The cost of equity for RIIO-2

Q4 2019 update

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Executive summary

In February 2018, Oxera published a report with early estimates of the cost of equity for RIIO-2 (the 2018 Oxera report), commissioned by the Energy Networks Association (ENA). This report serves as an update to the 2018 Oxera report and reflects new evidence from capital markets, as well as updates based on or in response to further thinking and evidence presented by various parties during Ofgem's consultations culminating in the RIIO-2 sector specific methodology decision (SSMD).

Total market return

The updated analysis supports the use of a higher total equity market return (TMR) than the 7.0–7.5% (CPIH-real) range used in the 2018 report. Notwithstanding, we have not updated the range because of the principle that the expected equity market return is a relatively stable parameter. The main factors in support of a higher TMR range are set out below.

First, Ofgem relies on advice from the authors of the UKRN study to deflate historical nominal equity market returns by an estimate of historical CPI inflation rather than using published data on RPI inflation. The CPI has only been published since 1997 and our investigation of the estimates of CPI prior to 1988 suggests that this data is likely to provide an upwardly biased estimate of CPI inflation. Therefore, in the current report we use the average nominal equity return deflated by an RPI series that we have adjusted for structural breaks caused by changes that have occurred over time in the methodology for calculating RPI.

The adjusted RPI series was developed by Oxera as part of work for Heathrow Airport that investigated what the historical RPI series might look like if restated using today's RPI calculation methodology.[1] The preliminary analysis in that report indicated that the average inflation based on a restated RPI series over the period 1899–2016 could be up to 1bp lower or 30bp higher than an estimate based on the official RPI series inflation published by the ONS.[2] On this basis, the arithmetic average of the historical annual real equity market return for the period 1899–2016 would be between 6.4% and 6.8% (RPI-real).[3] As the forecast for CPIH inflation is approximately 100bp lower than forecast RPI inflation, this represents an expected return of around 7.4–7.8% in CPIH-real terms.

Second, Ofgem relies on advice from the authors of the UKRN study to estimate the geometric average of historical equity returns and then adjust this number upwards to estimate the corresponding arithmetic average. This indirect approach to estimating the arithmetic average produces a lower estimate than the actual arithmetic average. More importantly, as explained by Cooper (1996),[4] both the geometric and arithmetic averages are likely to be

[1] Oxera (2019), 'The cost of equity for RIIO-2', prepared for Heathrow Airport Limited, 2 August.
[2] Oxera (2019), 'Estimating RPI-adjusted equity market returns', 2 August.
[3] Producing an accurate estimate of the equivalent arithmetic average calculated over the period 1899–2018 would require extending the analysis of the adjustments to the RPI series, which does not fall within the scope of this report.
[4] Cooper, I. (1996), 'Arithmetic versus geometric mean estimators: Setting discount rates for capital budgeting', *European Financial Management*, **2**:2, 1996, pp. 156–67. Available from http://faculty.london.edu/icooper/assets/documents/ArithmeticVersusGeometric.pdf, accessed 3 October 2019.

downward-biased estimators of the discount rate.[5,6] Therefore, one should expect the true discount rate to be higher than the arithmetic and geometric averages. Converting the historical return of 7.4–7.8% (CPIH-real) into an unbiased estimate of the discount rate to use for discounting equity market cash flows generates a range of 7.46–8.11% (CPIH-real).

Updated evidence from DDMs indicates an increase in the implied equity market discount rate since the 2018 Oxera report, regardless of how these models are specified. The results from the specification used by the Bank of England indicate a CPIH-real equity market discount rate of 9.5%.

Updated evidence from surveys indicates an increase in the TMR assumption relative to the survey data at the time of the 2018 Oxera report, although the survey responses continue to indicate expected market returns that are lower than the historical average.

We remain of the view that the evidence indicates a TMR assumption close to, but lower than, the unbiased estimate of the discount rate derived from historical equity returns. We retain the 7.0–7.5% (CPIH-real) range used in the 2018 report.

Risk-free rate

Yields on UK government bonds have declined since the 2018 Oxera report and hence we reduce our estimate for the CPIH-real risk-free rate to a range between -1.20% and -0.79%. This range is based on evidence from both nominal and RPI-linked gilts, converted to CPIH-real terms. The range includes the average forward premium in interest rates between our estimation date and the average during the RIIO-2 period.

Risk and beta

The updated analysis indicates a small reduction in the asset beta range. This reduction is the outcome of updated market evidence and a change in the relative weighting of the comparator companies.

We base the asset beta range on the averages of daily betas estimated over two- and five-year periods for the sample of UK and European energy networks. We are of the view that our comparator sample is preferable to that used in the SSMD for the following reasons:

- it excludes UK water companies
- it retains all the (two) UK energy networks from Ofgem's sample
- it includes a wider range of energy networks with similar risk characteristics to the UK energy networks.

In arriving at our preliminary range, we have also cross-checked our results against daily betas estimated over a ten-year period, weekly betas estimated over two- five- and ten-year periods, and monthly betas estimated over five- and ten-year periods. In de-levering equity betas we have adopted a debt beta

[5] The analysis in Cooper (1996) focuses on discount factors, which are the reciprocal of discount rates. As such, an upward bias in discount factors is equivalent to a downward bias in discount rates. To maintain consistency with the rest of this report, we refer to discount rates rather than discount factors.
[6] The reason for this bias is the shape of the function (the function is convex, which results in the expected value of the function being higher than the true expected value, as shown by Jensen's inequality) used to estimate the arithmetic and geometric average discount factors. The reason why the bias is the opposite direction for the discount rate to the discount factor is due to the discount rate being the inverse of the discount factor. Therefore, the bias is inverted.

of 0.05, based on empirical analysis, and calculated the gearing using company-specific values of net debt and equity.

Ofgem applies an EV/RAV adjustment of 1.1x when calculating the gearing for de-levering raw equity betas. We disagree with the application of the EV/RAV factor for a number of reasons. In particular, given that the raw equity betas are estimated by reference to outturn market returns, which are in turn affected by the companies' actual gearing levels, maintaining internal consistency requires that the raw equity betas should be de-geared by reference to same actual gearing levels that underpin the observed share price movements.

Ofgem applies a Market Value Factor when calculating the gearing for de-levering raw equity betas. In principle, we agree with Ofgem that assessing gearing based on market values is a more appropriate approach. However, this change in definition of gearing has to be applied consistently when re-levering asset betas at the notional level of gearing assumed when setting the revenue allowances for the price control. This is because the notional company is assumed to have raised debt prior to the start of the price control when interest rates were higher than they are today. As such, the notional company will be incurring a cost of debt that is higher than if the debt had been raised at the lower interest rates that currently prevail. In other words, the market value of debt for the notional company will be higher than notional gearing multiplied by the RAV for the same reason that the market value of debt exceeds the book value of debt for comparator companies.

There are two options that avoid creating an inconsistency between the definition of debt used in calculating the gearing used to de-lever comparator asset betas and the definition of debt used in calculating the gearing used to re-lever for the purpose of setting revenue allowances. The choice is between using market values or book values of debt in both steps of the calculation. Using book values for debt is the standard approach followed in regulatory price controls and therefore for the purpose of this report we do not apply the Market Value Factor when deriving asset betas from the comparator companies.

Similarly to the Oxera 2018 report, this report also recommends using the top half of the preliminary range as the recommended range for RIIO-2. The justification for doing so is consistent with the one provided in the Oxera 2018 report, albeit due to the additional empirical analysis conducted since the 2018 Oxea report, the rational focuses more heavily on the impact of policy and regulatory risk. In particular, we recommend using the top half of the preliminary range due to the following considerations:

- empirical studies demonstrate that the CAPM tends to underestimate the required equity return for holding equity with beta less than 1;
- there is evidence of systematic risk factors faced by energy networks that are not picked up in the CAPM market beta that are nevertheless priced by investors (e.g. policy and regulatory risk); and
- empirical analysis conducted since the 2018 Oxera report suggests that the level of political and regulatory risk, mentioned above, has increased over time, which, all else equal, would imply an increase in the level of return required by utility investors.[7]

[7] Oxera (2019), 'Assessment of political and regulatory risk', prepared for National Grid Group, 4 March.

Based on the reasoning above, we use a final asset beta range of 0.38–0.41 for this report.

Adjusting the equity return down to offset assumed out-performance

Ofgem applies a 50bp reduction to its cost of equity, in lieu of the fact that network companies may expect a certain level of out-performance on incentive mechanisms, cost of debt and tax. We do not make this adjustment because outperformance is only achievable if companies beat the efficiency targets, set by Ofgem. The possibility of outperformance encourages companies to make cost efficiency gains, which can subsequently be shared with consumers. Consumers already benefit from lower bills and better service when companies out-perform, and 'aiming off' on the cost of equity is not necessary to deliver these benefits. Notwithstanding the above, if Ofgem believes that the level of outperformance should be reduced, the correct approach would be to identify and directly reduce the scope for such outperformance via the relevant mechanisms. For instance, if excessive outperformance is expected relative to cost allowances, this needs to be addressed through a higher efficiency challenge, not through a lower allowance for the equity return.

CAPM-based required equity returns for RIIO-2

In summary, based on the newly available evidence on the CAPM parameters, we recommend updating the cost of equity range to 5.98–7.09% CPIH-real. This information is summarised in Table 1.1.

Table 1.1 Summary of RIIO-2 cost of equity estimates

	Oxera 2018		Current evidence		Change	
	Low	High	Low	High	Low	High
Real TMR (%)	7.00	7.50	7.00	7.50	-	-
Real RFR (%)	0.50	1.00	-1.20	-0.79	-1.70	-1.79
ERP (%)	6.50	6.50	8.20	8.29	1.70	1.79
Asset beta	0.40	0.42	0.38	0.41	-0.02	-0.01
Gearing (%)	60	60	60	60	-	-
Debt beta	0.05	0.05	0.05	0.05	-	-
Equity beta	0.93	0.98	0.88	0.95	-0.05	-0.03
Real cost of equity (%)	6.51	7.34	5.98	7.09	-0.53	-0.25

Note: All figures are presented in CPIH-real terms and do not include a 50bp downward adjustment for expected outperformance as advocated by Ofgem.

Source: Oxera analysis.

The top end of the cost of equity range is broadly aligned with the CPIH-real cost of equity derived from a DDM applied to National Grid (7.2%).

We also calculate what this cost of equity range implies for the risk premium an investor in regulated UK energy networks would expect if there was no leverage (i.e. the asset risk premium). The expected risk premium for investing in un-levered equity must be materially higher than the risk premium that would be expected for investing in debt secured against the same assets. If the differential between the asset and debt risk premia is not high enough to compensate for the incremental risk of investing in equity, then there will be no incentive to invest in the equity of these companies relative to the debt.

Oxera analysis previously provided to Ofgem has demonstrated that the differential between the asset and debt risk premia that is implied by the SSMD is low relative to estimates of this differential based on a large sample of bonds issued by UK utilities. Specifically, the middle of the CAPM-implied range in the SSMD (before making the adjustment for expected versus actual returns),[8] is around the 25th percentile of the distribution.

In contrast, the revised cost of equity range presented in this report implies a differential between the asset and debt risk premium that falls within the 39th–74th percentile (midpoint 55th percentile) of the empirically observed distribution. This implies that the cost of equity range proposed in this report is marginally higher than that implied by historically observed data. Such an outcome is to be expected, given the recent flight to quality and increased political and regulatory uncertainty, discussed previously.

The revised cost of equity range therefore reflects the reduction in yields on government bonds and bonds issued by UK utilities, whilst preserving the relationship between the expected returns on equity and debt. The cost of equity presented in this report is consistent with the networks remaining financeable from the perspective of equity investors.

Selecting the point estimate within the range requires striking the balance between higher consumer bills in the short-term and providing adequate incentives to invest to deliver the consumer benefits of network resilience and enhancement. Given that regulated networks make investment decisions that span multiple price control periods and that the potential consumer detriment from long-term underinvestment is significant, it would be appropriate to set the cost of equity allowance for RIIO-2 above the midpoint of the estimated range.

[8] See Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance', 24 May, Table 9.

1 Introduction

In February 2018, Oxera published a report with early estimates of the cost of equity for RIIO-2 (the 2018 Oxera report), commissioned by ENA. This report serves as an update to the 2018 Oxera report and reflects new evidence from capital markets, as well as updates based on or in response to further thinking and evidence presented by various parties during Ofgem's consultations on the RIIO-2 SSMD.

The report is structured as follows.

- Section 2 discusses the estimation of the market parameters, considering the current evidence on the risk-free rate (RFR), total market return (TMR) and equity risk premium (ERP). A range of cross-checks to the TMR is also considered.
- Section 3 considers the latest evidence on equity betas, debt betas and gearing to derive an estimate of the asset beta for the energy networks affected by RIIO-2. It also considers other risks priced by investors in the energy sector that may not be properly reflected in an equity beta estimate, such as the impact of political and regulatory risk.
- Section 4 combines the evidence from the previous two sections to provide an updated CAPM-based cost of equity range for RIIO-2.
- Section 5 provides an overview of alternative sources of evidence on the cost of equity estimate as well as a comparison of the implied asset risk premium relative to the debt risk premium.

The analysis provided in this report is based on current data and may alter by the time RIIO-2 begins.

2 Market parameters: the risk-free rate, total market return, and equity risk premium

2.1 RFR

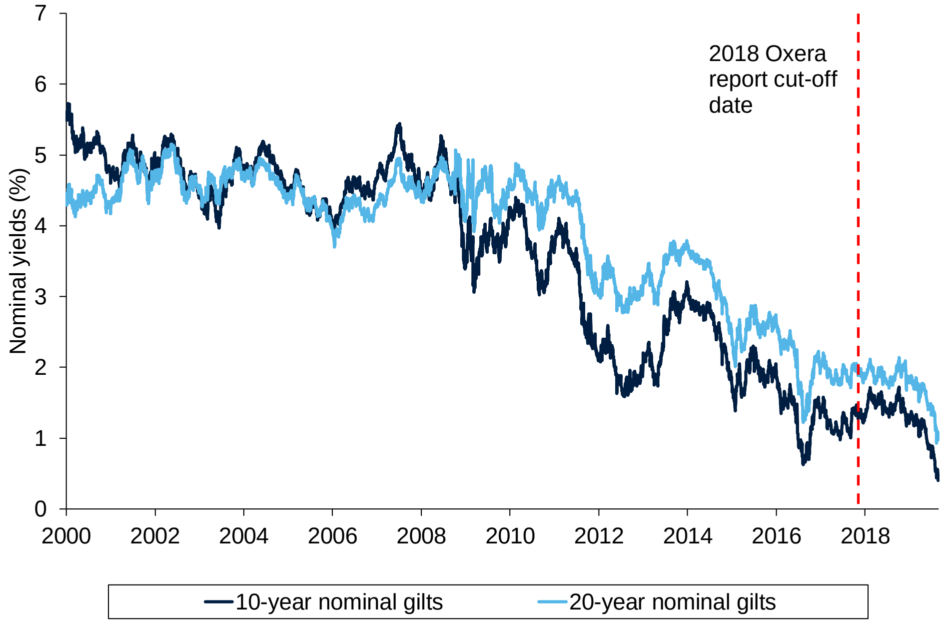
In our report from February 2018, we noted that since the start of RIIO-T1/GD1 (2013) and ED1 (2015), the market yields on 10-year maturity government bonds, commonly used to estimate the RFR, had decreased by around 50bp and 20bp respectively.[9] The decline in yields on 20-year maturity bonds had been larger—a reduction of 110bp since 2013 and 30bp since 2015.[10]

We have now updated our analysis from our previous report. Since November 2017 (i.e. the cut date-off date in our February 2018 report), the yields on 10-year maturity and 20-year maturity government bonds have decreased by around 100bp.

Specifically, as shown in Figure 2.1, the nominal yields on 10- and 20-year gilts have recently been around 0.4% and 1.0%, respectively, implying a negative real RFR.[11] The decline in the yield on UK government bonds is consistent with the concept of 'flight to quality', which reflects increased global uncertainty caused by the US–China trade war and the potential impact of a no-deal Brexit.[12]

[9] Oxera (2018), 'The cost of equity for RIIO-2,' 28 February, p. 11.
[10] Oxera (2018), 'The cost of equity for RIIO-2,' 28 February, p. 11.
[11] We have calculated the spot rates as of the cut-off date of 30 August 2019. The nominal RFRs imply an RPI-real RFR of approximately -2.4% and -1.9% respectively (using a 3% RPI inflation assumption). In CPIH terms, this amounts to -1.53% and -0.97%, respectively.
[12] The concept of 'flight to quality' describes a situation where investors reallocate a greater proportion of their portfolios from riskier assets to safer assets, thus increasing demand for the safer assets such as government bonds. In turn, the increase in demand for the safer assets causes upward pressure on their prices and downward pressure on their yields, while the price for the riskier assets falls and their yield increases.

Figure 2.1 Spot rates on nominal government bonds



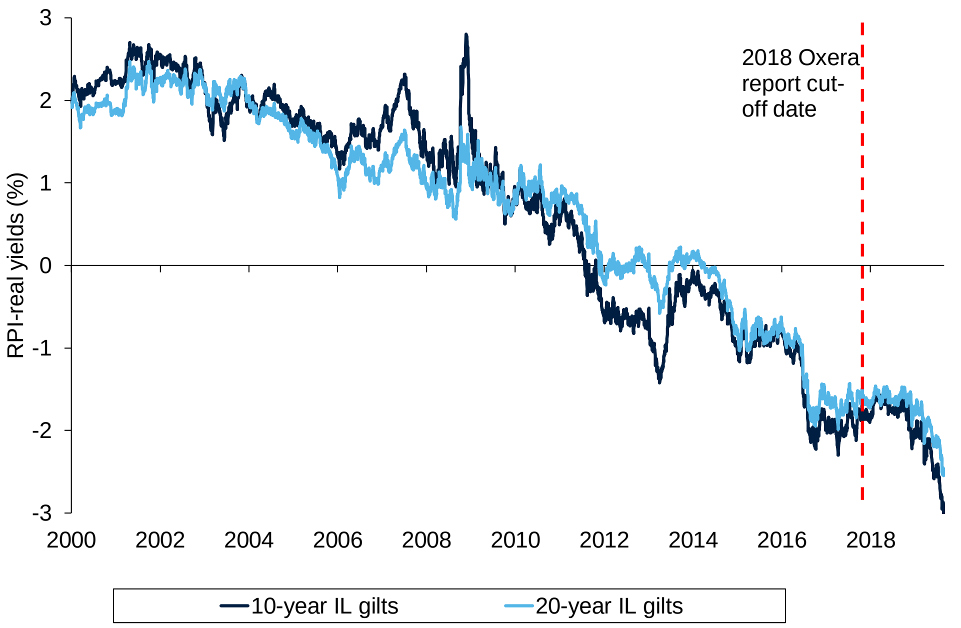
Note: The red dotted line represents the cut-off date from our first report.

Source: Oxera, based on Bank of England data.

In the RIIO-2 SSMD, Ofgem argued that the yields on the nominal gilts shown in Figure 2.1 contain a premium for inflation risk—a risk to which the energy networks are not exposed. As such, Ofgem proposes to use the yields on RPI index-linked government bonds as the basis for setting the RFR for RIIO-2.[13, 14] We have analysed how the yield on these index-linked government bonds has changed since our first report. This is shown in Figure 2.2 below.

[13] Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance,' 24 May, p. 30
[14] Ofgem has proposed to index the RAV for RIIO-2 to CPIH. As a result, Ofgem adjusts for the wedge between RPI and CPIH by applying a wedge of 1.049%.

Figure 2.2 Spot rates on index-linked government bonds



Note: The red dotted line represents the cut-off date from our first report.

Source: Oxera, based on Bank of England data.

Figure 2.2 shows that just like the nominal yields, the yields on index-linked government bonds have also fallen relative to the levels observed during our last report, as well as RIIO-T1/GD1 (2013) and ED1 (2015). In particular, we observe that since the publication of our last report, the yields on 10-year and 20-year maturity index-linked government bonds have fallen by around 120bp and 90bp respectively.

Together, the evidence shows that the most recent real yields are low relative to long-term historical yields observed in the UK, and as such, they may not be sustained at this level throughout the RIIO-2 price control periods. Since our last report, Ofgem has considered this notion and proposed to reflect any movements in the RFR through indexation.[15] In addition, Ofgem has proposed to rely on the yield on 20-year RPI-linked government bonds for setting the RFR.[16] Therefore, for the remainder of this report, we focus on the yield on 20-year government bonds when deriving our RFR assumption.

