate remains reasonable for benchmarking ARP.

3.1 The results of the ARP–DRP cross-check

Table 3.1 below summarises the ARP–DRP differential estimates for the four main scenarios considered in the report—i.e. the low and high bounds of the Ofgem roll-forward and Oxera RIIO-3 CoE estimates.

Table 3.1 ARP–DRP differentials

	Ofgem approach low	Ofgem approach high	Oxera approach low ¹	Oxera approach high ¹
RFR, CPIH-real	1.32%	1.32%	1.84%	1.84%
TMR, CPIH-real	6.25%	6.75%	6.50%	7.50%
Asset beta	0.32	0.37	0.32	0.37
CoE	4.75%	5.77%	5.08%	6.48%
ARP	1.59%	2.02%	1.50%	2.11%
CoND, nominal ²	2.31%	2.31%	2.31%	2.31%
RFR, nominal ³	0.61%	0.61%	0.61%	0.61%
Convenience premium	0.11%	0.11%	0.11%	0.11%
Expected loss	0.30%	0.30%	0.30%	0.30%
DRP⁴	1.29%	1.29%	1.29%	1.29%
ARP–DRP	0.30%	0.74%	0.22%	0.82%

Note: Differences may exist due to rounding. All parameters are as of our cut-off date of 20 December 2023. ¹ The CPIH-real RFR for the Oxera scenarios includes the convenience premium. ² CoND is calculated as a five-year average nominal yield of the iBoxx £ Utilities 10+ index. ³ Nominal RFR is calculated as a five-year average nominal gilt yield with maturity corresponding to the modified duration of the iBoxx £ Utilities 10+ index. ⁴ The DRP is estimated as the CoND, nominal minus the RFR, nominal, minus the convenience premium.

Source: Oxera analysis based BoE and IHS Markit data.

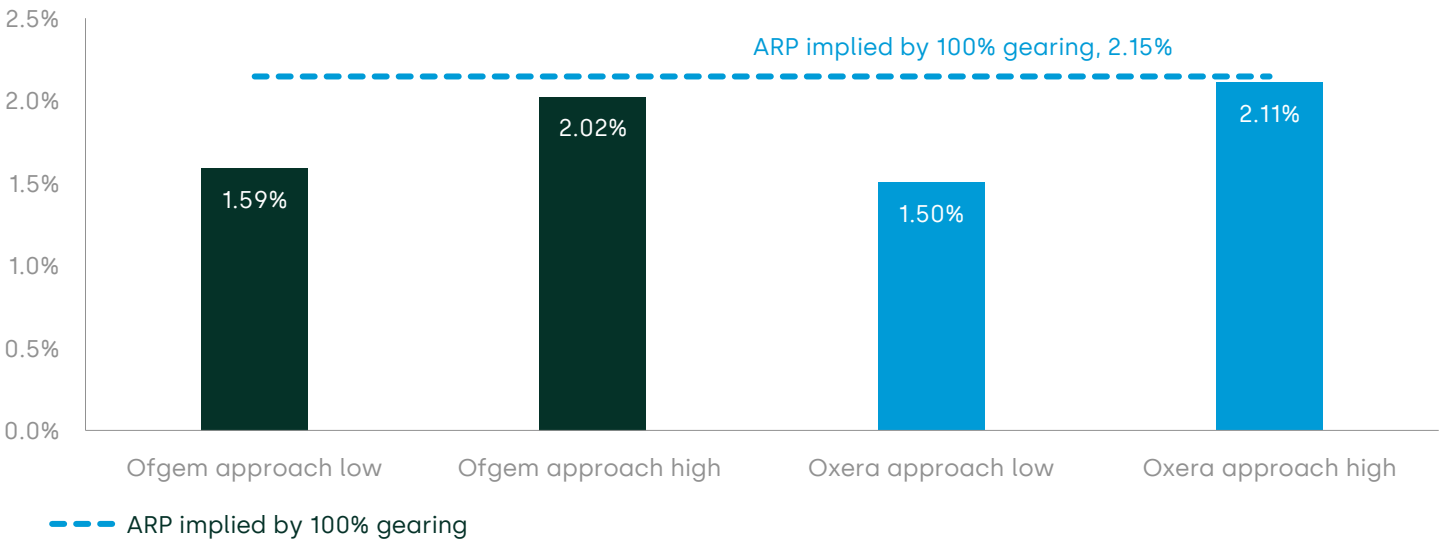
All tested scenarios satisfy the condition of a positive ARP–DRP differential. However, as discussed above, this is a necessary but not sufficient condition to cross-check the calibration of the return on capital. Therefore, we estimate the prediction of the ARP based on extrapolating the DRP to the 100% gearing level. The table below tests the prediction that the linear extrapolation of the DRP creates for the ARP and Figure 3.2 compares it with the ARP estimate corresponding to the Ofgem roll-forward and Oxera RIIO-3 ranges used in this report.

Table 3.2 ARP implied by 100% gearing

	Formula	Estimations
Notional gearing	[A]	60%
DRP	[B]	1.29%
ARP implied by 100% gearing	$[C]=[B]/[A]$	2.15%

Source: Oxera analysis.