Table 2.1 below summarises the CPIH-deflated RFR (using the yield on 20-year nominal and RPI-linked government bonds) as of three cut-off dates, namely (i) the cut-off date for our first report, (ii) the cut-off date in the SSMD and (iii) the cut-off date used in this report.[17]

[15] Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance,' 24 May, p. 26
[16] Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance,' 24 May, p. 26
[17] We assume RPI of 3% and a RPI–CPIH wedge of 1.049% in line with Ofgem's working assumption. See Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance,' 24 May, p. 7.

Table 2.1 RFR over time, CPIH-deflated

	20-year nominal government bonds:			20-year RPI-linked government bonds:		
	Nominal yield	CPIH inflation	Implied Real RFR Estimate (CPIH basis)	RPI-linked bond yields	RPI–CPIH Wedge	Implied Real RFR Estimate (CPIH basis)
Calculations:	A	B	C= (1+A)/(1+B)-1	D	E	F= (1+D)·(1+E)-1
2018 Oxera report cut-off date[1]	2.00%	2.00%	0.00%	-1.60%	1.05%	-0.57%
Ofgem's methodology decision cut-off date[2]	1.60%	2.00%	-0.40%	-1.99%	1.05%	-0.96%
Oxera updated cut-off date[3]	1.01%	2.00%	**-0.97%**	-2.47%	1.05%	**-1.45%**

Note: In our first report, we suggested a RFR of -0.5–0.0% RPI-deflated or 0.5–1.0% on a CPIH-deflated basis. This was based on forward curve evidence at the time of our first report and the assumption that the RFR for RIIO-2 would be fixed at the beginning of the price control. Since then, market conditions have changed and Ofgem has proposed to index the RFR and the cost of equity.
[1] Cut-off date of 10 November 2017. [2] Cut-off date of 29 March 2019. [3] Cut-off date of 30 August 2019.

Source: Oxera analysis of Bank of England data.

Consistent with the evidence presented in Figure 2.1 and Figure 2.2, Table 2.1 shows that the RFR implied by 20-year government bonds has fallen significantly since our first report and the SSMD. Additionally, we note that there is a substantial difference between estimating the real RFR by deflating 20-year nominal government bonds as opposed to inflating a 20-year RPI index-linked government bond. The difference is around 50bp, and is driven by the difference between breakeven inflation and the inflation assumptions used by Ofgem and ourselves to inflate or deflate the government bonds.[18]

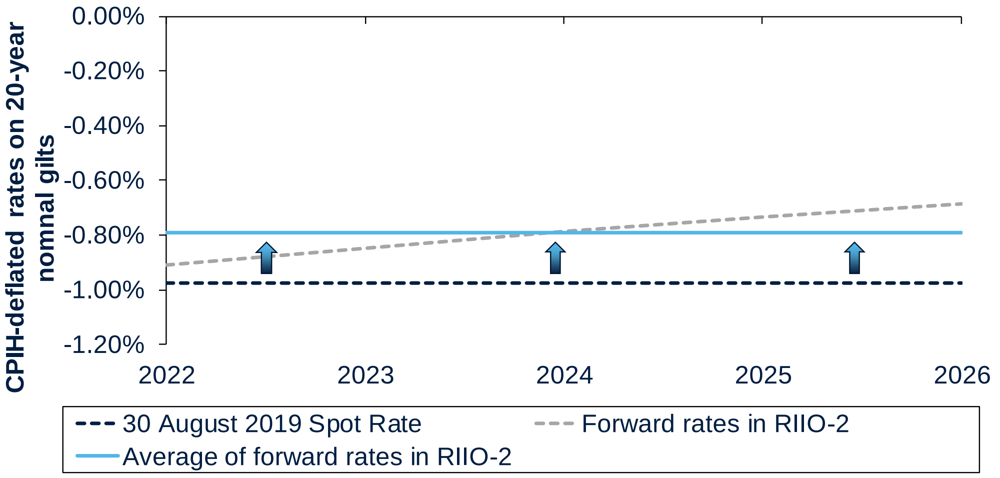
The updated evidence on spot yields presented in Table 2.1 suggests adopting an RFR range (CPIH-real) of -0.97% to -1.45% for this report. However, as noted above, Ofgem has proposed to index the cost of equity by adjusting the RFR to reflect changes in the spot rates prior to the beginning of each financial year in RIIO-2.[19] In practice, this means that the RFR estimates put forward in this report are only for indicative purposes, as the allowed RFR in RIIO-2 will be determined based on outturn data for each year of the control period.

In order to provide a more informed view of the allowed RFR during RIIO-2, we apply an uplift to current spot rate based on the difference between current spot rates and the average forward rates for RIIO-2. This approach is consistent with the framework put forward by Ofgem in the SSMD.[20]

Figure 2.3 presents how the forward uplift affects the RFR derived from the CPIH-deflated 20-year nominal gilts.

[18] Breakeven inflation is calculated as the difference between the yield on index-linked government bonds and nominal government bonds. This is used as a proxy for market expectations of inflation.
[19] Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance,' 24 May, para. 3.41.
[20] Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance,' 24 May, Table 6.

Figure 2.3 Adjusted RFR based on CPIH-deflated 20-year nominal gilts



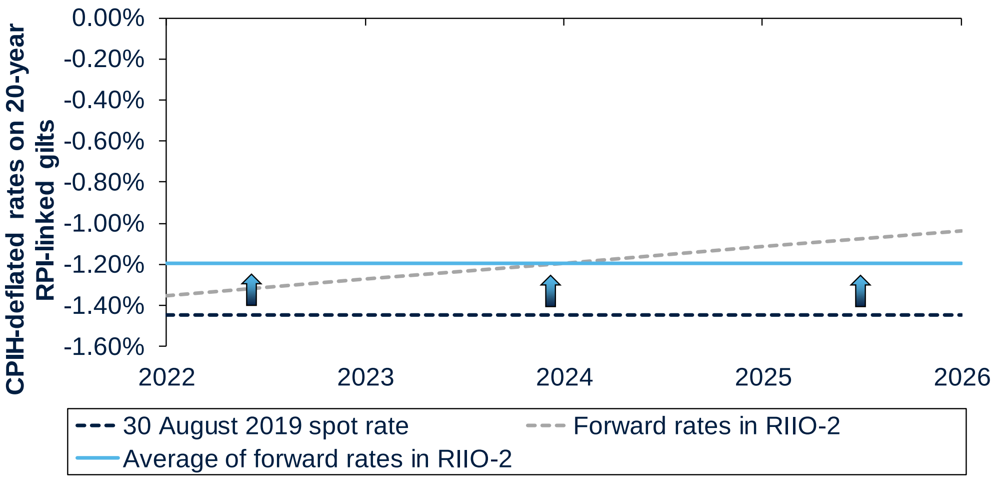
Note: Spot rates as per Table 2.1. Forward rates are bootstrapped from the nominal spot curve provided by the Bank of England, after applying a 2% CPIH inflation adjustment. To maintain consistency with Ofgem, the forward rate for each year corresponds to the prevailing 20-year forward rate starting on 15 October two years prior (e.g. the forward rate shown for 2022 corresponds to the 20-year forward rate starting on 15 October 2020).[21] The Bank of England data only provides rates as of discrete intervals (e.g. plus 2 years, plus 2.5 years, etc.) from the date of estimation. Given that our analysis is performed as of 30 August 2019, the rates for October of any given year are calculated by linear interpolation of the forward rates preceding and succeeding that month of October (e.g. the 20-year forward rate starting on 15 October 2020 is calculated by linear interpolation between the 20-year forward rates starting 30 August 2020 and 30 August 2021).

Source: Oxera analysis based on Bank of England data.

Figure 2.3 shows that the 20-year nominal forward curve suggests an RFR estimate of -0.79% (CPIH-real) for RIIO-2. This implies an uplift of around 18bp from the spot rate estimated as of 30 August 2019.

Figure 2.4 below shows how the forward uplift affects the RFR derived from the 20-year RPI-linked gilts, presented in CPIH-real terms.

Figure 2.4 Adjusted RFR based on 20-year RPI-linked gilts (presented in CPIH-real terms)



Note: Spot rates as per Table 2.1. Forward rates are bootstrapped from the RPI-linked spot curve provided by the Bank of England and converted to CPIH-real by applying the 1.049% CPI-

[21] Ofgem (2018), 'RIIO-2 Sector Specific Methodology Consultation – Finance,' 18 December, Footnote 18.

RPI wedge. To maintain consistency with Ofgem, the forward rate on each year corresponds to the prevailing forward rate on 15 October two years prior (e.g. the forward rate shown for 2022 corresponds to the 20-year forward rate starting on 15 October 2020).[22] The Bank of England data only provides rates as of discrete intervals (e.g. plus 2 years, plus 2.5 years, etc.) from the date of estimation. Given that our analysis is performed as of 30 August 2019, the rates for October of any given year are calculated by linear interpolation of the forward rates preceding and succeeding that month of October (e.g. the rate for 15 October 2020 is calculated by linear interpolation between the 20-year forward rates starting 30 August 2020 and 30 August 2021).

Source: Oxera analysis based on Bank of England data.

Figure 2.4 shows that the evidence from the 20-year RPI-linked forward curve suggests an RFR estimate of -1.20% (CPIH-real) for RIIO-2. This implies an uplift of around 25bp from the spot rate estimated as of 30 August 2019.

Table 2.2 consolidates the information on the forward-adjusted CPIH-real RFR obtained from the 20-year nominal and RPI-linked government bonds.

Table 2.2 Summary of CPIH-Real RFR estimates

	20-year nominal government bonds	20-year RPI-linked government bonds	Calculation
Spot Rates	-0.97%	-1.45%	A
Forward Adjustment	0.18%	0.25%	B
Proposed RFR estimate	-0.79%	-1.20%	C = A + B

Source: Oxera analysis based on Bank of England data

In summary, based on the information presented in Table 2.2, we use an RFR range (CPIH-real) of -0.79% to -1.20%.

Having determined an appropriate range for the RFR, the next step in determining the cost of equity via the CAPM is to assess an appropriate level for the TMR. The TMR is the sum of the RFR and a risk premium for investing in equity. When implementing the CAPM, the estimation of the RFR cannot be considered in isolation from the ERP. Section 2.2 considers the evidence on the TMR and the ERP.

2.2 TMR and ERP

This section sets out the updated evidence on the TMR. As in the Oxera 2018 report, and consistent with the methodology proposed by Ofgem, we rely on historical evidence from DMS as the primary source of input, together with the forward looking evidence derived from the Oxera implementation of the Bank of England DDM as a primary cross-check. We also present the evidence from academic surveys by Graham and Harvey and by Fernandez et all, as well as evidence from investment management firms and recent regulatory announcements.

2.2.1 Historical evidence

Ofgem has expressed a clear position that 'the best objective measure of TMR is the long-run outturn average'.[23]

The 2018 Oxera report presented the long-run average UK equity market returns based on the 2017 edition of the DMS book, which covered data from 1899 to 2016. At that time, the long-run geometric and arithmetic averages of the real UK equity market returns were 5.5% and 7.3%, respectively. Based on

[22] Ofgem (2018), 'RIIO-2 Sector Specific Methodology Consultation – Finance,' 18 December, Footnote 18.
[23] Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance,' 24 May, para. 3.45.

the 2019 edition of DMS, which covers data from 1899 to 2018, the long-run geometric and arithmetic averages of the real UK equity market returns have fallen by 0.1%, to 5.4% and 7.2%, respectively.

Considering nominal returns, the long-run geometric and arithmetic averages have decreased from 9.4% to 9.2%, and from 11.2% to 11.0% respectively, compared to the 2018 Oxera report.[24]

We note that recent academic papers have published UK equity returns data for years prior to 1899. These studies appear to show that averaging equity returns for the period 1899–2018 produces the lowest average relative to any other averaging period, either shorter or longer. This suggests that estimates of the long-term equity market return based on the period covered by the DMS dataset may be downward-biased.[25]

Furthermore, we note that, while the 2018 Oxera report relied directly on the real returns estimated by DMS to infer the RPI-real TMR, this method is no longer appropriate. This is due to the fact that, in the latest edition of DMS, the authors have deflated the nominal returns with an inflation series that is a hybrid of RPI and CPI inflation.[26] This implies that, in order to obtain real returns that are consistent with RPI or CPI inflation over time, we can no longer rely on the DMS real estimates. Rather, the nominal returns shown in the 2019 edition of DMS need to be deflated by a different inflation series from the one presented therein.

In light of the above, the rest of this section analyses the two main issues that arise when deciding on an appropriate CPIH-real TMR allowance for RIIO-2, based on the historical evidence:

1. identification of the appropriate inflation series for calculating the historical real return;
2. conversion of the resulting average to an unbiased market discount rate that can be used to set the allowed TMR.

Each of these issues is discussed in turn below.

Identification of the appropriate inflation series for calculating the historical real return

The inflation series used to deflate nominal UK equity market returns in the 2019 issue of DMS is composed of several series: CPI from 1988 onwards, RPI from 1962 to 1988, and the index of retail prices before 1962.[27] However, Ofgem has proposed that the TMR for RIIO-2 will be stated consistently in CPIH-real terms. Therefore, it is necessary to understand how the 2019 DMS

[24] Dimson, E., Marsh, P., and Staunton, M. (2019), 'The 2019 Global Investment Returns Yearbook: 119 years of financial history and analysis.', p. 211.
Dimson, E., Marsh, P., and Staunton, M. (2018), 'The 2019 Global Investment Returns Yearbook: 119 years of financial history and analysis.', p. 209.
[25] See for instance, Grossman, R. S. (2014), 'Bloody Foreigners! Overseas Equity on the London Stock Exchange, 1869 to 1928', January, Wesleyan University, Connecticut; Turner, J., Acheson, G., Hickson, C. and Ye, Q. (2008), 'Has equity always earned a premium? Evidence from nineteenth-century Britain', 10 May, https://voxeu.org/article/has-equity-always-earned-premium-evidence-nineteenth-century-britain, accessed 3 October 2019; NGET (2019), 'National Grid's response to Ofgem's RIIO-2 sector-specific methodology consultation – Finance', pp. 24–25.
[26] Dimson, E., Marsh, P. and Staunton, M. (2019), 'Credit Suisse Global Investment Returns Yearbook 2018', February.
[27] Dimson, E., Marsh, P. and Staunton, M. (2019), 'Credit Suisse Global Investment Returns Yearbook 2018', February, p. 210.

series of historical nominal returns needs to be deflated in order to be presented as CPIH-real.

One way to achieve this is to deflate the nominal average TMR by the historical RPI inflation from ONS, and then apply an uplift equal to the forecast CPIH-RPI wedge to obtain CPIH-real returns.[28] We refer to this approach as Method 1.

An alternative method was analysed and proposed by a UKRN study in 2018.[29] Under this alternative, the nominal average return was deflated directly by estimates of historical CPI inflation (used as a proxy for historical CPIH inflation)[30] obtained from the Bank of England publication 'A millennium of macroeconomic data for the UK'.[31] We refer to this approach as Method 2.

Both of the methods outlined above deflate historical nominal returns with a historical measure of inflation. A third method would be to deflate the average of the historical nominal returns by the CPI inflation forecast (used as a proxy for CPIH inflation forecast).[32] This method is less conventional than the other two as it combines historical information with forecast data. However, as we explain below, there is significant uncertainty over the reliability of the historical inflation data, which in turn suggests that the series need to be adjusted for possible biases before they can be used to deflate nominal returns. In this context, deflating historical nominal returns by a forecast estimate of inflation provides an alternative to adjusting historical and backcasted CPI data for biases. Following this method yields a CPIH-real arithmetic average return of 8.8%, based on a nominal arithmetic average historical return of 11%.

Nonetheless, as Ofgem has proposed to deflate the historical nominal returns with historical inflation, the focus of the next section is to set out the adjustments that need to be applied to the historical RPI and CPI inflation series used under Method 1 and Method 2, respectively.

Method 1 – add the forecast RPI-CPIH wedge to RPI-real historical returns

As mentioned above, one way of converting the 2019 DMS historical nominal returns to CPI-real is to deflate the nominal TMR by the historical ONS RPI series inflation series, and then apply an uplift based on the forecast wedge between RPI and CPIH, using CPI forecast as a proxy for CPIH forecast).

The main limitation of this framework is that the method for calculating RPI inflation has evolved over time. For instance, a recent Oxera report for Heathrow Airport has identified possible structural breaks due to methodological changes as follows:[33]

1. in 1992, following the introduction of domestic and foreign holidays in the basket of goods;
2. in 1997, following the introduction of housing depreciation in 1995; and

[28] This is a simplified explanation. As shown below, it is first necessary to apply an uplift that converts the RPI-real arithmetic average into an unbiased estimate of future returns, before the CPI-RPI wedge is applied.
[29] UK Regulators Network (2018), 'Estimating the cost of capital for implementation of price controls by UK Regulators', March, Appendix D.
[30] Bank of England does not publish a backcast of CPIH series as part of its Millennium dataset.
[31] Under this method, the uplift for converting the average to an unbiased estimate of future returns is applied directly to the CPIH-real returns.
[32] Ofgem assumes that forecast for CPI is equal to CPIH. See Ofgem (2018), 'RIIO-2 Sector Specific Methodology Consultation – Finance,' 18 December, para. 10.7.
[33] Oxera (2019), 'The cost of equity for RIIO-2', prepared for Heathrow Airport Limited, 2 August.

3. in 2011, following changes in the methodology for calculating clothing prices.

These issues have been acknowledged in the UKRN study, which relied on the following argument to justify deflating the nominal historical returns directly by estimates of historical CPI inflation (i.e. when following Method 2):

> Changes to the underlying methodology mean that the RPI is not comparable over time, whereas historical CPI estimates try to match current methodology. Historic equity returns deflated by RPI will therefore have limited informational content about future equity returns deflated by RPI.[34]

However, relying on RPI inflation (as opposed to CPI inflation) has an important advantage: the historical time series for RPI is longer, with actual data published since 1947 and estimates for the period 1870–1947 based on the 1947 definition of the RPI.[35] On the other hand, the historical CPI series in the Bank of England's Millennium dataset is a 'backcast' (i.e. estimated) series, as there is no actual data for CPI before 1988.[36] This means that, all else equal, the historical CPI inflation series will be less accurate than the historical RPI series, as it relies on estimates rather than outturn values. For this reason, we believe that it is more accurate to use the RPI inflation series, while adjusting for changes in methodology that have occurred in the past.

The Oxera report for Heathrow Airport investigated what the historical RPI series might look like if restated using today's RPI calculation methodology.[37] The report used statistical analysis in combination with an investigation of how the RPI methodology has changed over time to identify structural breaks in the level and rate of change in the RPI series. The preliminary analysis indicated that the average inflation based on a restated RPI series over the period 1899–2016 could be up to 1bp lower or 30bp higher than if based on the official RPI series published by the ONS.[38]

On this basis, the arithmetic average of the historical annual real equity market return for the period 1899–2016 would be between 6.4% and 6.8% (RPI-real).[39] Adding our estimate of the forecast difference between RPI and CPI inflation of 100bp produces a range of 7.4–7.8% (CPIH-real).

Method 2 – deflate nominal returns by CPI inflation

The alternative method put forward in the UKRN study deflates the nominal returns by estimates of historical CPI inflation, taken from the Bank of England's publication 'A millennium of macroeconomic data for the UK'. The publication defines two types of annual CPI series:[40]

[34] UK Regulators Network (2018), 'Estimating the cost of capital for implementation of price controls by UK Regulators', March, D-109.
[35] Johnson, P. (2015), 'UK Consumer Price Statistics: A Review', January, Table D4.
[36] CPI was first published in 1997 as the 'Harmonised Index of Consumer Prices' (HICP). The ONS subsequently constructed the HICP estimates back to 1988 and indicative figures for 1975–87. More recently, the ONS has produced a modelled back series for the CPI covering the period 1950–2011, which it states are indicative, modelled figures that should be treated with some caution. See ONS (2014), 'Consumer Price Indices. Technical manual', January, p. 17 and O'Donoghue, J. (1998), 'Harmonised Index of Historical Prices', Economic Trends' No. 541, December, p. 49.
[37] Oxera (2019), 'The cost of equity for RIIO-2', prepared for Heathrow Airport Limited, 2 August.
[38] Oxera (2019), 'Estimating RPI-adjusted equity market returns', 2 August.
[39] Figures rounded to one decimal place. Producing an accurate estimate of the equivalent arithmetic average calculated over the period 1899–2018 would require extending the analysis of the adjustments to the RPI series, which does not fall within the scope of this report.
[40] Bank of England (2017), 'A millennium of macroeconomic data for the UK', 30 April, tab 'A47. Wages and prices'.

1. CPI ‘preferred measure’;
2. CPI ‘original method’.

Based on the ‘original method’ CPI series, the arithmetic average of CPI inflation over the period 1899–2016 amounts to 4.06%. Based on the ‘preferred measure’, the arithmetic average CPI over the period 1899–2016 amounts to 4.10%.

These series have been developed for research purposes and do not constitute official Bank of England data or National Statistics.[41] Both indices represent an amalgamation of different datasets, and, more importantly, as pointed out before, both rely on backcasted data prior to 1988, unlike the RPI series, which relies on actual data from 1947.

It appears likely that both the measures of CPI inflation in the Millennium Data Book are upwardly biased estimates of the underlying CPI inflation.

Prior to 1950, the CPI series are based on the Consumption Expenditure Deflator (CED) series from Feinstein (1972) or Feinstein (1991).[42] These CED series pre-date the publication of CPI in 1997, and are therefore likely to be based on underlying series constructed using a methodology comparable to RPI. The CED series would therefore include at least some of the upward biases from the RPI formula effect, which would overstate CPI inflation. We have discussed this hypothesis with the ONS, who expressed their agreement with this interpretation.

From 1950 to 1988, the CPI series are based on back-casts of CPI. The authors of the back-cast series caution that: [43]

> …the results of the estimation procedure are analysed in order to make a broad assessment of whether or not the estimates appear reasonable. It is difficult to assess the accuracy of the series, as the true CPI can never be known. For that reason it is also worth emphasising that these modelled estimates can only be considered as broad indications of the level of the CPI series at best and caution should be exercised when using these series. For the same reason, these estimates are not National Statistics.

The modelled ‘formula effect’ for the ‘all items’ indices is 0.29% per annum for the 1950–1988 period. In comparison, since CPI was published as an official statistic in 1997, the average annual difference between RPI and CPI inflation has been 0.84%.[44] The 0.29% modelled ‘formula effect’ is surprisingly small, appears to tend towards zero and becomes noticeably less volatile as the back-cast horizon is extended. No economic reasoning is presented to justify these features of the back-cast, which suggests that the estimated formula effect may be driven by the ARIMA modelling specification, particularly as the back-cast horizon is extended. These observations apply even more to the back-casts of the 12 CPI sub-indices. For eight of these the modelled formula effect is exactly zero for at least some of the early years of the back-cast period. For ‘Education’ the modelled formula effect is zero for almost all of the back-cast period.[45] The back-cast to 1947 cannot be regarded as a robust estimate of CPI, and appears more likely than not to be an overestimate of the

[41] Bank of England (2017), ‘A millennium of macroeconomic data for the UK, 30 April, tab ‘Front page’.
[42] Feinstein (1991), Feinstein, C. H. (1972), ‘National Income, Expenditure and Output of the United Kingdom 1855-1965’.
[43] O’Neill, R. and Ralph, J. (2013), ‘Modelling a Back Series for the Consumer Price Index’, p.7.
[44] Bank of England (2017), ‘A millennium of macroeconomic data for the UK’, 30 April, tab ‘A47. Wages and prices’.
[45] O’Neill, R. and Ralph, J. (2013), ‘Modelling a Back Series for the Consumer Price Index’, Appendix E.

CPI inflation rate due to underestimates of the ‘formula effect’ relative to the ‘adjusted RPI’ series constructed in the back-cast paper.

Overall, it appears that the true average CPI inflation over the period 1899–2018 is likely to be lower than the average of either the ‘original methodology’ or the ‘preferred measure’ CPI series in the Millennium Data Book. An estimate of the size of the bias can be constructed based on the 0.84% average annual difference between RPI and CPI inflation since the CPI was published in 1997.[46]

- For the period 1899–1950, the CPI series is based on the CED series, which are likely to be based on underlying series constructed using a methodology comparable to RPI. For this period, a downward adjustment equal to 75% of the 0.84% difference between RPI and CPI inflation (i.e. an adjustment of 0.63%) appears reasonable. With the arithmetic average of the ‘original’ CPI series over 1899–1950 equal to 2.86%, the CPI inflation adjusted for the upward biases from the RPI formula effect amounts to 2.23%.
- For the period 1950–1988, the CPI series is based on the back-cast estimates, which appear more likely than not to overestimate CPI inflation due to underestimation of the ‘formula effect’. The arithmetic average of the back-cast CPI series is 6.67% for this period. Applying the 0.84% downward adjustment retroactively corrects for the RPI-CPI wedge, not accounted for in the CPI backcast for this period. Adding back the 0.29% ‘formula effect’ estimated using the back-cast methodology yields a CPI inflation estimate of 6.12%.
- For the period 1988–2016, the average inflation based on the CPI series from the Millennium Data Book is 2.57%. As the inflation estimates for this period were constructed on the data consistent with the CPI methodology, there is no evidence to suggest that any adjustment is required.
- Combining the adjusted (as required) CPI inflation estimates for the three periods above produces average CPI inflation of 3.61% for the period 1899–2016, which is 0.45% lower than that implied by the ‘original’ CPI series in the Millennium Data Book.

Using the long-run nominal arithmetic average equity return of 11.0% for the period 1899–2018 together with the ‘original method’ CPI inflation of 4.06% produces an estimate of 6.96% for the real equity market return. However, this is likely to underestimate the real arithmetic average equity market return relative to CPI (and consequently, relative to CPIH, as the two series are assumed equal). As indicated above, correcting for the downward bias would lead to an upward revision of around 0.45% to the CPIH-real equity market return, resulting in an estimate of 7.41%.

Notwithstanding the above adjustments, we recommend calculating long-run CPIH-real equity returns by following Method 1, given that the historical CPI inflation series is less reliable than its RPI counterpart.

Having analysed the issues around the appropriate inflation series used to obtain CPIH-real returns, we now turn to the question of how to convert the

[46] Bank of England (2017), ‘A millennium of macroeconomic data for the UK’, 30 April, tab ‘A47. Wages and prices’.

resulting averages to an unbiased market discount rate that can be used to determine the TMR assumption.

Converting from a historical average to an unbiased market discount rate

As explained in the 2018 Oxera report, an unbiased estimate of the market discount rate (i.e. TMR) will be closer to the arithmetic average than the geometric average. However, as explained by Cooper (1996),[47] both the geometric and arithmetic averages are likely to be downward-biased estimators of the discount rate.[48,49] Therefore, one should expect the true discount rate to be higher than the arithmetic and geometric averages.

Below, we apply Cooper's methodology to convert real TMR estimates obtained with Method 1 described above to unbiased estimates of the market discount rate.

Table 2.3 below shows how the RPI-real TMR obtained from Method 1 converts to an unbiased estimate of the market discount rate using a range of assumptions on forecast horizon.

Table 2.3 Estimating RPI-deflated TMR

	Lower bound	Upper bound
Arithmetic average	6.44%	6.76%
Assumed forecast horizon		
1 year	6.46%	6.78%
5 years	6.53%	6.85%
10 years	6.62%	6.94%
20 years	6.79%	7.11%

Note: We have updated Cooper (1996) to reflect the volatility in UK equity market returns and the same time horizon used in the UKRN study. Note that this analysis covers the period of 1899–2016.

Source: Oxera analysis based on Cooper (1996).

The table shows that the unbiased estimate of the RPI-deflated market discount rate is c. 6.46–7.11% depending on the investment horizon. Adding our estimate of the forecast difference between RPI and CPIH inflation of 100bp, yields an unbiased estimate of the CPIH-deflated market discount rate of 7.46–8.11%.

Conclusion on historical evidence

In conclusion, we recommend deflating historical nominal returns by the adjusted RPI inflation series. This is because the RPI series is more accurate than the CPI series from the Bank of England, as the latter largely relies on backcasted estimates that appear to be subject to upward bias. The arithmetic average of the RPI-real estimate should then be converted to an unbiased

[47] Cooper, I. (1996), 'Arithmetic versus geometric mean estimators: Setting discount rates for capital budgeting', *European Financial Management*, **2**:2, 1996, pp. 156–67. Available from http://faculty.london.edu/icooper/assets/documents/ArithmeticVersusGeometric.pdf, accessed 3 October 2019.
[48] The analysis in Cooper (1996) focuses on discount factors, which are the reciprocal of discount rates. As such, an upward bias in discount factors is equivalent to a downward bias in discount rates. To maintain consistency with the rest of this report, we refer to discount rates rather than discount factors.
[49] The reason for this bias is the shape of the function (the function is convex, which results in the expected value of the function being higher than the true expected value, as shown by Jensen's inequality) used to estimate the arithmetic and geometric average discount factors. The reason why the bias is the opposite direction for the discount rate to the discount factor is due to the discount rate being the inverse of the discount factor. Therefore, the bias is inverted.

estimate of the discount rate using Cooper (1996) methodology. Finally, the RPI-CPIH wedge of 100bp should be added to the resulting figures in order to obtain an unbiased estimate of the CPIH-real market discount rate. We showed that following this method leads to a range of 7.5–8.1%.

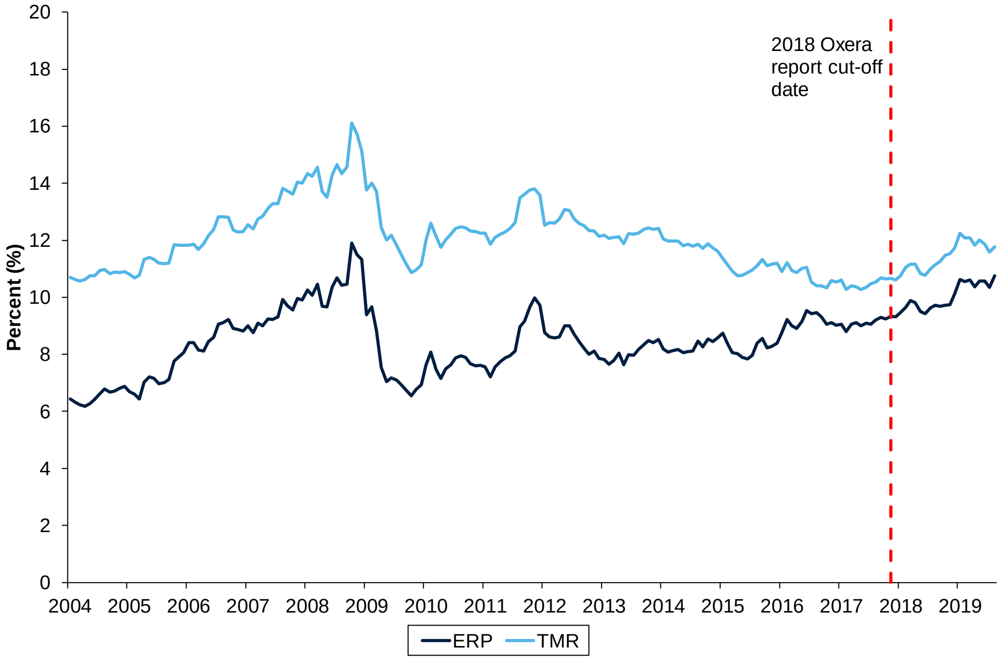
Therefore, the updated analysis of historical data supports a higher range than the one proposed in the Oxera 2018 report (7–7.5% CPIH-real, 6.0–6.5% RPI-real).

2.2.2 DDMs

As part of the analysis conducted for our previous report on the RIIO-2 cost of equity, we constructed a DDM following the Bank of England's methodology. We observed that the ERP derived from our DDM was much more volatile than the equity market discount rate derived from the same model.[50] We also observed that the equity market discount rate had not followed the same downward trend as observed in the yields on government bonds, implying relative stability of the TMR.[51]

We have now updated our DDM for the passage of time since our first report. This is shown in Figure 2.5.

Figure 2.5 Nominal equity market discount rate and ERP based on a DDM for the FTSE All-share index



Note: The red dotted line is the cut-off date for our previous analysis. ERP estimates take account of the full profile of the nominal yield curve.

Source: Oxera analysis based on Bloomberg, Refinitiv Datastream, and the IMF World Economic Outlook.

The figure shows that, looking at the time series since 2004, the equity market discount rate has changed less than the ERP, yielding support to the view that the TMR is a largely stable parameter over time. In addition, Figure 2.5 also shows an increase in equity market discount rate since our 2018 report.

[50] Oxera (2018), 'The cost of equity for RIIO-2,' 28 February, p. 27.
[51] Oxera (2018), 'The cost of equity for RIIO-2,' 28 February, p. 27.

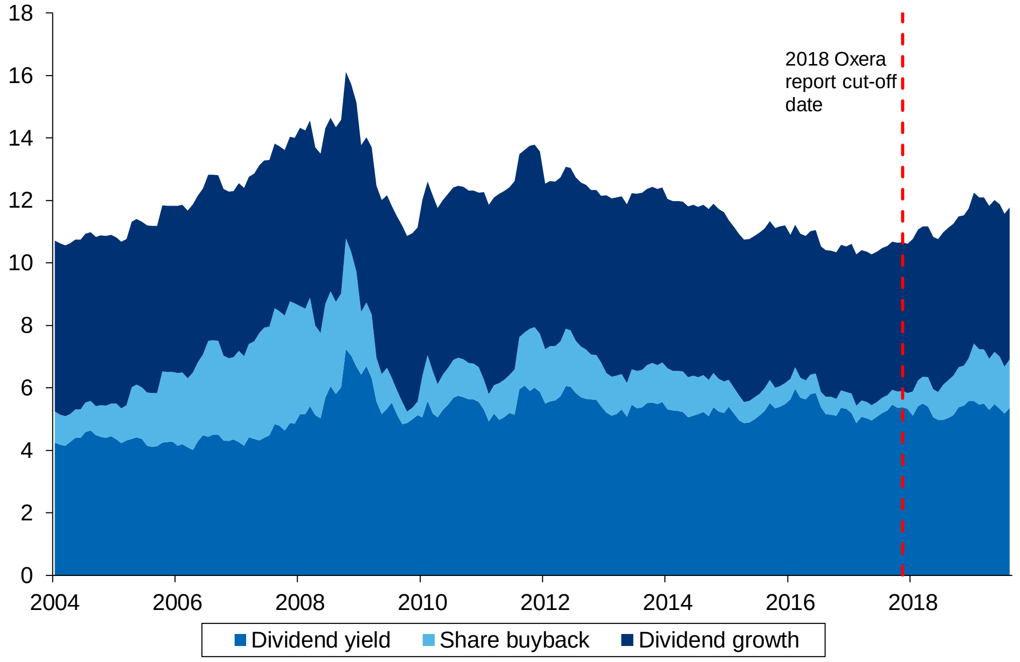
As in our original report, to examine the drivers of the current estimates, we have disaggregated the equity market discount rate estimate in Oxera's DDM model into the following three components:

1. the dividend yield;
2. the share buy-back yield;
3. dividend growth rates.

Figure 2.6 shows that the main driver of the increase in the DDM's estimate of the equity market discount rate is the reversion of the share buyback yield towards its average of 1.54% over the last 15 years.

The Bank of England model links the long-term dividend growth rate to forecasts of the long-term growth rates of gross domestic product (GDP) for a weighted sample of countries. This is because the UK-listed companies in the index used in the DDM operate internationally and derive a significant proportion of their revenues from outside the UK. As such, the growth and risk of their dividends will be affected by international economic developments and not only by the UK economy. This risk will be reflected in the equity betas obtained by regressing company equity returns against the FTSE All-share index, and therefore consistency requires that these growth forecasts are used to infer the equity market discount rate from the DDM.

Figure 2.6 Components of the equity market discount rate (nominal)



Source: Oxera analysis based on Bloomberg, Refinitiv Datastream, and the IMF World Economic Outlook.

As of 30 August 2019, both the spot value and the 10-year average for the nominal equity market discount rate was 11.7%. Deflating these estimates by 2% expected CPIH inflation implies a CPIH-real equity market discount rate of 9.5%.[52] This information is summarised in Table 2.4 below:

[52] Using a CPIH assumption of 2.0%.

Table 2.4 Equity market discount rate estimates implied by DDM

Nominal		CPIH-real[1]	
Spot value as of 30 August 2019	10-year average to 30 August 2019	Spot value as of 30 August 2019	10-year average to 30 August 2019
11.70%	**11.68%**	**9.51%**	**9.49%**

Note: [1]CPIH inflation of 2% is assumed.

Source: Oxera analysis.

DDMs are typically highly sensitive to the dividend growth rate assumptions, in particular to the long-term growth rate. To illustrate this sensitivity, a single-stage DDM was estimated using forecast GDP growth for the UK as opposed to a weighted sample of countries. This resulted in a CPIH-real equity market discount rate of around 7.1% (or 6.1%, RPI-real).[53] This approach is conservative in comparison to the multi-stage DDM because:

- it does not incorporate analyst forecasts of dividend growth over the short term, which are generally higher than long-term GDP growth rates;
- the long-term growth assumption considers only UK GDP growth. This assumption is conservative, as companies listed on the London Stock Exchange are generally exposed to international markets, which on average have higher GDP growth rates than the UK.

We note that the DDM model used by Ofgem in the SSMD has a different specification to that used by the Bank of England, as the specification used by Ofgem uses only long term growth forecasts for the UK. However, in 2018, companies in the FTSE All-Share Index generated only 20% of revenues in the UK, with the rest coming from international activities.[54] As such, we believe this specification to be incorrect, as it does not seem reasonable to assume that earnings generated outside the UK will grow at the same rate as the GDP of the UK. Given that international markets in which the FTSE All-Share companies operate have, on average, higher GDP growth rates than the UK, The specification used in the SSMD would be a downward-biased estimate of the true DDM-implied equity market discount rate.

Overall, the evidence from the DDM is consistent with the view that the TMR is relatively stable over time, and that changes in the ERP largely offset changes in the RFR. Nonetheless, the DDM also suggests that, if we were to take the view that the TMR is sensitive to short-term changes in the market evidence, an increase in our TMR assumption would be appropriate. For example, the nominal equity market discount rate for our original cut-off date of 10 November 2017 was 10.64%, while for our latest cut-off date this has increased by 1.06% to 11.70%.

2.2.3 Survey evidence

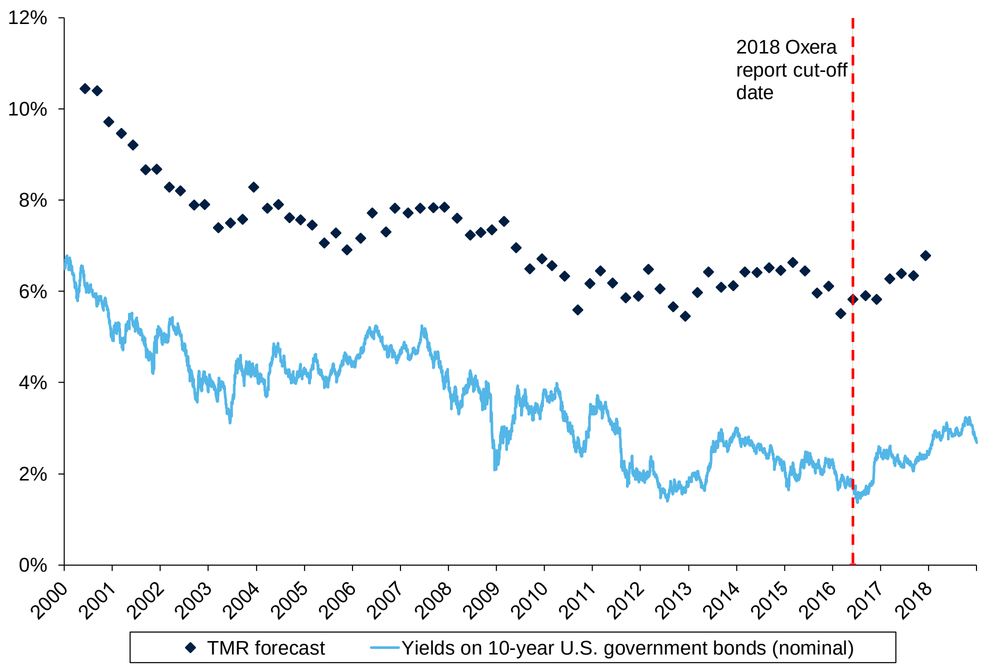
As described in our first report, while surveys could be viewed as another source of evidence for the ERP and TMR, their results need to be interpreted with caution. Issues with interpretation of survey evidence include the following:

[53] The input assumptions are: dividend yield (4.79%), buy-back yield (1.66%), RPI-deflated (assuming 3% RPI) real GDP growth rate (0.6%).
[54] Oxera analysis based on Bloomberg data.

- respondents' answers may be influenced by the way questions are phrased—for example, whether the question asks about required returns to equity or expected returns on a specified stock market index;
- there is a tendency for respondents to extrapolate from recent realised returns, making the estimates less forward-looking and prone to be anchored on recent short-term market performance;
- the results are based purely on judgement, which may also be influenced by the respondent's own position or biases, and are less reliable than estimates based more on market evidence on pricing.