Figure 3.2 The ARP implied by 100% gearing compared with the ARP implied from the Ofgem roll-forward and Oxera RIIO-3 CoE ranges



Source: Oxera analysis.

As shown in Table 3.2 above, the theoretical relationship between the risk premia on debt and assets suggests that the ARP should be around 2.15%, which is above the ARP in all of the tested scenarios—i.e. 1.59–2.02% and 1.50–2.11% for the Ofgem and Oxera scenarios respectively. As the ARP reflects the assumed ERP and asset beta, this shows that only values towards the top of the TMR and asset beta ranges produce a risk premium on assets that is sufficiently high relative to the risk premium observed on debt. When combined with the evidence used to form our estimate of the RFR, this suggests that the allowed CoE should be set near the top end of the Oxera estimation range, if market conditions remain the same at the time of the RIIO-3 decision.

4 Concluding remarks

In this report, we have reviewed the methodology used by Ofgem to calculate the allowed CoE in RIIO-2, and the initial comments that it made in relation to its intended methodological approach as part of the RIIO-3 SSMC. In addition, we have estimated a reasonable range for the allowed CoE for RIIO-3, by applying the methodology that we consider be appropriate in light of developments in regulatory precedents, capital markets and academic evidence. However, we do not account for sector-specific forward-looking risk factors, the assessment of which is outside of our scope.

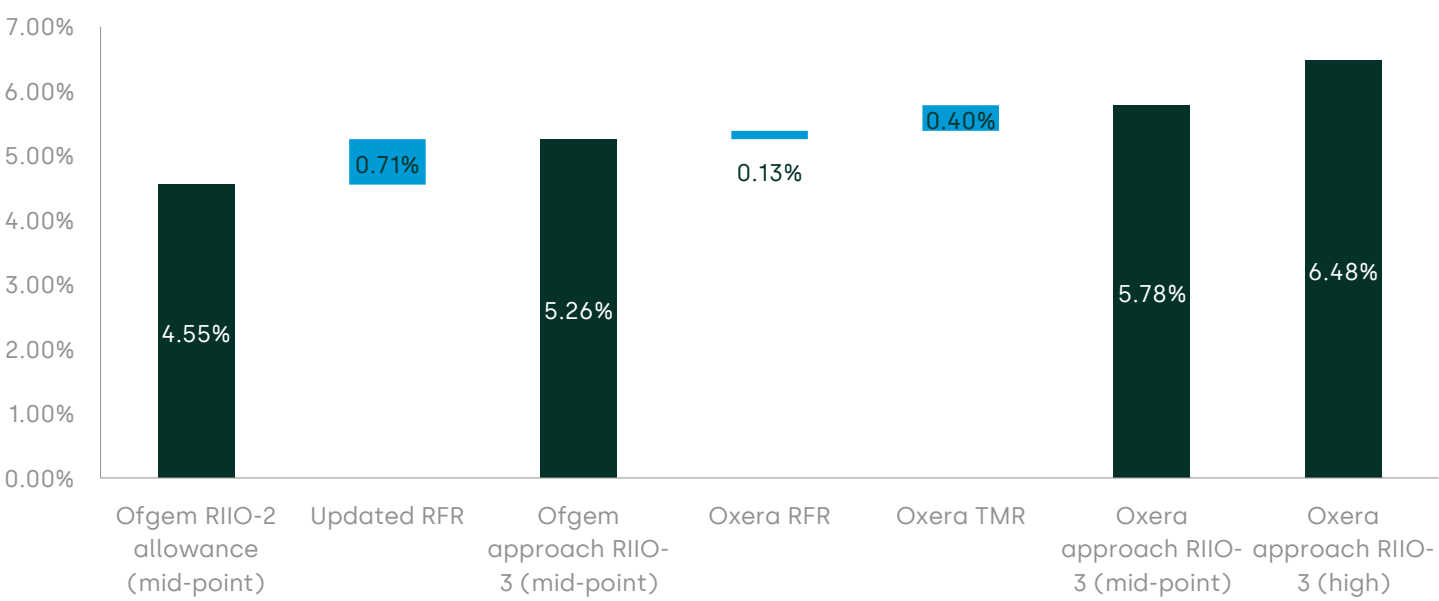
Using Ofgem's assumed methodology to estimate the RIIO-3 CoE allowance leads to a CoE range of **4.75–5.77%** (at 60% gearing, CPIH-real), with a mid-point at 5.26%. This is 71bps higher than the CoE estimate in the RIIO-GD&T2 final determinations, where the CoE allowance for the 60% gearing was 4.55%.¹⁵⁴ The increase is driven by an increase in the RFR.

Oxera's CAPM-based analysis leads to a CoE estimate of **5.08–6.48%** (at 60% gearing, CPIH-real), with a mid-point at 5.78%. The difference is explained by higher TMR and RFR estimates. The ARP–DRP cross-check further suggests that the appropriate point estimate needs to be towards the upper end of the range. This is supported by our observation that Ofgem has historically reduced its TMR allowances when interest rates decreased—based on this pattern, it would be appropriate for Ofgem to increase the TMR allowance towards its level in 2005–11, given that interest rates in RIIO-3 are expected to be approximately at the prevalent level in those years.