Notwithstanding the need to interpret the survey evidence with caution, this sub-section presents up-to-date evidence in relation to respondents' expectations about ERP and TMR. First, Figure 2.7 shows TMR survey evidence for the USA, based on a quarterly survey of Chief Financial Officers (CFOs) in the USA conducted by Duke University and *CFO Magazine*. Among other questions, the CFOs were asked about their view of the long-term expected return on the S&P 500.

Figure 2.7 TMR (nominal) survey data for the USA: Graham and Harvey study



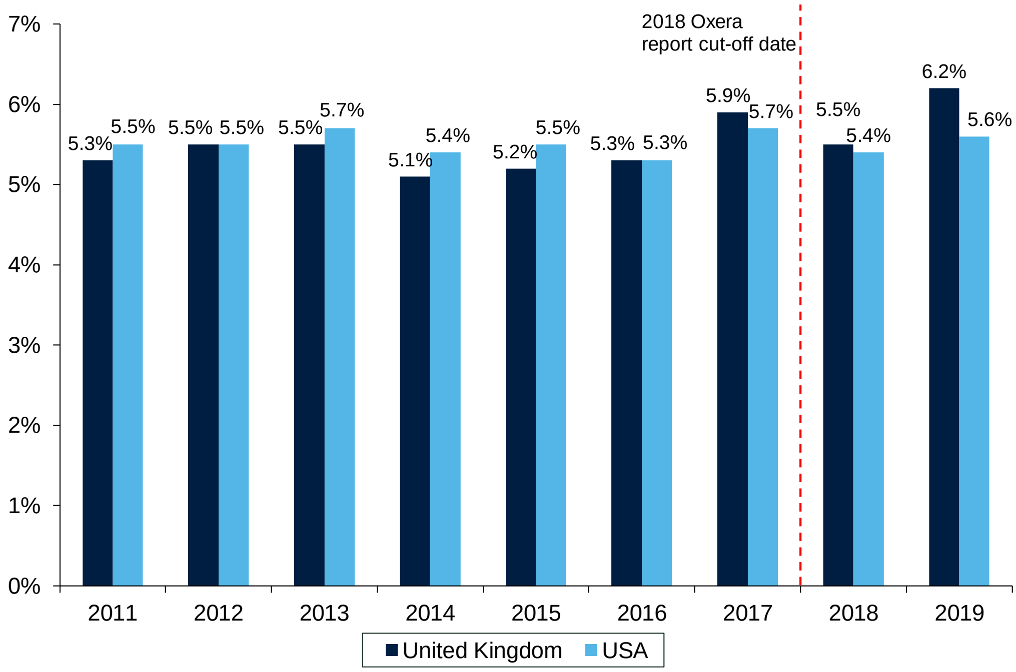
Note: The red dotted line represents the cut-off date from our first report.

Source: Oxera analysis based on Graham, J. and Harvey, C. (2018), 'The Equity Risk Premium in 2018', 28 March.

The survey evidence presented in Figure 2.7 suggests that between our last report and the end of 2018, the expected nominal TMR in the USA had increased from around 6% to 7%. This is in line with the observed increase in the (nominal) yield of 10-year US government bonds (which had increased from around 1.8% to 2.8% in between the latest survey dates and the last data point in our first report) over the same time period, and, therefore, implicitly the survey respondents are on average assuming a fairly stable ERP.

Survey evidence from Fernandez et al. for the UK and USA suggests that survey respondents have slightly increased their view of the ERP since our last report, by 0.3 percentage points.[55] This is presented in Figure 2.8, which shows the evolution for the average ERP from annual surveys of finance and economics professors, analysts and company managers in the UK and USA over time.[56] In both countries, the expected ERP has stayed within a range of around 5–6%.

Figure 2.8 ERP survey data from Fernandez et al. for the UK and USA



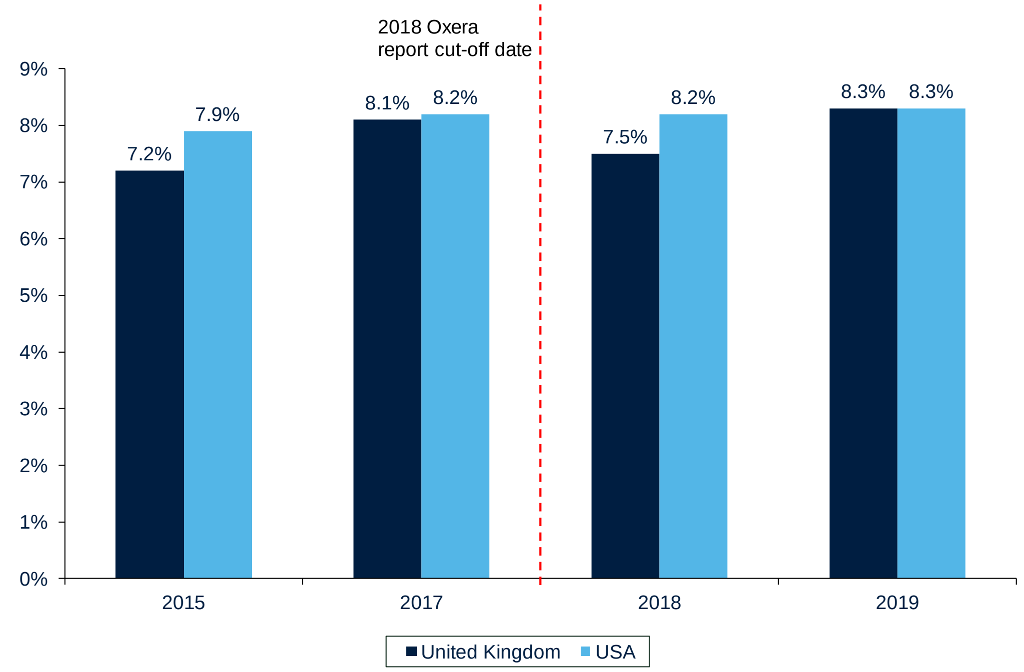
Note: The red dotted line represents the cut-off date from our first report.

Source: Oxera analysis based on Fernandez, P., Pershin, V. and Acín, I. F. (2017), 'Discount Rate (Risk-Free Rate and Market Risk Premium) used for 41 countries: a survey', 17 April; (2016), 'Market Risk Premium used in 71 countries in 2016: a survey with 6,932 answers', 9 May. Ibid. Fernandez, Pershin, Acin (2019), 'Market Risk Premium Used in 69 Countries in 2019: A Survey', 26 May.

In the 2019 version of Fernandez et al, the authors have also presented estimates of the nominal TMR for 2015, 2017, 2018 and 2019. We present this information in Figure 2.9 below.

[55] Fernandez, P., Pershin, V. and Acín, I. F. (2017), 'Discount Rate (Risk-Free Rate and Market Risk Premium) used for 41 countries: a survey', 17 April; (2016), 'Market Risk Premium used in 71 countries in 2016: a survey with 6,932 answers', 9 May. Fernandez, Pershin, Acin (2019), 'Market Risk Premium Used in 69 Countries in 2019: A Survey', 26 May.
[56] Fernandez, P., Pershin, V. and Acín, I. F. (2017), 'Discount Rate (Risk-Free Rate and Market Risk Premium) used for 41 countries: a survey', 17 April; (2016), 'Market Risk Premium used in 71 countries in 2016: a survey with 6,932 answers', 9 May. Fernandez, Pershin, Acin (2019), 'Market Risk Premium Used in 69 Countries in 2019: A Survey', 26 May.

Figure 2.9 TMR survey data from Fernandez et al. for the UK and USA



Note: The red dotted line represents the cut-off date from our first report.

Source: Oxera analysis based on Fernandez, Pershin, Acin (2019), 'Market Risk Premium Used in 69 Countries in 2019: A Survey', 26 May.

As shown in Figure 2.9, the expected nominal TMR has remained within a range of around 7–8%.

2.2.4 Evidence from investment management firms

In deriving its TMR estimate, as a cross-check, Ofgem considered TMR estimates published by investment managers, as well as the rates of return prescribed by the FCA for the purposes of marketing retail financial products.[57] Ofgem used these projections in two ways—first as a cross-check on the TMR range, and second as a cross-check of the CAPM-implied cost of equity. Upon reviewing the evidence, we concluded the following.

- The TMR estimates produced by investment managers have the primary purpose of providing prudent estimates of future returns to their clients, to ensure that clients are managing their finances prudently. This is mainly a function of the regulatory framework, namely the FCA Conduct of Business Sourcebook, section 13, which states the maximum rates of return that financial services companies must use in their calculations when providing retail customers with projections of future benefits:[58]

  > Firms are required to use rates of return in their projections that reflect the performance of the underlying investments, but the ceilings imposed by the FCA aim to prevent consumers being misled by inappropriately high rates.

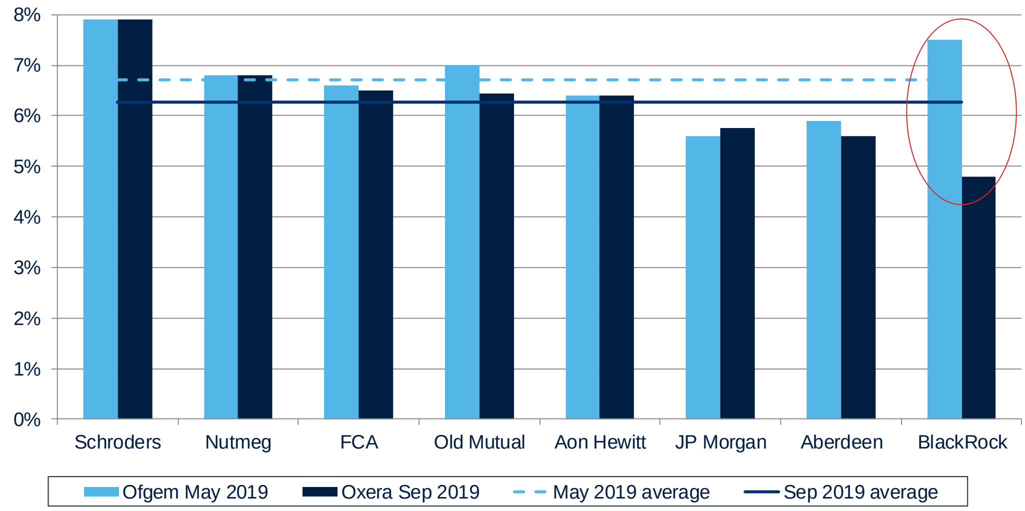
  This suggests that at best this evidence should be regarded as providing a lower bound on the expected compound rate of growth in the value of an investment in the equity market.

[57] Ofgem (2019), 'RIIO-2 Sector Specific Methodology Consultation – Finance,' 24 May, Table 10.
[58] Financial Conduct Authority (2017), 'Rates of return for FCA prescribed projections', p. 5.

- If any weight is to be placed on this evidence in deriving the discount rate appropriate for setting the cost of equity allowance, an upward adjustment has to be made to correct for the downward bias arising due to geometric averaging.

Figure 2.10 illustrates the change in the TMR estimates by investment managers between the time of Ofgem's SSMD (May 2019) and the present report (September 2019).

Figure 2.10 Evolution of evidence on TMR estimates by investment managers



Note: Figures are presented in nominal terms. In its original analysis, Ofgem also covered publications from Vanguard and Willis Towers Watson. Those data points were subsequently excluded in the methodology decision. The Vanguard estimate was excluded from the sample as the underlying portfolio included a 40% bond weighting, and the Willis Towers Watson estimate was excluded as it was based on hedged returns as opposed to forward-looking estimates. Adding these two observations to the dataset decreases the average nominal TMR estimate as of September 2019 from 6.28% to 5.74%.

Source: Oxera analysis based on Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance', 24 May, Figure 6, para. 3.92, Schroders (2019), '30-year return forecasts', p. 8; Nutmeg (2017), 'How we forecast potential investment returns', para. 9; FCA (2017), 'Rates of return for FCA prescribed projections', p. 10; Old Mutual (2017), 'Latest asset allocation quarterly review', p. 3; Aon Hewitt (2018), 'Capital markets assumptions', p. 9; JP Morgan (2019), 'Long-term capital markets assumptions', p. 64; Aberdeen AM (2017), 'Long-term investment outlook', p. 7; Blackrock (2019), 'Capital market assumptions', p. 1.

As the figure illustrates, while most investment managers under consideration have not issued an update to their forecasts, the average projection has decreased by 34bps, from 6.65% to 6.31%. The change in the average is largely driven by BlackRock, which made more than a 2% downward revision of its market return estimate.

As conjectured in the Oxera report on rates of return used by investment managers and subsequently confirmed by Ofgem,[59] the published estimates correspond to a geometric mean expected market return. However, setting the cost of capital requires an unbiased estimate of the discount factor that should be applied to future cash flows. As explained in the section on historical average equity market returns, this would require an estimate that above the equivalent arithmetic (and consequently, geometric) average return.

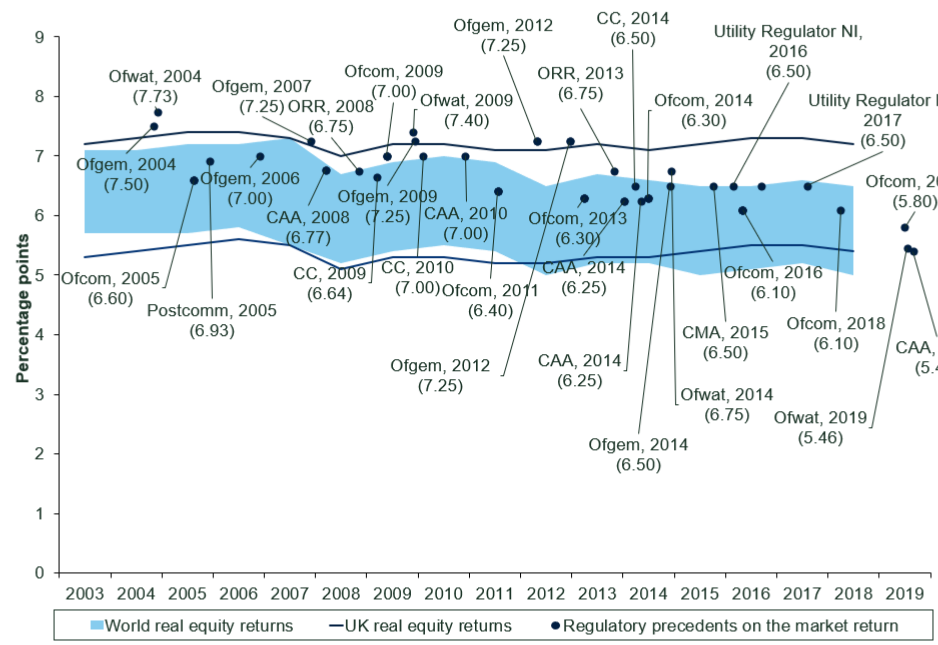
[59] Oxera (2019), 'Review of RIIO-2 finance issues. Rates of return used by investment managers', 6 March, section 3.3; Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance', 24 May, para. 3.90.

In light of the shortcomings of using these estimates to inform cost of capital calculations, we cannot recommend placing any weight on this evidence.

2.2.5 Regulatory announcements on TMR

UK regulatory precedent and recent announcements on the TMR are shown in Figure 2.11, together with the evolution of the long-run average real equity returns for the UK and the world portfolio since 2003. The three most recent announcements in the UK shown in the figure, all from 2019, are the Ofcom PIMR, the Ofwat PR19 draft determination, and the CAA Reference Period 3 (RP3) Final Decision.[60] These announcements feature an RPI-real allowed TMR of 5.8% and 5.4% respectively, which are materially lower than the TMR precedents observed historically.

Figure 2.11 Historical averages and UK regulatory precedent on the RPI-real TMR



Note: The top UK line and the top end of the world range represent arithmetic averages; the bottom UK line and the bottom end of the world range represent geometric averages. DMS calculation methodology is not constant over time.

Source: Oxera analysis based Dimson, E., Marsh, P., and Staunton, M. (2019), 'The 2019 Global Investment Returns Yearbook: 119 years of financial history and analysis.', p. 14 and regulatory decisions.

It is important to note several important characteristics of the latest regulatory announcements. First, in contrast to Ofgem, Ofcom does not have a financing duty.[61] This allows Ofcom to attribute less weight to financeability constraints, thus allowing, all else being equal, to assume a lower cost of equity. Second, the latest announcement from Ofwat represents a draft determination rather than a final decision, which means that the TMR estimate remains subject to revision. Finally, the latest announcement from the CAA has recently been

[60] Ofcom (2019), 'Promoting competition and investment in fibre networks: review of the physical infrastructure and business connectivity markets', 28 June, CAA (2019), 'UK RP3 CAA decision document'.
[61] Ofgem (2013), 'Joint Regulators Group (JRG) Cost of Capital and Financeability', March, https://www.ofgem.gov.uk/ofgem-publications/37070/jrg-report-cost-capital-and-financeability-final-march-2013-pdf, accessed 3 October 2019.

referred to the CMA.[62] Similarly, this implies that the TMR estimate could potentially be revised following the CMA investigation into the matter.

The recent UK regulatory announcements also rely heavily on a number of recommendations made in the UKRN study.[63] The similarity of approach and assumptions across different regulators means that these cannot be regarded as independent data points, which undermines their value as cross-checks.

In sum, while the most recent regulatory publications have used a TMR below the historically observed level, these cannot be relied on for determining the TMR assumption for RIIO-2.

2.3 Conclusion

While the RFR has declined since the 2018 Oxera report, the evidence points to an increase in the TMR. Specifically, since the publication of the 2018 Oxera report:

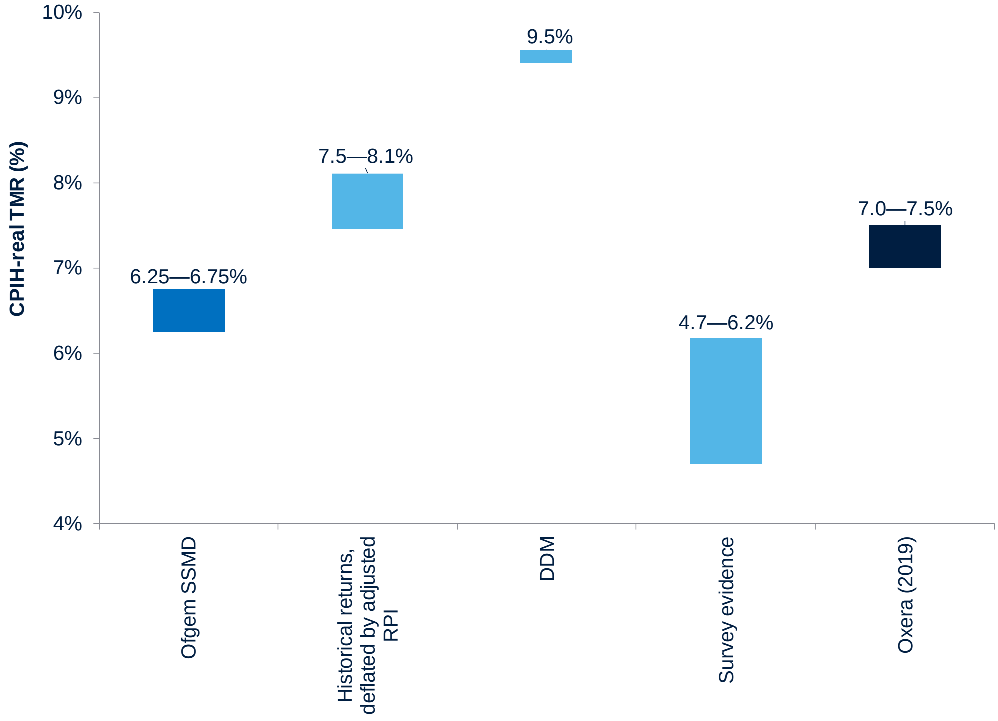
- the estimate of an unbiased market discount rate based on historical data for the UK equity market, adjusted for averaging and inflation, amounts to 7.5–8.1% (CPIH-real),[64] which is above the range recommended in the 2018 Oxera report;
- evidence from our primary cross-check, the DDM, points towards an increase in the TMR estimate;
- survey evidence also points towards an increase in the TMR since the 2018 Oxera report.

In spite of the above, we maintain our position that the evidence is supportive of the assumption that the TMR is relatively stable over time. As such, we are of the view that the updated historical data remains supportive of the 7–7.5% CPIH-real (6.0–6.5% RPI-real) TMR range presented in the 2018 Oxera report. However, we note that, if we had taken the view that the TMR is sensitive to short-term changes in the market evidence, the evidence would, on balance, have supported a higher TMR range.