Figure 4.1 summarises the CoE estimates and the impact of the differences in each parameter, before accounting for changes in forward-looking risks.

¹⁵⁴ Ofgem (2021), 'RIIO-2 Final Determinations – Finance Annex (REVISED)', 3 February, p. 24, https://www.ofgem.gov.uk/sites/default/files/docs/2021/02/final_determinations_-_finance_annex_revised_002.pdf (last accessed on 16 January 2024).

Figure 4.1 The impact of individual methodological choices on Ofgem's and Oxera's CoE estimates (CPIH-real)



Note: The mid-points are calculated as averages of the low and high CoE scenarios, rather than the average of each specific CoE parameter. The quantification of the impact of the change in individual parameters is indicative, as it depends on the sequence in which adjustments of individual parameters are performed. Minor discrepancies may occur due to rounding. The estimates do not separately account for the forward-looking sector-specific risks.

Source: Oxera analysis.

A1 Calculation of alternative ex post TMR estimators

In this appendix, we briefly describe the methodologies used to estimate the Blume, Cooper, JKM and MSE ex post historical estimators. The context in which these are used is provided in section 2.2.2.

A1.1 Blume (1974) adjusted estimator

Blume (1974) proposed a 'weighted unbiased' estimator of ex post historical TMR, which is calculated as a weighted average of the arithmetic average return plus one (A) and the geometric average return plus one (G), based on the time period for which observations are available (T) and the returns holding period assumed for the estimator (H).¹⁵⁵

The formula for this estimator is as follows:¹⁵⁶

$$\text{Blume adjusted estimator} = \left(A^H \left(\frac{T-H}{T-1} \right) + G^H \left(\frac{H-1}{T-1} \right) \right) - 1$$

Hence, where the holding period (H) is one year, the weighting is entirely on the arithmetic mean (A^H), and when the holding period is equal to the maximum time period for which observations are available, the weighting is entirely on the geometric mean.

A1.2 Cooper (1996) estimator

Cooper (1996) uses an analysis similar to Blume, varying the weight of the arithmetic average return plus one (A) and the geometric average return plus one (G), based on the time period for which observations are available (T) and the returns holding period assumed for the estimator (H).¹⁵⁷

However, unlike the Blume estimator, the Cooper estimator provides an unbiased estimate of the discount factor, which is generated by applying a weighting to annuities. According to Cooper, the unbiased

¹⁵⁵ Blume, M.E. (1974), 'Unbiased Estimators of Long-Run Expected Rates of Return', *Journal of the American Statistical Association*, **69**:347, September, pp. 634–638.

¹⁵⁶ In order to annualise the estimator one needs to take it to the power of 1/N.

¹⁵⁷ Cooper, I. (1996), 'Arithmetic versus geometric mean estimators: Setting discount rates for capital budgeting', *European Financial Management*, **2**:2, pp. 157–167.

estimator of the discount factor (D) lies outside the range from A^{-H} to G^{-H} , and is given by the following formula:¹⁵⁸

$$D = \frac{H+T}{T-1} * A^{-H} + \left(1 - \frac{H+T}{T-1}\right) * G^{-H}$$

The unbiased discount factor can then be transformed into an unbiased yearly estimator of the expected return as outlined by Kaserer (2022):¹⁵⁹

$$\text{Cooper estimator} = \left(\frac{H+T}{T-1} * A^{-H} + \left(1 - \frac{H+T}{T-1}\right) * G^{-H} \right)^{-\left(\frac{1}{H}\right)} - 1$$

A1.3 JKM (2005) unbiased and MSE efficient estimators

Jacquier, Kane and Marcus (JKM) (2005) present two estimators, the 'unbiased JKM' estimator and the 'minimum mean squared error (MSE) efficient' estimator.¹⁶⁰ The general form of both estimators is given by the following formula:

$$JKM \text{ and MSE estimators} = e^{(u+0.5\sigma^2k)H}$$

Where u is the arithmetic mean log return and σ is the standard deviation of returns. The 'JKM unbiased' estimator imposes a value on k such that $k = 1 - (H/T)$, whereas the 'MSE efficient' estimator sets $k = 1 - (3H/T)$, where H is the returns holding period and T is time period for which observations are available.

As with the Blume estimator, both the JKM and MSE estimators apply a downward adjustment to the arithmetic mean. The size of this downward adjustment increases as the holding period assumed increases.

¹⁵⁸ Ibid.

¹⁵⁹ Kaserer, C. (2022), 'Estimating the market risk premium for valuations: arithmetic or geometric mean or something in between?', *Journal of Business Economics*, 5 September, <https://link.springer.com/article/10.1007/s11573-022-01104-w> (last accessed on 30 January 2024).

¹⁶⁰ Jacquier, E., Kane, A. and Marcus, A. (2005), 'Optimal estimation of the risk premium for the Long Run and Asset Allocation: A case of compounded estimation risk', *The Journal of Financial Econometrics*, 3, December, pp. 37–55.



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