Figure 2.12 summarises the different sources of evidence that informed our recommended TMR range for RIIO-2.

[62] Letter of Martin Rolfe to Richard Moriarty dated 10 September 2019, https://www.caa.co.uk/uploadedFiles/CAA/Content/Accordion/Standard_Content/Commercial/Airspace/Air_Traffic_Control/CAARPSFinalDecisionDocument_NATS_Letter.pdf
[63] UK Regulators Network (2018), 'Estimating the cost of capital for implementation of price controls by UK Regulators'.
[64] Using our proposed method of deflating the arithmetic average of historical nominal returns by RPI inflation, before applying the Cooper (1996) adjustment, and adding the 100bp CPIH-RPI wedge.

Figure 2.12 Summary of TMR evidence



Source: Oxera analysis.

3 Risk and beta

3.1 Choice of comparators

To enable a robust estimation of the beta, it is important to ensure that reliable data is available and that the stocks being analysed are sufficiently liquid. In particular, when estimating the beta for a given economic activity, the main challenge is finding publicly listed companies that are largely involved in the specific activity of interest. For example, in a regulatory context, the majority of profits or revenues should come from the regulated part of the business.

As explained in the 2018 Oxera report,[65] we draw on two sources of comparators—UK comparators, comprised of listed UK energy and water companies, and European comparators, comprised of comparable listed energy networks.

The choice of comparators is described in turn below.

3.1.1 UK comparators

In the 2018 Oxera report, we considered the following five listed UK comparators:

- National Grid;
- Pennon;
- United Utilities;
- Severn Trent;
- SSE.

For the purposes of determining the asset beta range, we had excluded SSE from the sample on the basis that ‘a significant portion of its business stems from generation and supply, which is not directly comparable to the business profile of an energy network’.[66] Similarly, we showed that: [67]

> […] the divergence of SSE’s beta from the rest of the UK utilities in the last two years suggests that its sharp increase in beta may not be wholly attributable to the perceived risk of its network business.

However, since the publication of the 2018 Oxera report, SSE has taken a series of steps to dispose of its energy supply and services business,[68] which would make its revenue mix more similar to that of the UK regulated energy networks. Following these developments, SSE’s two-year beta converged with those of the other networks (see Figure 3.3), suggesting an alignment of SSE’s risk profile with that of the other networks. Therefore, in this report, we also include SSE as a UK comparator.[69]

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[65] Oxera (2018), ‘The cost of equity for RIIO-2’, 28 February.
[66] Oxera (2018), ‘The cost of equity for RIIO-2’, 28 February, Section 3
[67] Oxera (2018), ‘The cost of equity for RIIO-2’, 28 February, Section 3
[68] Thomas, N. (2019), ‘SSE aims to offload retail energy business by second half of 2020’, *The Financial Times*, 22 May, https://www.ft.com/content/268b55b0-7c5e-11e9-81d2-f785092ab560, accessed 3 October 2019.
[69] We only include SSE as a comparator in the estimates of the two-year beta, as the divestiture was only announced less than two years ago. Including SSE in the 5- and 10-year betas would capture substantial data from a time when SSE’s operations were not sufficiently similar to those of the other UK energy networks.

Nonetheless, even after adding SSE, the UK sample contains only two comparators from the energy sector, neither of which are ‘pure play’ regulated UK energy networks. As such, the resulting UK sample is too small to be considered a representative sample that accurately captures all the systematic risks faced by UK energy networks. It is for this reason that we recommend broadening the sample to consider European energy networks.

3.1.2 European comparators

Given the lack of listed energy networks comparators in the UK, we believe that including the European comparators is necessary to secure a representative sample of an adequate size. Indeed, it is not immediately obvious why water companies in England and Wales would represent a better reflection of the asset risk for GB energy networks than European (and other global) energy networks.

We recommend focusing on Europe, as this approach is consistent with the way in which market analysts assess and value UK regulated utilities. For example:

- Equity Research from Deutsche Bank groups Snam, Italgas,[70] Terna, Red Electrica and Enagas in a single comparator sample of regulated utilities, alongside UK regulated utilities;[71]
- Equity Research from Morgan Stanley uses the same sample as the one used by Deutsche Bank above, with the addition of Veolia and Suez.[72,73,74]

Given the above, as in the previous report, we use the following four listed energy networks comparators in our sample:

- Enagás;
- Red Eléctrica;
- Snam;
- Terna.

We note that, in the SSMD, Ofgem stated that it did not believe that any weight should be placed on non-UK evidence: [75]

> We note that the suggestion to [rely on European comparators] appears to be based on the observation that stocks outside the UK tend to have higher observed betas. In all likelihood these higher betas are driven by risk differences. It is difficult to place weight on international evidence without a clear basis for the benefits and a clear understanding of the risk differences.

While we agree with the fact that different betas are likely to be driven by exposure to different risks, we disagree with Ofgem’s conclusion that this reason warrants an exclusion of the European comparators from the sample. Indeed, our main rationale for looking at betas outside the UK is that the UK

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[70] We do not include Italgas in our sample as there are less than 2 years of available trading data
[71] Deutsche Bank (2019) ‘European Utilities’, 6 September, p.6
[72] We do not include Veolia in our sample as only 21% of its revenues are generated from the Energy business, with the remaining part coming from Water and Waste. Additionally, 44% of Veolia’s revenue is generated outside of Europe. See Veolia (2019),‘2018 Annual Report’, p. 7
[73] We do not include Suez in our sample as none of its revenues are generated from regulated energy networks activities. See Suez (2019), ‘2018 Annual Results Presentation’, p.9
[74] Morgan Stanley (2019) ‘European Utilities’, p. 13
[75] Ofgem (2019), ‘RIIO-2 Sector Specific Methodology Consultation – Finance,’ 24 May, para. 3.154.

comparator sample is unlikely to accurately capture all the systematic risks faced by the energy networks in RIIO-2.

Contrary to Ofgem's method, as we show below, it would be inappropriate to place a high weight on the betas of the UK water networks, as doing so would neglect the fact that these betas have been consistently lower than the ones of National Grid and SSE, the only two energy networks in Ofgem's sample. Applying the same logic used by Ofgem and quoted above, these differences in observed betas may reflect a different and lower risk exposure of water companies. This alternative implication of the data cannot be disregarded.

Furthermore, as we show below, the daily betas of National Grid and SSE fall within the range of European betas when measured over a 2-year window, and whilst we do not estimate 5-year betas for SSE, National Grid's 5-year beta is only 0.01 lower than the low end of the European sample range. As we demonstrate below, and as Ofgem also acknowledged,[76] the beta estimates for National Grid are likely to be a downwardly-biased estimate of the beta for National Grid's UK business. One possible explanation for this phenomenon is that National Grid operates assets not only in the UK, but also in the US, where the regulatory regime is different. While the UK regulation can be classified as incentive regulation, the US regulatory model leans towards rate of return regulation. Empirical studies have found that rate of return regulation is associated with lower asset betas than incentive regulation:[77]

> Both the sectoral averages and the overall regime estimates show a clear trend: high-powered incentives [feature of incentive regulation] appear to be related to higher systematic risk, while low-powered incentives [feature of rate of return regulation] imply low market risk.

With these differences corrected, it would no longer be the case that the stocks outside the UK have higher observed betas, which is Ofgem's stated reason for excluding the European sample.

In summary, we understand that comparators from other jurisdictions may exhibit features specific to their local markets, which ideally should be stripped out of the beta estimation. However, absent a clear reason for why the additional energy networks would introduce a material systematic bias in one direction or another to the beta estimation, we believe that expanding the sample to include European comparators will improve the quality of the beta estimate for energy networks as it will offer a better representation of the risk exposure faced by energy networks in particular, as opposed to regulated utilities in general.

3.2 Technical estimation issues for equity beta

In our previous report, we measured the comparators' equity betas using daily data over two- and five-year periods. Since then, a range of different evidence was considered for the data frequency and the estimation window for equity betas. On balance, none of the new evidence has led us believe that we

[76] Preliminary analysis of this issue presented in the Indepen Report, on which Ofgem relies for arriving at its asset beta range, found that National Grid's US betas are 0.15 to 0.19 lower than National Grid's UK betas. See Indepen. (2018), 'Ofgem Beta Study – RIIO-2 Main report', pp. 38-9 https://www.ukrn.org.uk/wp-content/uploads/2019/01/final_beta_project_riio_2_report_december_17_2018_0.pdf, accessed 21 October 2019.

[77] Mayer, C., Alexander, I. and Weeds, H. (1996), 'Regulatory Structure and Risk and Infrastructure Firms: An International Comparison', p. 29.

should deviate from our chosen methodology. Therefore, we continue to rely on two- and five-year daily betas as our primary sources of evidence.

Nonetheless, in order to provide a comprehensive overview of evidence, this report also presents additional cross-checks, namely (i) daily betas estimated over a ten-year period, (ii) weekly betas estimated over a two-year, a five-year, and a ten-year period, and (iii) monthly betas estimated over a five-year and a ten-year period.[78]

The rest of this section considers the other two main technical estimation issues, namely gearing and debt betas.

3.2.1 Gearing and the relationship between equity beta and asset beta

Assuming a combination of debt and equity financing, the asset beta is a weighted average of the equity beta and the debt beta, as described by the following equation (the 'Harris–Pringle formula'):[79]

$$\beta_a = \beta_e \cdot (1 - g) + \beta_d \cdot g$$

where g = the gearing ratio defined as $\frac{debt}{debt+equity}$.

For a fully equity-financed firm, the asset beta is the same as the equity beta. However, for a firm with significant amounts of debt financing, the asset beta and the equity beta may be very different.

The process of converting estimated equity betas to asset betas is especially important when using evidence from a selection of firms in the market with different levels of gearing.

3.2.2 Market value of debt

When estimating the gearing levels for a listed company, the value of equity is usually estimated by reference to the market capitalisation, which is equal to the number of shares outstanding multiplied by their market price. This information is easily accessible for listed companies.

In contrast, the information on the market value of net debt, in particular non-traded debt, is not as readily available. For this reason, the value of net debt is often calculated by reference to book values.

In our first report, we calculated the comparators' gearing levels using estimates of the book value of net debt, as per the following formula:

$gearing = \frac{net\ debt}{enterprise\ value\ [EV]}$, where

$net\ debt = book\ value\ of\ debt - cash\ and\ cash\ equivalents$ (obtained from Bloomberg), and

$EV = market\ capitalisation + net\ debt.$

[78] We note that this approach is broadly consistent with the one adopted by Ofgem in the SSMD, where raw equity betas were analysed over a longer time horizon of up to 17.5 years. Additionally, the SSMD also reported that 'most network companies explicitly agreed with the Indepen approach of using: high frequency data (daily or weekly)'.

[79] The Harris–Pringle formula assumes that the firm maintains a constant level of gearing, and therefore that the same WACC can be used to discount the cash flows in each period. The appeal of the Harris–Pringle formula in a regulatory context is that it is consistent with the notion of a regulator assuming a constant gearing ratio throughout the price control period.

A limitation of this method is that it does not reflect the current market value of a company's debt.

In the SSMD, Ofgem proposed to apply certain adjustments to the gearing levels in order to obtain a more precise estimate of the market value of debt. In particular, Ofgem proposed the following formula for calculating the level of gearing:

$gearing = \frac{net\ debt}{EV} \times Market\ Value\ Factor\ [MVF] \times EV/RAV$, where

$EV = market\ capitalisation + net\ debt,$

$MVF = \frac{(book\ value\ of\ net\ debt + MVA)/(EV+MVA)}{book\ value\ of\ net\ debt/EV}$ (obtained from Bloomberg, except for MVA),

$MVA = (fair\ value\ of\ debt - book\ value\ of\ debt)$ (obtained from the annual reports), and

$EV/RAV = 1.1$ (based on Ofgem's assumption).

In this report, we do not follow Ofgem's methodology for the calculation of gearing. Our rationale for not doing so is laid out below.

3.2.3 Our position on the application of EV/RAV adjustment in the calculation of gearing

We disagree with the application of the EV/RAV factor for a number of reasons.

First, the value of 1.1 seems to be based on a subjective judgement by Ofgem, rather than on a clear methodological approach.

Second, we note that the value of the EV/RAV ratio can vary over time and so it is unclear whether applying a fixed factor of 1.1 is appropriate. Ofgem itself has previously mentioned this fact:[80]

> […] independent research [from Barclays] shows that the "Premium / Discount to RAV" (analogous to the EV:RAV ratio) can rise and fall […]

Third, and most importantly, the raw equity betas are estimated by reference to outturn market returns, which are in turn affected by the companies' actual gearing levels. Therefore, to maintain internal consistency, the raw equity betas should be de-geared by reference to same actual gearing levels that underpin the observed share price movements. Ofgem's adjusted gearing approach produces a hybrid asset beta that reflects an assumed level of financial risk that is inconsistent with the actual level of market risk. Therefore, the resultant asset beta and re-geared equity beta will be under-estimated given the 1.1x assumed multiple.

Finally, we note that the positive EV/RAV ratio is likely to be a manifestation of investors' expectations of the networks' financial outperformance during the price control period. As such, applying a higher gearing level in de-levering the raw equity betas by reference to the observed EV/RAV ratio effectively lowers allowed returns by an order of magnitude that is directly linked to the expected level of outperformance. Since the December 2018 Finance Annex, Ofgem has proposed to apply a downward adjustment to the cost of equity estimate in

[80] Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance', p. 50.

order to neutralise the impact of expected outperformance stemming from information asymmetries between the networks and Ofgem. Assuming that investors react quickly to such developments, the market returns, which are forward looking estimates used to derive the betas of the UK energy networks, would already reflect a lower expected level of outperformance since December 2018. As such, applying an EV/RAV adjustment of 1.1, which is based on data from a time period when the expected outperformance was not yet factored in, on top of the outperformance adjustment to the cost of equity, would double-count the impact of the adjustment for expected outperformance when applied to betas that rely on returns observed after December 2018.

Therefore, for the reasons given above, we do not agree with Ofgem's 1.1 EV/RAV adjustment, and do not include it in our calculations.

3.2.4 Our position on the application of MVF adjustment in the calculation of gearing

In principle, we agree with Ofgem that assessing gearing based on market values is a more appropriate approach. However, this change in definition of gearing has to be applied consistently when re-gearing asset betas at the notional level of gearing assumed when setting the revenue allowances for the price control. This is because the notional company is assumed to have raised debt prior to the start of the price control when interest rates were higher than they are today. As such, the notional company will be incurring a cost of debt that is higher than if the debt had been raised at the lower interest rates that currently prevail. In other words, the market value of debt for the notional company will be higher than notional gearing multiplied by the RAV for the same reason that the market value of debt exceeds the book value of debt for comparator companies.

There are two options that avoid creating an inconsistency between the definition of debt used in de-gearing comparator asset betas and the definition debt used in calculating the of gearing used to re-gear for the purpose of setting revenue allowances. The choice is between using market values or book values of debt in both steps of the calculation. Using book values for debt is the standard approach followed in regulatory price controls therefore for the purpose of this report we do not apply the MVF when deriving asset betas from the comparator companies.

In summary, in this report, the level of historical gearing was calculated using the following formula, consistent with the Oxera 2018 report.

$$gearing = \frac{book\ value\ of\ net\ debt}{book\ value\ of\ net\ debt + market\ capitalisation}$$

The next section explores the appropriate level of debt beta.

3.2.5 Debt beta

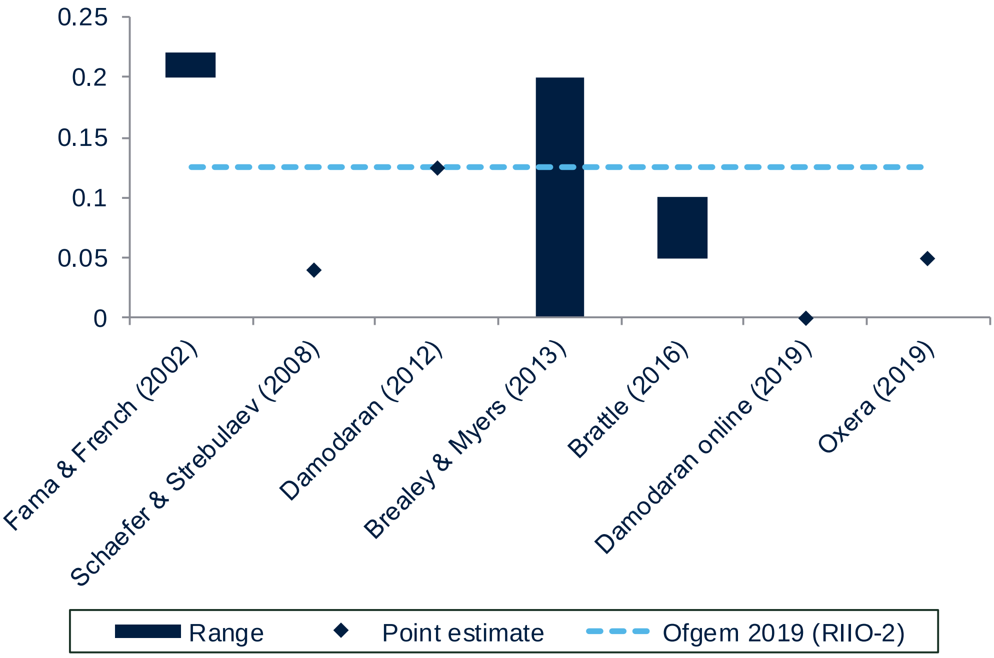
In the Oxera 2018 report, we had assumed that 0.05 was an appropriate level at which to set the debt beta during RIIO-2. Since then, earlier this year, we submitted a report that analysed this issue in more detail and provided more up to date and relevant evidence on the debt beta than had been considered by any UK regulator up to that point.[81] That report also concluded that a debt beta level of 0.05 would be appropriate.

[81] Oxera (2019), 'Review of RIIO-2 finance issues. Asset risk premium, debt risk premium and debt betas', 23 January.

On the other hand, in the SSMD, Ofgem used out of date and less relevant information to propose a higher debt beta range of 0.10 to 0.15, and relied on the mid-point of this range, 0.125, as an input to set its working assumptions for the allowed equity returns in RIIO-2.

Figure 3.1 provides an overview of academic and industry evidence reported by Ofgem in the SSMD, based on analysis from NERA, as well as two additional observations added by Oxera.

Figure 3.1 Comparison of academic and industry evidence on debt betas with Ofgem's debt beta assumption for RIIO-2



Source: Oxera analysis, based on Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance', Figure 12. The underlying sources are: Schaefer, S. and Strebulaev, I. (2008), 'Structural models of credit risk are useful: Evidence from hedge ratios on corporate bonds', Journal of Financial Economics, XC:1, pp. 1-19; Damodaran, A (2012): 'Investment Valuation – Tools and Techniques for Determining the Value of any Asset', p. 411; Brealey, R. A. and Myers, S. C. (2014), 'Principles of Corporate Finance, 11th edition', p. 463; Brattle Group (2016), 'Review of approaches to estimate a reasonable rate of return for investments in telecoms networks in regulatory proceedings and options for EU harmonization.', p. 88 and http://pages.stern.nyu.edu/~adamodar/New_Home_Page/home.htm. Oxera (2019), 'Review of RIIO-2 finance issues. Asset risk premium, debt risk premium and debt betas', 23 January.

As Figure 3.2 shows, the only two estimates of debt beta that are higher than the range provided by Ofgem are the top of the range suggested by Fama and French and by Brealey & Myers.

In the SSMD, Ofgem refers to analysis conducted by NERA.[82] We have checked the NERA report and the underlying sources, and we note that the Fama and French (2002) paper does not seem to suggest a value for debt betas. Indeed, the source cited for the Fama and French (2002) estimate in Table 4.2 of the NERA report is a Fama and French paper from 1993. In that paper, table 7b suggests that the debt betas of investment grade bonds are

[82] https://www.ofcom.org.uk/__data/assets/pdf_file/0018/124740/nera-wacc-report.pdf

between –0.02 and 0.02.Regarding the Brealey & Myers reference, we note that no evidence is provided to support this range, as the authors simply note that 'debt betas of large firms are typically in the range of 0 to 0.2'.[83]

In light of the evidence presented above, we maintain our recommendation that the appropriate assumption for the value of the debt beta of regulated networks is 0.05. We note that there are three reasons for the divergence between our estimate and those of other publications. First, our estimate is based on data from regulated networks only, whereas other estimates include data from other sectors. Second, our estimation methodology measures the sensitivity of corporate debt to equity in a way that accounts for the correlation between returns to equity and government debt. Finally, relative to other studies, our estimates are based on more recent data.

The rest of this section (i) provides an overview of different methodologies for the estimation of debt beta and (ii) explains why the methodology that we have adopted is expected to produce a more accurate estimate of the debt beta.

Methodology overview

There are two broad methods used to estimate debt beta:

1. decomposition of debt spreads;
2. regression analysis.

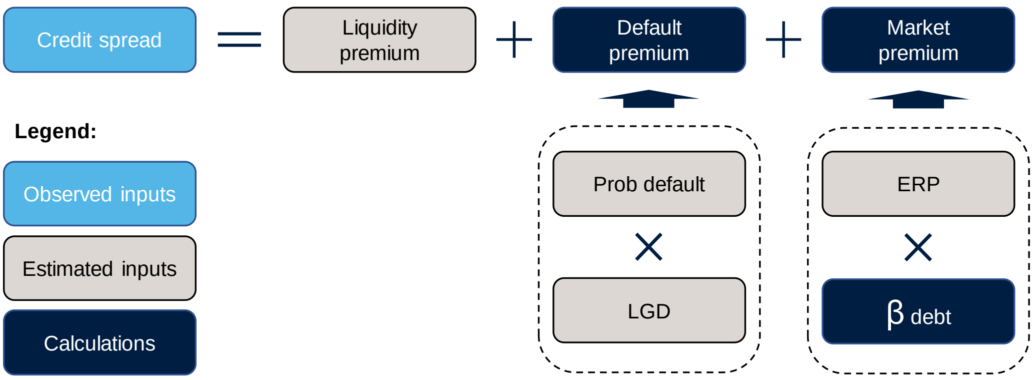
The spread decomposition method assumes that the observed debt spread is made up of several distinct premia. The debt beta is then backed out as a residual, based on assumptions about the size of these other premia.

A standard approach assumes three premia embedded within the debt spread:

1. liquidity premium;
2. default premium;
3. market risk premium.

Figure 3.2 illustrates the spread decomposition method.

Figure 3.2 Summary of spread decomposition method



Source: Oxera analysis.

As the figure illustrates, the spread decomposition method requires the modeller to assign values to four unobservable parameters. The issues involved in estimating the ERP are well known. Further difficulties in

[83] Brealey, R. A. and Myers, S. C. (2014), 'Principles of Corporate Finance, 11th edition', p.436

implementing the spread decomposition method are to do with estimating (i) the default probability and (ii) the liquidity premium.

In a 2018 paper, Feldhutter and Schaefer[84] show that even with long estimation windows, estimates of default probability based on historical default rates for a given horizon and rating are highly inaccurate. For example, Feldhutter and Schaefer show that using a 31-year history to estimate the expected default rate on debt that has a true 10-year default rate of 5.09%[85] would lead to a 95% confidence interval for the 10-year default probability of 1.2% to 12.8%.[86] With an LGD of around 60%, this means that the 95% confidence interval for the annualised default premium is between 7bps and over 80bps. Thus default probabilities based on historical default rates for a given rating and horizon are too imprecise to be of practical value in backing out debt betas.[87]

The size of the liquidity premium in corporate debt—and even its existence—is also controversial. For example, in a 2012 study, Dick-Nielsen, Feldhutter and Lando (2012)[88] found that aside from during the recent crisis, the liquidity premium on investment grade debt is typically in the range of zero to 10bps; this is certainly much smaller than the credit component.

In contrast, in the regression approach, debt betas are measured directly from bond returns, and the statistical reliability of these estimates does not therefore require the availability of a long data series to the same extent. The accuracy with which the debt betas are measured is also obtained directly from the standard regression output.

With respect to debt betas, it is useful to include in the regression not only the return on the market, but also the return on government bonds. This approach measures the sensitivity of debt returns to the issuing firm's equity. During most periods, there is a strong statistical relationship between returns on investment grade bonds and the returns on government bonds. Therefore, including returns on government bonds in the regression also increases the R-squared and improves the precision of the debt beta estimates.

Results

We have analysed the debt beta of the following UK regulated companies:[89]

- National Grid;
- Severn Trent;
- United Utilities;
- Pennon Group.

For these companies, we collected data on the sterling-denominated bonds issued by the parent company and subsidiaries from 1998 onwards.

[84] Feldhutter, P., and Schaefer, S. (2018), 'The Myth of the Credit Spread Puzzle', The Review of Financial Studies, Volume 31, Issue 8, August 2018, pp. 2,897–2,942.
[85] The actual average BBB default rate from 1970–2001 in the US.
[86] Note that while a 31-year history may appear excessively long in the context of equity beta estimation for a price control, histories of this length are frequently used in the credit risk literature.
[87] Feldhutter and Schaefer describe a model-based method for aggregating default histories that significantly improves precision.
[88] Dick-Nielsen, J., Feldhutter, P., and Lando, D. (2012), 'Corporate bond liquidity before and after the onset of the subprime crisis', para. 2.
[89] This section provides a summary of our approach and results. For more details see Oxera (2019), 'Review of RIIO-2 finance issues. Asset risk premium, debt risk premium and debt betas', 23 January .

The analysis has been performed as follows.

- The bond data for each company was cleaned, removing index-linked, fungible, convertible, complex, perpetual, callable and floating bonds in order to prevent these characteristics from affecting the results.
- We then obtained the relative debt beta for each bond, regressing the bond return against the company equity index and the UK government bond index.
- The coefficient estimated for the explanatory variable representing the company's equity index in the previous step represents the sensitivity of a bond's return to the company's equity return. Therefore, we multiply these coefficients by the company's equity beta to derive the sensitivity of the bond returns to market returns.[90]
- Finally, we obtained the debt beta for each company, taking the weighted average of the companies' bond debt betas.[91]

Table 3.1 presents debt betas for each company in our sample, with sensitivities across time to maturity and the date of observation.

Table 3.1 Debt beta coefficients—whole sample

	National Grid	Severn Trent	United Utilities	Pennon Group[1]
Debt beta	**0.01**	**0.01**	**0.01**	**0.02**
Average observation date in the last five years	0.00	0.02	0.02	0.02
Average observation date not in the last five years	0.02	0.01	0.00	-
Time to maturity[2] greater than 10 years	0.04	0.02	0.04	0.02
Time to maturity[2] less than 10 years	0.01	0.01	0.00	-

Note: The coefficients are calculated using the weighted average with respect to the inverse of the squared standard error of each bond.

[1] Only one bond was analysed. [2] Calculated as the difference between the maturity date and the average observation date.

Source: Oxera analysis.

For the whole sample the more recently issued bonds show a slightly higher estimated coefficient compared to bonds issued less recently.[92] Furthermore, the results suggest a positive relation between debt beta and time-to-maturity. This is in line with financial theory that suggests that longer bonds are more credit risky than shorter bonds as they are more exposed fluctuations in the value of the issuing firm's assets. The average debt beta for the whole sample does not exceed 0.05, the estimate assumed in our 2018 report on RIIO-2 cost of equity.

We note, however, that in some instances, the debt beta coefficient appears statistically indistinguishable from zero. Table 3.2 presents the results based exclusively on bonds where debt beta is statistically significant from zero.

[90] The equity betas used are the following; National Grid (0.61), Severn Trent (0.52), United Utilities Group (0.58) and Pennon Group (0.43). The coefficients differ from what was used in previous sections as we use the same time period as used to estimate sensitivity of a bond's return to the company's equity return.
[91] Weighted average with respect to the inverse of the squared standard error.
[92] Looking at all bonds, it is possible to appreciate an upward trend for Severn Trent and United Utilities Group, while the observations for National Grid show noise. However, considering only statistically significant bonds, it is possible to better appreciate the upward trend for all companies.

Table 3.2 Debt beta coefficients—statistically significant coefficients only

	National Grid	Severn Trent	United Utilities	Pennon Group[1]
Debt beta	**0.03**	**0.02**	**0.04**	**-**
Average observation date in the last five years	0.07	0.02	-	-
Average observation date not in the last five years	0.03	0.02	0.04	-
Time to maturity[2] greater than 10 years	0.04	0.04	0.04	-
Time to maturity[2] less than 10 years	0.02	0.02	-	-

Note: The coefficients are calculated using the weighted average with respect to the inverse of the squared standard error of each bond and of the statistically significant estimations only.

[1] Only one bond was analysed. [2] Calculated as the difference between the maturity date and the average observation date.

Source: Oxera analysis.

As expected, eliminating statistically insignificant estimates from consideration increases the average debt beta.[93] However, even in this case, the average debt beta remains below 0.05 for all companies. As such, we are of the view that our proposed estimate of 0.05 is a conservative assumption for the debt beta in RIIO-2.

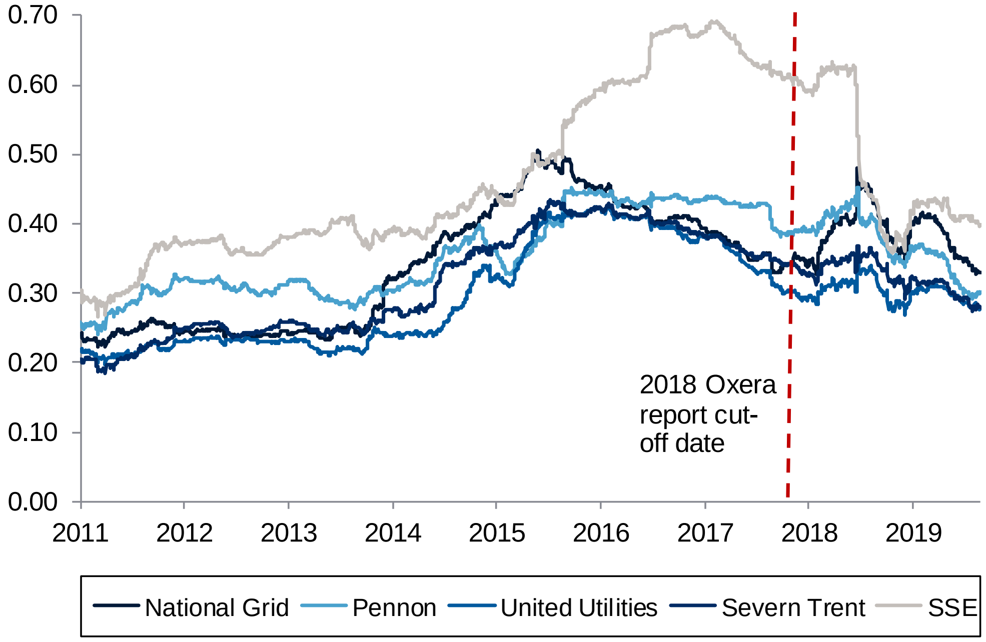
Having addressed the technical issues with estimating the equity betas, we turn to the results of our asset beta analysis.

3.3 Asset beta estimation results

Figure 3.3 shows the two-year daily asset betas for each of the companies in our UK comparator sample. We show two-year daily asset betas as an illustrative way to assess the evolution of the data over time. However, as explained in Section 3.1, when constructing a range for the asset beta for RIIO-2, we maintain our previous methodology of relying on two- and five-year daily estimates.

[93] In general, eliminating non-significant coefficients might lead to upward bias. In this case, however, a number of the bonds had returns that exhibited low trading characteristics, and these betas are almost certainly downward-biased. Eliminating these bonds therefore appears justified.

Figure 3.3 Two-year daily asset betas for listed UK comparator companies



Note: Equity betas were estimated relative to the FTSE All-share index. A debt beta of 0.05 is assumed. The cut-off date is 30 August 2019.

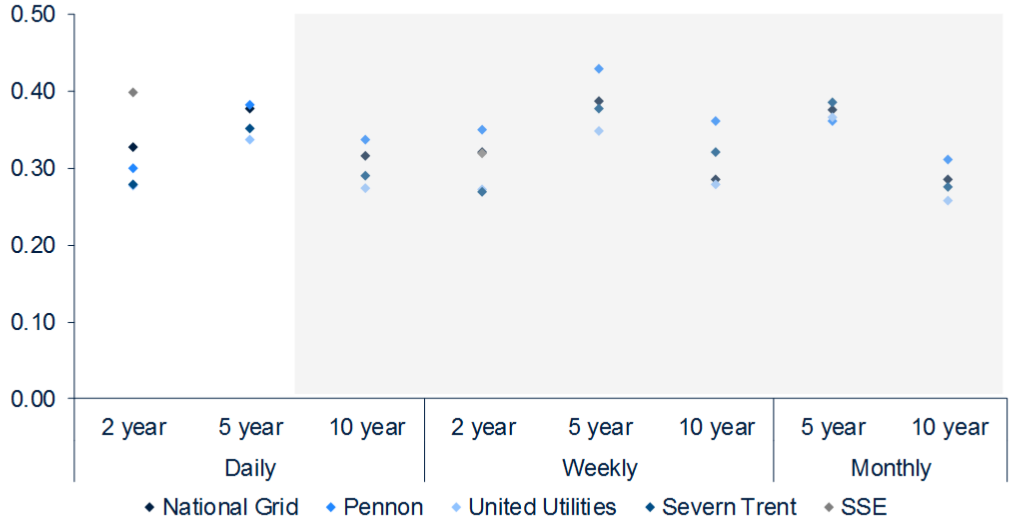
Source: Oxera analysis based on Bloomberg data.

As shown in Figure 3.3, since our last report, SSE's two-year daily asset beta has fallen and converged to a similar level as National Grid. The sharp drop occurs around mid-June 2018, which is approximately half a month after the firm announced the divestiture of its energy supply and services business, thus reflecting a change in investors' expectations about the forward-looking risk profile of the business.[94] Therefore, we believe that it is reasonable to include SSE as a comparator in the estimation of two-year betas, but not in the five- and ten-year betas, as doing so would capture substantial data from a time period when SSE's operations were not sufficiently similar to those of the other UK energy networks.

Figure 3.4 shows asset beta estimates for the entire UK comparator sample for the full range of frequencies and estimation windows.

[94] Thomas, N. (2019), 'SSE aims to offload retail energy business by second half of 2020', *The Financial Times*, 22 May, https://www.ft.com/content/268b55b0-7c5e-11e9-81d2-f785092ab560, accessed 3 October 2019.

Figure 3.4 Asset betas for listed UK comparator companies under different frequencies and estimation windows



Note: The cut-off date is 30 August 2019. The area to right of the 5-year daily asset betas has been shaded to reflect the notion that our range is derived from the 2-year and 5-year daily estimates, while the rest of the data points are only used as cross-checks. Weekly betas have been averaged for each work day of the week leading to 30 August 2019.

Source: Oxera analysis based on Bloomberg data.

Figure 3.4 shows that, considering the whole UK comparator sample, the results suggest a range of 0.28–0.40 under our proposed method of relying on two- and five-year daily estimates as the primary inputs. However, as mentioned in Section 3.1, we believe that it would not be appropriate to rely on this range, as doing so would likely underestimate the beta for UK energy networks. This is because of two main reasons, which we discuss in turn below.

First, we note that the asset beta estimated for National Grid is likely to be an underestimate of the true asset beta of National Grid's UK regulated business. This is because the estimate presented in this report reflects elements of lower risk faced by National Grid's US business.

The notion that US betas tend to be lower than UK betas has been illustrated in a study by Mayer et al. (1996).[95] We report the relevant findings from the study in Table 3.3, below.

Table 3.3 Comparison of UK and US asset betas

Country	Electricity	Gas	Water	Telecoms
UK	0.60	0.84	0.67	0.87
US	0.30	0.20	0.29	AT&T: 0.72 Others: 0.52

Source: Mayer et al. (1996).

As shown in the table, US betas for Electricity and Gas companies are on average 0.30 and 0.64 lower than their UK counterparts. The authors of the

[95] Mayer, C., Alexander, I. and Weeds, H. (1996), 'Regulatory Structure and Risk and Infrastructure Firms: An International Comparison', p. 27.

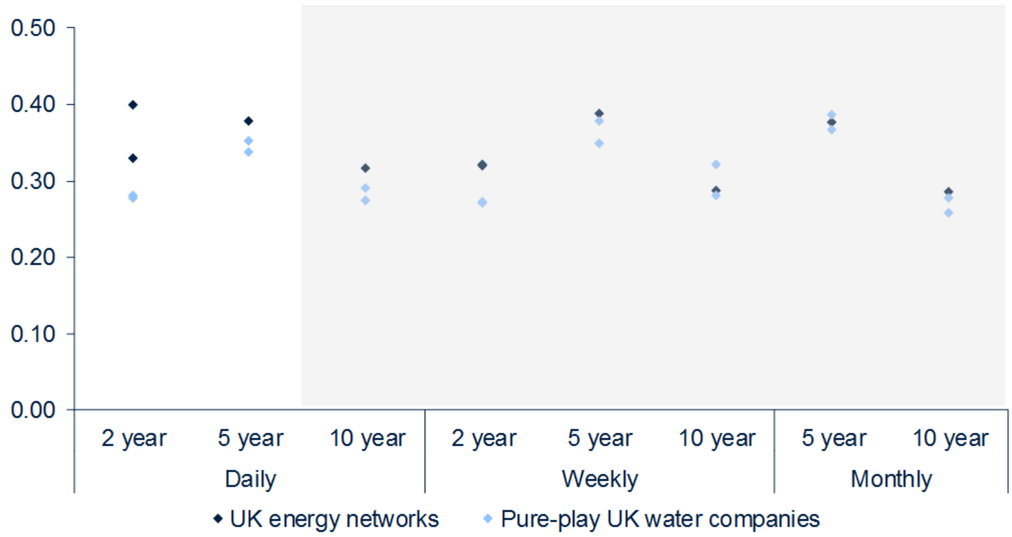
study note the existence of 'a clear disparity between the beta values of utility companies in the United States and the UK, which is usually attributed to the relatively safe operating environment in the United States'.[96]

This difference between the UK and the US asset betas suggests that the value of asset beta of National Grid's UK regulated business is likely to be higher than that of the National Grid Group.

In addition, we note that a preliminary analysis of this issue was presented in the Indepen Report, which Ofgem relies on for arriving at its asset beta range. The preliminary analysis in that report found that National Grid's US betas are 0.15 to 0.19 lower than National Grid's UK betas.[97]

Second, as shown in Figure 3.5 below, with the exception of the 10-year weekly estimates, the average asset beta for the energy networks (i.e. National Grid and SSE) has been consistently higher than the average asset beta of the two pure-play water comparators—United Utilities and Severn Trent.[98]

Figure 3.5 Comparison of asset betas for UK energy networks and UK pure-play water companies



Note: The cut-off date is 30 August 2019.

Source: Oxera analysis based on Bloomberg data.

As explained in the 2018 Oxera report, rapid technological change and an increased focus on decarbonisation give reasons to believe that the fundamental risk of energy networks is greater than that faced by water networks. Since then, new evidence to that effect has become available.

[96] Mayer, C., Alexander, I. and Weeds, H. (1996), 'Regulatory Structure and Risk and Infrastructure Firms: An International Comparison', p. 30.
[97] Indepen. (2018), 'Ofgem Beta Study – RIIO-2 Main report', pp. 38-9 https://www.ukrn.org.uk/wp-content/uploads/2019/01/final_beta_project_riio_2_report_december_17_2018_0.pdf, accessed 21 October 2019.
[98] Unregulated activities comprise a large proportion of Pennon Group's business. This is due to a waste management business relating to 'the recycling, energy recovery and waste management services provided by Viridor'. Waste management accounted for 59% of revenues and 23% of operating profits in 2017. See Pennon (2017), 'Annual Report and Accounts 2017', p. 120.

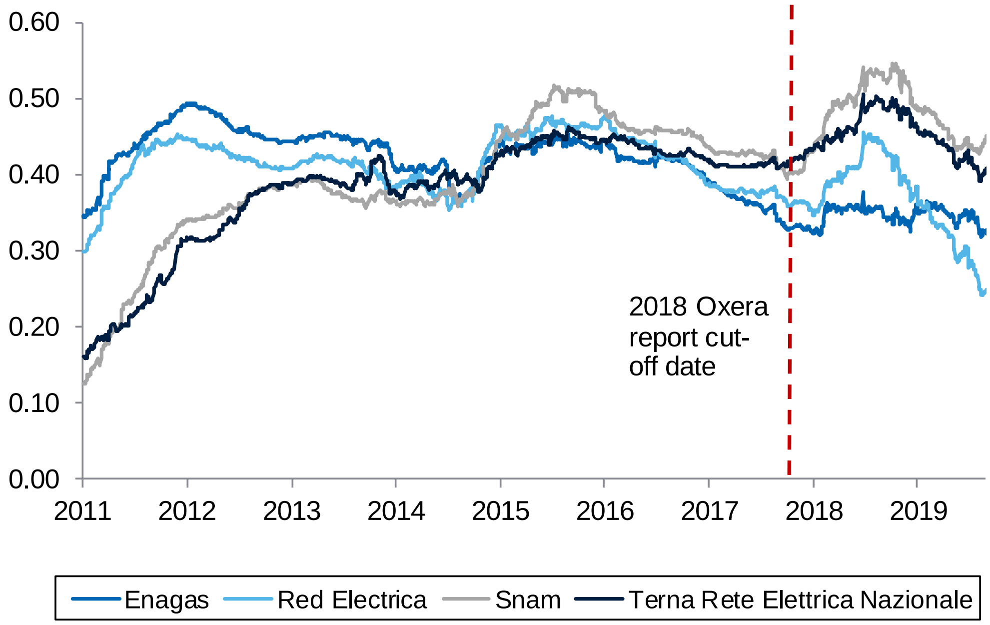
For example, in July 2018, National Grid introduced a new scenario for meeting carbon targets—'Community Renewables'.[99] This scenario differs in that it assumes that the carbon targets are met under a system with a high degree of decentralisation.[100] The large roll-out of decentralised intermittent generation may require significant adaptation from the grid. In March 2019, the UK government banned gas heating for new houses, with the aim of decarbonising domestic heating.[101] This raises the question of what utilisation gas networks will be able to achieve throughout RIIO-2 period and beyond, and is another example of heightened risk for energy networks compared to water networks.

In combination, the two issues outlined above suggest that there is a need to expand the comparator sample beyond the UK, as the UK comparator sample is unlikely to accurately reflect the risk profile for the energy networks in RIIO-2. As explained in Section 3.1.2, and consistent with our approach in the Oxera 2018 report, we see merit in considering also a sample of regulated European energy networks. Indeed, we are of the view that the assessment by investors of the underlying business risk may be more closely aligned to that of UK energy networks, as all of the companies in the European sample derive the majority of their revenues largely from European regulated activities.[102]

Figure 3.6 shows the evolution of two-year daily asset betas for each of the companies in our European comparator sample.

[99] National Grid (2018), 'Future Energy scenarios', July, p. 15, Figure 2.1 Scenario matrix, http://fes.nationalgrid.com/media/1363/fes-interactive-version-final.pdf, accessed 3 October 2019. For comparison, see the previous year's version: National Grid (2017), 'Future Energy scenarios', July, pp. 14–17, 'Scenario descriptions', http://fes.nationalgrid.com/media/1253/final-fes-2017-updated-interactive-pdf-44-amended.pdf, accessed 3 October 2019.
[100] See 2017 FES Workbook, tab 'ES3', and 2018 FES Workbook, tab 'ES2'.
[101] Harrabin, R. (2019), 'Gas heating ban for new homes from 2025', BBC News, 13 March, https://www.bbc.co.uk/news/science-environment-47559920, accessed 3 October 2019.
[102] Enagas (2019), '1H2019 Results', 30 July, p. 3, https://www.enagas.es/stfls/ENAGAS/Relaci%C3%B3n%20con%20inversores/Documentos/CNMV%201H2019.pdf, accessed 3 October 2019; KMPG (2018), 'Red Eléctrica Corporación, S.A.: Consolidated Annual Accounts', 31 December, p. 13, https://www.ree.es/sites/default/files/downloadable/CCAA_ingles.pdf, accessed 3 October 2019; Snam (2019), '2019 Half Year Report', 30 June, p. 23, https://www.snam.it/export/sites/snam-rp/repository/ENG_file/investor_relations/reports/interim_reports/2019/SNAM_2019_Half_Year_Report.pdf, accessed 3 October 2019; Terna (2019), 'Energy Is Our Responsibility: 2019 Half-Year Report', 30 June, p. 57, https://download.terna.it/terna/TERNA%20RELAZ_SEM%20ENG_8d715c21e8c2880.pdf, accessed 3 October 2019.

Figure 3.6 Two-year daily asset betas for listed European comparator companies



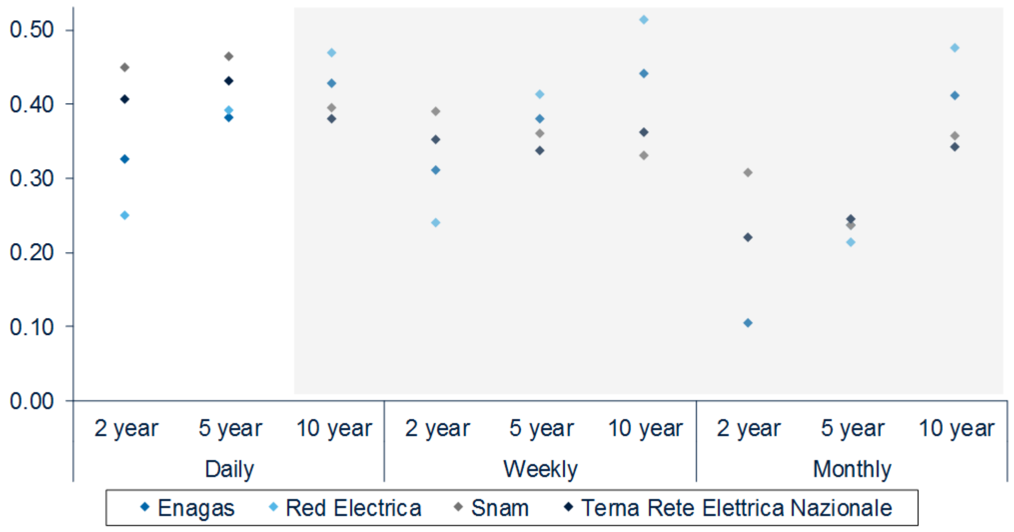
Note: Equity betas were estimated relative to the Eurostoxx TMI index. A debt beta of 0.05 is assumed. The cut-off date is 30 August 2019.

Source: Oxera analysis based on Bloomberg data.

The figure shows that since our last report, the asset betas for the energy networks in the European comparator group have decreased, which is consistent with the UK evidence. It is also notable that the asset beta of Red Eléctrica has diverged from the rest of the comparator sample.

Figure 3.7 demonstrates asset beta estimates for the European comparator sample for a range of frequencies and estimation windows.

Figure 3.7 Asset betas for listed European comparator companies under different frequencies and estimation windows



Note: The cut-off date is 30 August 2019.

Source: Oxera analysis based on Bloomberg data.

As Figure 3.7 illustrates, the European evidence for two- and five-year daily data suggests a slightly wider asset beta range of 0.25–0.46 than that implied by the UK evidence (0.28–0.40).

Having presented all the evidence on the estimation results, we now turn to the question of setting an appropriate asset beta range for RIIO-2.

In summary, following the arguments laid out above, we are of the view that an appropriate method for determining a preliminary asset beta range is to construct a sample made up exclusively of UK and European energy networks, and to take an average of the two- and five-year daily asset betas from that sample as the extremes of the range. Based on this method, we propose a preliminary asset beta range of 0.36 to 0.41. This information is presented in Table 3.4 below.

Table 3.4 Derivation of the preliminary asset beta range

	Daily	
	2 year	**5 year**
Enagas	0.33	0.38
Red Electrica	0.25	0.39
Snam	0.45	0.46
Terna	0.41	0.43
NG	0.33	0.38
SSE	0.40	n.a.
Average	**0.36**	**0.41**

Note: The cut-off date is 30 August 2019.

Source: Oxera analysis based on Bloomberg data.

As we explain in the next section, and consistent with the rationale set out in the Oxera 2018 report, the CAPM market beta does not necessarily capture all of the systematic risk faced by regulated networks. Therefore, in selecting a point estimate for the asset beta, we recommend using the upper half of the range. As such, we recommend a final asset beta range of 0.38–0.41 for this report.

We note that this range is lower than the one we had presented in the Oxera 2018 report. The decrease reflects the change in the market evidence.

3.4 The impact of political and regulatory risk

In our February 2018 report, we recommended setting the regulatory allowed cost of capital for energy networks in RIIO-2 by selecting an asset beta within the top half of the asset beta range. This recommendation was based on a number of considerations, including the forward-looking risks that energy networks face and the empirical shortcomings of the capital asset pricing model (CAPM) framework. For instance, we noted that the CAPM tends to under-predict equity returns for assets whose equity betas are less than 1 such as regulated utilities (see also later in this section, in relation to the 'low beta anomaly'). We maintain our position on those conclusions, and in addition, we note that, in March 2019, we submitted another report, on behalf of National Grid, that examined the political and regulatory risks that regulated utilities currently face ('The March 2019 Report').[103] The findings from that report, which we summarise below, provide additional evidence that the beta in the CAPM equation is unlikely to reflect the full level of risk faced by UK energy networks. As such, we maintain our earlier recommendation of selecting a beta point estimate towards the top end of the asset beta range.

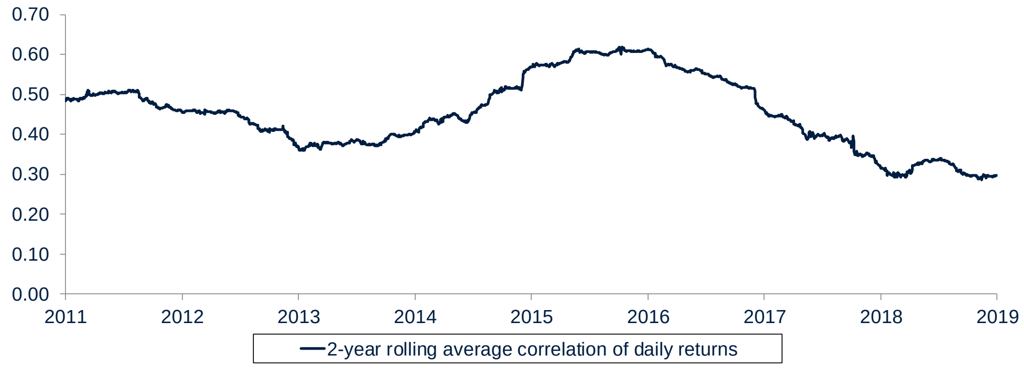
In the March 2019 report, we noted that an increase in political and regulatory risk for UK energy network is evident from:

- more frequent political and regulatory news triggering share price falls (i.e. sharp declines in reaction to news);
- an increase in share price volatility since 2016—a period during which the UK Labour party has asserted its policy of renationalising utilities if it were to come to power;
- a decline in the status of National Grid and other regulated utilities as 'defensive stocks';
- an increased focus on regulatory and political risk as a valuation driver in analyst assessments.

In addition to these findings, we now show that since mid-2016, the correlation of the UK networks and market returns has fallen substantially. This is illustrated in Figure 3.8.

[103] Oxera (2019), 'Assessment of political and regulatory risk', prepared for National Grid Group, 4 March.

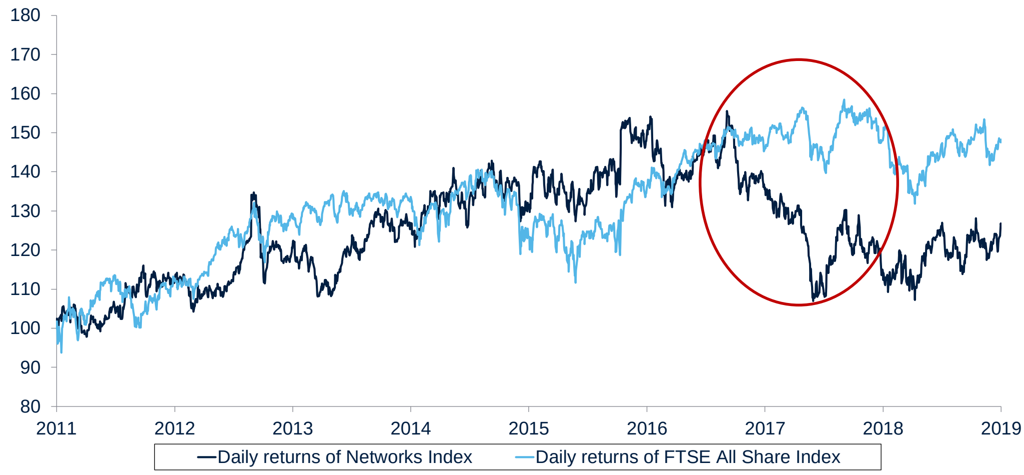
Figure 3.8 Average two-year rolling correlation of daily returns on UK networks and FTSE All Share Index



Source: Oxera analysis based on Datastream data.

By analysing the evolution of daily returns, we find that the decline in correlation is a result of the fall in the value of the networks' equity at the time of a growing/stable wider equity market. This is presented in Figure 3.9 below:

Figure 3.9 Total equity returns of the UK networks and the FTSE All Share indices (2011=100)



Source: Oxera Analysis based on Datastream data

As noted above, 2016 represents the time when the UK Labour party asserted its policy of renationalising utilities if it were to come to power. As such, we are of the view that the fall in the networks' value versus the FTSE All Share Index over the same period is a further demonstration that, in recent times, UK network companies have been exposed to heightened regulatory and political uncertainty.

We outlined a conceptual framework to account for the impact of this risk in the March 2019 report. The framework breaks down the total risk of a stock (as measured by share price volatility) to three types of risk as shown in the equation below:

Total risk (volatility of stock price) =

market systematic risk + other systematic risk + idiosyncratic risk

Political and regulatory risk can therefore manifest itself in three areas:

1. through market-wide risk (i.e. systematic market risk)—captured by the CAPM equity beta;
2. through other systematic risks—factors that affect multiple companies, the exposure to which cannot be eliminated by investing in a larger, more diversified portfolio of companies;
3. through idiosyncratic risk, i.e. company-specific consequences of political and regulatory actions. Understanding how this risk affects required returns and the cost of capital requires a set of assumptions about how investors price assets.

From the three risks outlined above, the CAPM predicts that investors only require a return for exposure to the systematic market risk, as it assumes that all other risks can be eliminated by investing in a well-diversified portfolio. However, in practice, the literature on arbitrage pricing theory and multi-factor models suggests the existence of systematic risk factors that are not picked up in the CAPM market beta but that are nevertheless priced by investors.[104]

For instance, tests of the empirical performance of the CAPM have revealed that the accuracy of the standard CAPM in predicting the cost of equity decreases the further away the equity beta is from unity.[105] One of the most relevant pieces of empirical evidence on the matter shows that in the USA, stocks with a low beta (such as utility companies) have consistently outperformed high-beta stocks.[106] This phenomenon, termed the 'low beta anomaly', suggests that the CAPM tends to underestimate the required return on equity for stocks with relatively low betas, such as utilities. This, in turn, suggests that investors require additional return that is not priced by the standard CAPM framework.

The premium that investors require for exposure to political and regulatory risk factors would in principle be best estimated using multifactor models. However, in the absence of appropriately calibrated multi-factor models and the preference of UK regulators to use the CAPM, it is important that due consideration is given to other systematic and priced idiosyncratic risk factors when interpreting the outputs from the CAPM for determining the cost of equity allowance for RIIO-2.

A pragmatic way to do this would be to select a beta point estimate towards the top end of the plausible beta range derived from the CAPM. Although this will not guarantee that investors will be adequately compensated for exposure to political and regulatory risk, it will reduce the probability of such factors creating an underinvestment problem in network assets.

3.5 Conclusion

In summary, based on the evidence presented in this section, we suggest a preliminary asset beta range of 0.36–0.41. We base this range on the averages of daily betas estimated over two- and five-year periods for the

[104] Chen, N., Roll, R. and Ross, S. (1986), 'Economic Forces and the Stock Market', *The Journal of Business*, **59**:3, pp. 383–403; Ross, S. (1976), 'The Arbitrage Theory of Capital Asset Pricing', *Journal of Economic Theory*, **13**, pp. 341–60.
[105] Asness, C., Moskowitz, T. J. and Pedersen, L. H. (2013), 'Value and momentum everywhere', *The Journal of Finance*, **LXVIII**:3; Fama, E. and French, K. (2015), 'Dissecting Anomalies with a Five-Factor Model', *The Review of Financial Studies*, **29**:1, 1 January 2016, pp. 69–103.
[106] Fama, E. and French, K. (2015), 'Dissecting Anomalies with a Five-Factor Model', The Review of Financial Studies, 29:1, 1 January 2016, pp. 69–103.

sample of UK and European energy networks. We are of the view that our comparator sample is preferable to Ofgem's for the following reasons:

- it excludes UK water networks
- it retains all the (two) UK energy networks from Ofgem's sample
- it includes a wider range of energy networks with similar risk characteristics to the UK energy networks.

In arriving at our preliminary range, we have also cross-checked our results against daily betas estimated over a ten-year period, weekly betas estimated over two-, five-, and ten-year periods, and monthly betas estimated over five- and ten-year periods. In de-levering equity betas we have adopted a debt beta of 0.05, based on empirical analysis. We have calculated the gearing using company-specific market values of equity and book values of net debt.

Similarly to the Oxera 2018 report, this report also suggests using the top half of the preliminary range as the recommended range for RIIO-2. The justification for doing so is consistent with the one provided in the Oxera 2018 report, albeit due to the additional empirical analysis conducted since the 2018 Oxea report, the rational focuses more heavily on the impact of policy and regulatory risk. In particular, we recommend using the top half of the preliminary range due to the following considerations:

- empirical studies demonstrated that the CAPM tends to underestimate the required equity return for holding equity with beta less than 1;
- there is evidence of systematic risk factors faced by energy networks that are not picked up in the CAPM market beta that are nevertheless priced by investors (e.g. policy and regulatory risk); and
- empirical analysis conducted since the 2018 Oxera report suggests that the level of political and regulatory risk, mentioned above, has increased over time, which, all else equal, would imply an increase in the level of return required by utility investors.

Based on the reasoning above, we use a final asset beta range of 0.38–0.41 for this report.

Having decided on the appropriate level of the CAPM parameters, we turn to the task of estimating the CAPM-implied cost of equity.

4 CAPM-based required equity returns for RIIO-2

Table 4.1 summarises the updated cost of equity parameters for the CAPM. In light of the updated evidence presented in Section 2 and Section 3, we recommend updating the cost of equity range to 5.98–7.09% CPIH-real.

Table 4.1 Summary of RIIO-2 cost of equity estimates

	Oxera 2018		Current evidence		Change	
	Low	High	Low	High	Low	High
Real TMR (%)	7.00	7.50	7.00	7.50	-	-
Real RFR (%)	0.50	1.00	-1.20	-0.79	-1.70	-1.79
ERP (%)	6.50	6.50	8.20	8.29	1.70	1.79
Asset beta	0.40	0.42	0.38	0.41	-0.02	-0.01
Gearing (%)	60	60	60	60	-	-
Debt beta	0.05	0.05	0.05	0.05	-	-
Equity beta	0.93	0.98	0.88	0.95	-0.05	-0.03
Real cost of equity (%)	6.51	7.34	5.98	7.09	-0.53	-0.25

Note: All figures are presented in CPIH-real terms and do not include a 50bp downward adjustment for expected outperformance as advocated by Ofgem.

Source: Oxera analysis.

As shown in Table 4.1, the cost of equity range exhibits a decrease relative to the levels estimated in the 2018 Oxera report, driven mostly by changes in the capital market evidence, and partly by changes in methodology (i.e. the method for weighting the evidence on asset betas).[107] The bridge between the cost of equity estimate put forward by Ofgem in the SSMD and the CAPM-based cost of equity range proposed in this report is set out in Appendix A1.

In the next section, we check the validity of the CAPM-based cost of equity range against a number of alternative sources of evidence.

[107] We discuss these changes in more detail in Section 3.

5 Alternative sources of evidence

This section provides alternative sources of evidence as points of comparison for the cost of equity range proposed in the previous section. The alternative sources of evidence include:

- the asset risk premium (section 5.1);
- the individual stock DDM (section 5.2);
- returns on winning OFTO bids (section 5.3);
- discount rates used by infrastructure funds (section 5.4);
- regulatory precedent (section 5.5).

5.1 Asset risk premium

The asset risk premium is the additional compensation over the RFR that investors require to invest in a company as a whole. This is the premium for bearing equity risk assuming zero gearing, and should be higher than the risk premium on debt given the lower priority of equity relative to debt in terms of claims on cash flows.

A risk premium on energy network assets would be expected to be greater than that on the investment-grade bonds that these companies issue. On the day of Ofgem's cut-off date for their analysis for the RIIO-2 Methodology Decision, 29 March 2019,[108] the debt risk premium was around 150bp for A- and BBB-rated corporate bonds.[109]

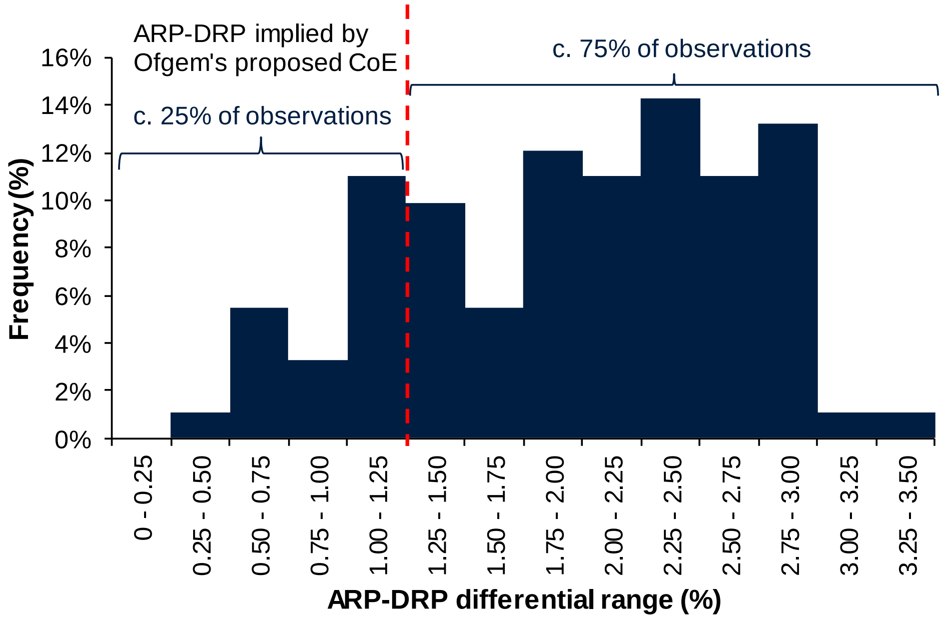
The CAPM parameters recommended by Ofgem for RIIO-2, had an asset beta range of 0.35–0.40 (assuming a debt beta range of 0.10–0.15),[110] and ERP of 7.00–7.50%,[111] implying an asset risk premium of 2.45–3.00%.[112] As described in section 3.2.5, a debt beta greater than 0.05 is not supported by market evidence. Correcting Ofgem's range for this fact results in an asset beta range of 0.30–0.37 and an asset risk premium of around 2.10–2.80%. This implies a differential between the asset risk premium and the debt risk premium of around 0.95–1.50% or 0.60–1.30% depending on the debt beta assumption.

Ofgem's proposed estimate for the cost of equity under RIIO-2, 4.80% CPIH-deflated,[113] broadly corresponds to the middle of its CAPM-implied range (before making the adjustment for expected versus actual returns).[114] Therefore, we take the middle of the range calculated in the previous paragraph as the implied differential between the asset risk premium and debt risk premium (the ARP–DRP differential). We then benchmark the ARP–DRP

[108] Based on Ofgem's analysis of the RFR being as of 29 March 2019, we assume this was Ofgem's cut-off date for their analysis. See Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance,' 24 May, Table 6.
[109] This is calculated by taking the average of the yield on the iBoxx A and BBB 10-year+ index as of Ofgem's assumed cut-off date. We then subtract Ofgem's working RFR assumption of -0.75% (CPIH-deflated) after inflating for Ofgem's working CPIH assumption of 2.00%, see (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance,' 24 May, para. 1.11 and Table 9. We then subtract the expected loss assumption from our asset risk premium report of 30bp. See Oxera (2019), 'Risk premium on assets relative to debt,' 25 March, p. 7.
[110] Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance,' 24 May, Table 8.
[111] We derive the ERP using the estimates from Table 9 in Ofgem's decision. See Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance,' 24 May, Table 9. This is calculated as ERP = TMR – RFR, e.g. 6.25% – (-0.75%) = 7.00% and 6.75% – (-0.75%) = 7.50%.
[112] We calculate asset risk premium using the formula: Asset risk premium = Asset beta × ERP
[113] See Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance', 24 May, Table 4.
[114] See Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance', 24 May, Table 9.

differential implied by Ofgem's estimates to the ARP–DRP observed for the debt issued by UK utilities. We find that Ofgem's ARP–DRP differentials lies in the bottom quartile of the ARP–DRP differential observed for the bonds issued by UK utilities.[115] Figure 5.1 illustrates this graphically.

Figure 5.1 Summary of ARP–DRP cross-check



Note: The analysis, presented in the figure assumes a debt beta in the middle of Ofgem's range of 0.10–0.15, i.e. 0.125. If our assumption on debt beta equal to 0.05 is adopted instead, Ofgem's ARP-DRP differential still falls within the bottom quartile.

Source: Oxera analysis.

Taking the debt risk premium as given, the fact that Ofgem's ARP–DRP differential falls to the low end of the distribution implies that Ofgem's cost of equity allowance is low, relative to values observed in the market.

In contrast, Oxera's revised cost of equity range implies a differential between the asset and debt risk premium that falls within 39th–74th percentile (midpoint 55th percentile) of empirically observed distribution. This implies that the cost of equity proposed by Oxera is marginally higher than that implied by historically observed data. Such an outcome is to be expected, given the recent flight to quality and increased political and regulatory uncertainty, discussed previously.

5.2 Individual stock DDM

In our report from February 2018, we applied a DDM similar to that used to estimate the ERP and TMR to the UK-listed networks as a cross-check to the cost of equity estimates implied by the CAPM. Precisely, we used a single-stage DDM with a long-term dividend growth forecast equal to the five-year nominal UK GDP growth rate.[116] The long-term growth rate assumption is based on the UK growth assumption as in the single-stage market DDM model presented in section 2.2.2.

[115] For more detail on the methodology, please see Oxera (2019), 'Risk premium on assets relative to debt. Benchmarking CAPM-implied equity returns', 25 March.
[116] Based on IMF (2008), 'World Economic Outlook, October 2018: Challenges to Steady Growth', 3 October.

Since the publication of our 2018 report, the nominal cost of equity for National Grid implied by the individual stock DDM increased from 8.9% to 9.3%.

The range of the nominal costs of equity for water implied by spot estimates of individual stock DDMs also increased, from 7.7%–8.7% to 8.3%–9.2%. The direction and magnitude of the change are broadly consistent with insights from the equity market DDM. As in the previous report, the cost of equity estimates for National Grid are still the highest in the comparator sample, further supporting the view that the fundamental risk of energy networks is greater than that faced by water networks. Furthermore, as noted in Section 3, the UK division of National Grid's regulated business has a higher risk profile than the US division. As the DDM analysis reflects the implied cost of equity for the entire National Grid business, the estimates presented in this report are likely to be an underestimate of the DDM-implied cost of equity of National Grid's UK business. The results from this analysis are presented in Table 5.1.

Table 5.1 DDM cost of equity estimates (%)

	2018 Oxera report	Current estimates	Change
National Grid	**8.9**	**9.3**	**+0.4**
Pennon	8.4	9.2	+0.8
United Utilities	8.7	8.9	+0.2
Severn Trent	7.7	8.3	+0.6

Note: The cut-off date for the 2018 Oxera report is 10 November 2017. The cut-off date for current estimates is 30 August 2019.

Source: Oxera analysis based on Bloomberg, Refinitiv Datastream, and IMF World Economic Outlook.

In light of the arguments presented in section 3, we focus on DDM-implied cost of equity as our primary cross-check.

Deflating the nominal cost of equity implied for National Grid using a CPIH assumption of 2% yields a CPIH-real cost of equity of 7.16%, which is broadly aligned with the top end of our proposed cost of equity range of 5.98–7.09%.

5.3 OFTO returns

As a cross-check to its cost of equity estimate, Ofgem considered the implied equity IRRs from winning OFTO bids.[117] Using the latest OFTO tender round bids, Ofgem arrived at a nominal equity IRR of 7.2% and a CPIH-real equity IRR of 5.1%.[118]

OFTO projects are operational assets with a very different risk profile compared to the onshore energy networks regulated by RIIO-2. As such, we consider that any comparison is inevitably invalid and likely to significantly underestimate the cost of capital for a network that undertakes capital and replacement expenditure in addition to operational expenditure.

In addition to the above, we also note that Ofgem has revealed only summary information for the implied equity IRRs based on portfolios of OFTO bids at different points in time.[119] The opacity of this evidence and the calculations

[117] Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision – Finance', 24 May, paras 3.183.
[118] Ofgem (2019), 'RIIO-2 Sector Specific Methodology Decision', 24 May, para. 3.186 and Table 2.
[119] Ofgem (2018), 'RIIO-2 Sector Specific Methodology Annex: Finance', 18 December, Figure 14.

performed on it is a concern, given the central role it plays in determining the implied value of OFTO equity IRR.

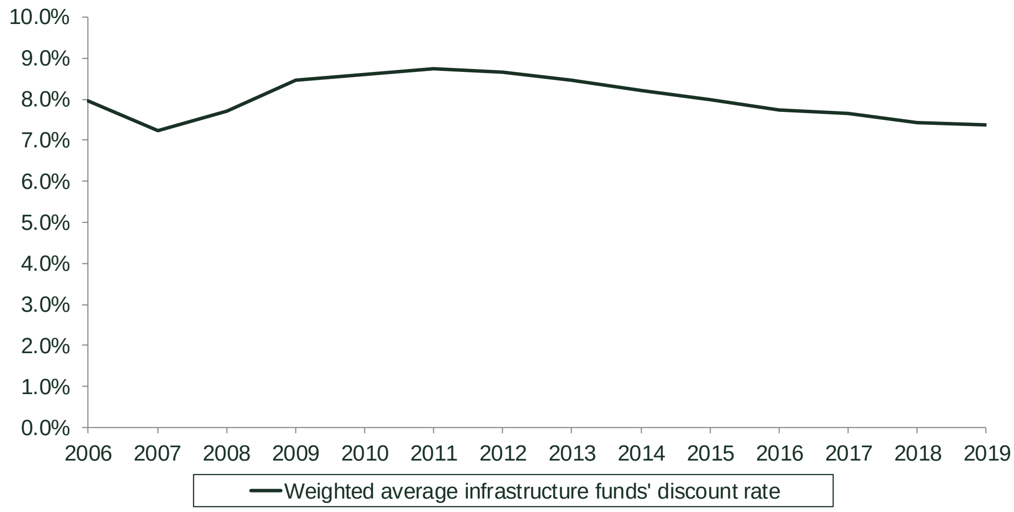
We therefore consider that the OFTO data cannot be used to infer the cost of equity for a regulated energy network.

5.4 Infrastructure fund discount rates

In March 2019, we submitted a report in which we assessed the appropriateness of using the discount rates used by the six listed infrastructure funds identified by Ofgem as a cross-check for the cost of equity in RIIO-2. That report presented a comprehensive review of the infrastructure funds' risk and return characteristics. The conclusion of the review suggested that the funds' discount rates were not an appropriate cross-check for the CAPM cost of equity range. This was mainly driven by the fact that the funds' asset composition makes them less risky than energy networks. Moreover, where funds' portfolio investments face greater revenue or volume risks than energy networks, these are generally hedged by long-term or availability-based contracts and/or government subsidies e.g. renewable obligation certificates (ROCs). However, for completeness, we present the updated evidence on infrastructure fund discount rates below.

The updated evidence on the infrastructure funds discount rate shows that the weighted average discount rate has remained constant at 7.4% based on the funds' 2018 and 2019 annual reports.[120] This is shown in Figure 5.2 below.

Figure 5.2 Evolution of infrastructure funds' weighted average discount rate



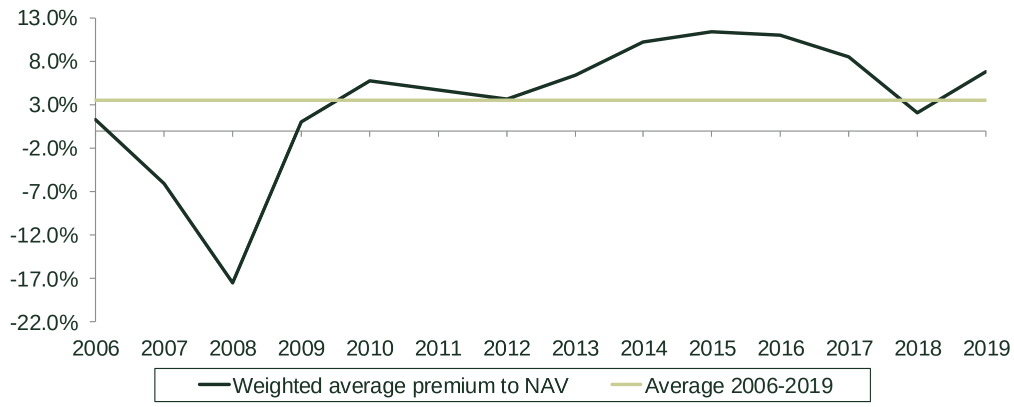
Note: Sample made up of BBGI SICAV, JLIF, HICL, GCP Infrastructure, and INPP. 2019 figures do not include JLIF, as the fund was sold in late 2018, and INPP, who has not yet published the 2019 annual report.

Source: Oxera analysis based on the funds' annual reports.

At the same time, the premium to NAV has increased from 2.1% (based on the 2018 annual reports) to 6.5% (based on the 2019 annual reports).[121] The evolution of the NAV premium is shown in Figure 5.3 below.

[120] This figure excludes 3i Infrastructure from the sample. Including 3i in the sample increases the weighted average discount rate to 8.6%.
[121] These figures exclude 3i Infrastructure from the sample. If 3i was included in the sample, the NAV premium would increase to 10.7%.

Figure 5.3 Weighted average premium to NAV for infrastructure funds



Note: Premiums to the NAV are estimated using the closing share price on the same day that the NAV was calculated by the fund, or using the next available share price. 'Long-term average' is the average premium to the NAV estimated over 2006–19. NAVs are taken from the company's annual or interim reports and share price data is taken from Refinitiv Datastream.

We note that not all the funds have data available from 2006, as most of them were listed after 2006. Precisely, the earliest available data for the funds are as follows: BBGI, 2011; HICL, 2006; JLIF, 2010; GCP, 2011; INPP, 2006.

2019 figures do not include JLIF, as the fund was sold in late 2018, nor INPP, which has not yet published the 2019 annual report.

Source: Oxera analysis based on data from annual reports of infrastructure funds and Refinitiv Datastream.

A positive NAV premium may be caused by one or both of the reasons below:

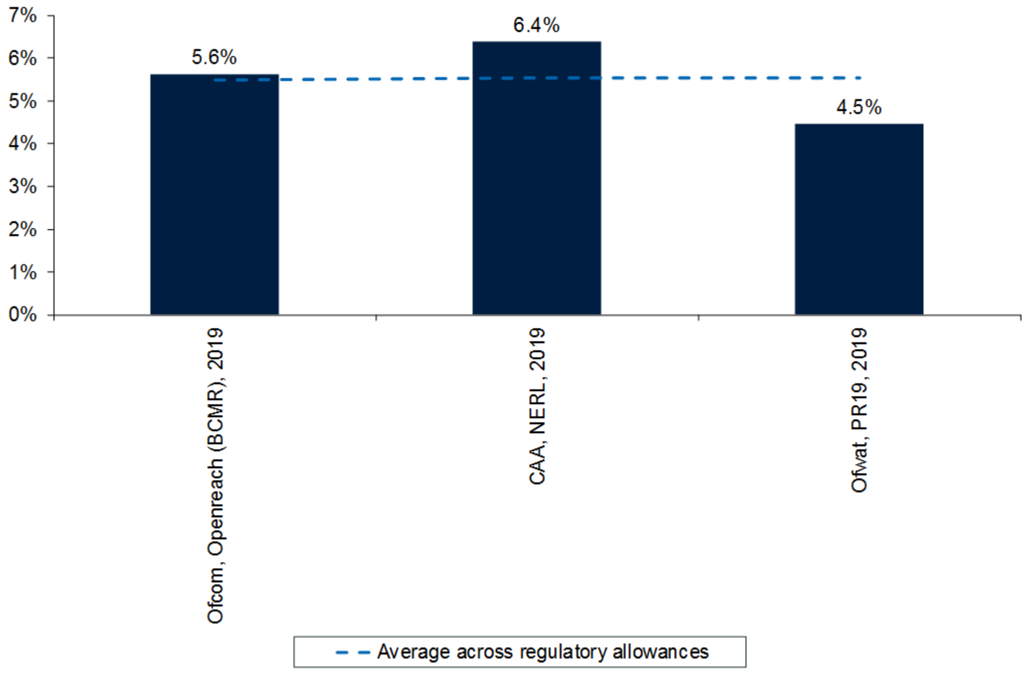
- the discount rate used to appraise the value of assets in the fund is higher than the market discount rate for the same assets;
- the assumptions on the future cash flows of the fund, used to appraise the NAV, are more conservative than those implicitly used by the fund investors.

In sum, we remain of the opinion that the infrastructure funds' discount rates are not an appropriate benchmark for the cost of equity in RIIO-2 due to the fundamental differences in the risk profile of the infrastructure funds' assets and those of the UK energy networks.

5.5 UK regulatory announcements

Figure 5.4 shows the allowed cost of equity adopted in regulatory announcements in the UK for 2019.

Figure 5.4 UK regulatory announcements for the allowed cost of equity in 2019 (post-tax, CPIH real)



Note: We present CPIH real numbers to allow an easier comparison with the RIIO-2 range. We convert the RPI real precedents to CPIH real by adding our assumed wedge of 100bp.

Source: Oxera analysis based on regulatory determinations.

Recent regulatory announcements have been lower on average than the cost of equity range recommended in this report. However, none of these determinations are final, as they are all subject to update and appeal. This means that these figures might be amended and become redundant in the near future. As such, it would not be appropriate to treat them as cross-checks until any potential appeal points are officially resolved.

The recent UK regulatory announcements also rely heavily on a number of recommendations made in the UKRN study.[122] The similarity of approach and assumptions across different regulators means that these cannot be regarded as independent data points, which undermines their value as cross-checks.

5.6 Conclusion

In summary, this section provided an overview of the alternative sources of evidence for the cost of equity.

Our primary cross-check is the DDM-implied cost of equity for National Grid. This suggests a CPIH-real cost of equity of 7.16%, which is broadly in line with the top end of our proposed cost of equity range of 5.98–7.09%.

In addition, as in the 2018 Oxera report, we also focus on benchmarking the differential between asset and debt risk premium against that implied by the debt issued by UK utilities, as a way to check the cost of equity allowance. This suggests that Ofgem's cost of equity allowance is low relative to the returns expected in the industry, as the differential between asset and debt risk

[122] UK Regulators Network (2018), 'Estimating the cost of capital for implementation of price controls by UK Regulators'.

premium implied by Ofgem’s allowance falls towards the low end of the empirical distribution. In contrast, Oxera’s cost of equity range implies a differential between asset and debt risk premium that falls within the 34th–79th (midpoint 55th) percentile of the empirically observed distribution.

6 Conclusions

As presented in section 4, the CAPM evidence suggests a 5.98–7.09% range for CPIH-real cost of equity. Our primary cross-check, the DDM-implied cost of equity for National Grid, is broadly consistent with the top end of this range, at 7.16%.

We have also conducted the cross-check for internal consistency of the cost of equity calculation by benchmarking the asset risk premium implied by our cost of equity range to the debt premia on the bonds of UK utilities. Oxera's cost of equity range implies a differential between asset and debt risk premium that falls within the 39th–74th (midpoint 55th) percentile of the empirically observed distribution. This implies that the cost of equity range proposed in this report is marginally higher than that implied by historically observed data. Such an outcome is to be expected, given the recent flight to quality and increased political and regulatory uncertainty, discussed previously.

The revised cost of equity range therefore reflects the reduction in yields on government bonds and bonds issued by UK utilities, whilst preserving the relationship between the expected returns on equity and debt. The cost of equity presented in this report is consistent with the networks remaining financeable from the perspective of equity investors.

In contrast, Ofgem's working assumptions on cost of equity fall towards the lower end of the empirical distribution, when subjected to the test. This implies that Ofgem's risk premium allowance for equity relative to debt is relatively low and raises questions about whether the networks would be financeable from the perspective of equity investors.

As explained in the Oxera 2018 report, selecting the point estimate within the range requires striking the balance between higher consumer bills in the short-term and providing adequate incentives to invest to deliver the consumer benefits of network resilience and enhancement. This trade-off is particularly important over the long term, as the rational response to an allowed return lower than the cost of capital would be to develop business plans that minimise investment, posing a risk to reliability and innovation in the sector.

Based on Oxera's analysis of this trade-off, the New Zealand Commerce Commission maintained the view that in the case of electricity networks, the potential damage from the loss of reliability is significant and thus, requires applying a consistent premium to the midpoint of the range across multiple price control periods.[123] This implies that for RIIO-2, it would be appropriate for the cost of capital allowance to be set above the midpoint of the range as well.

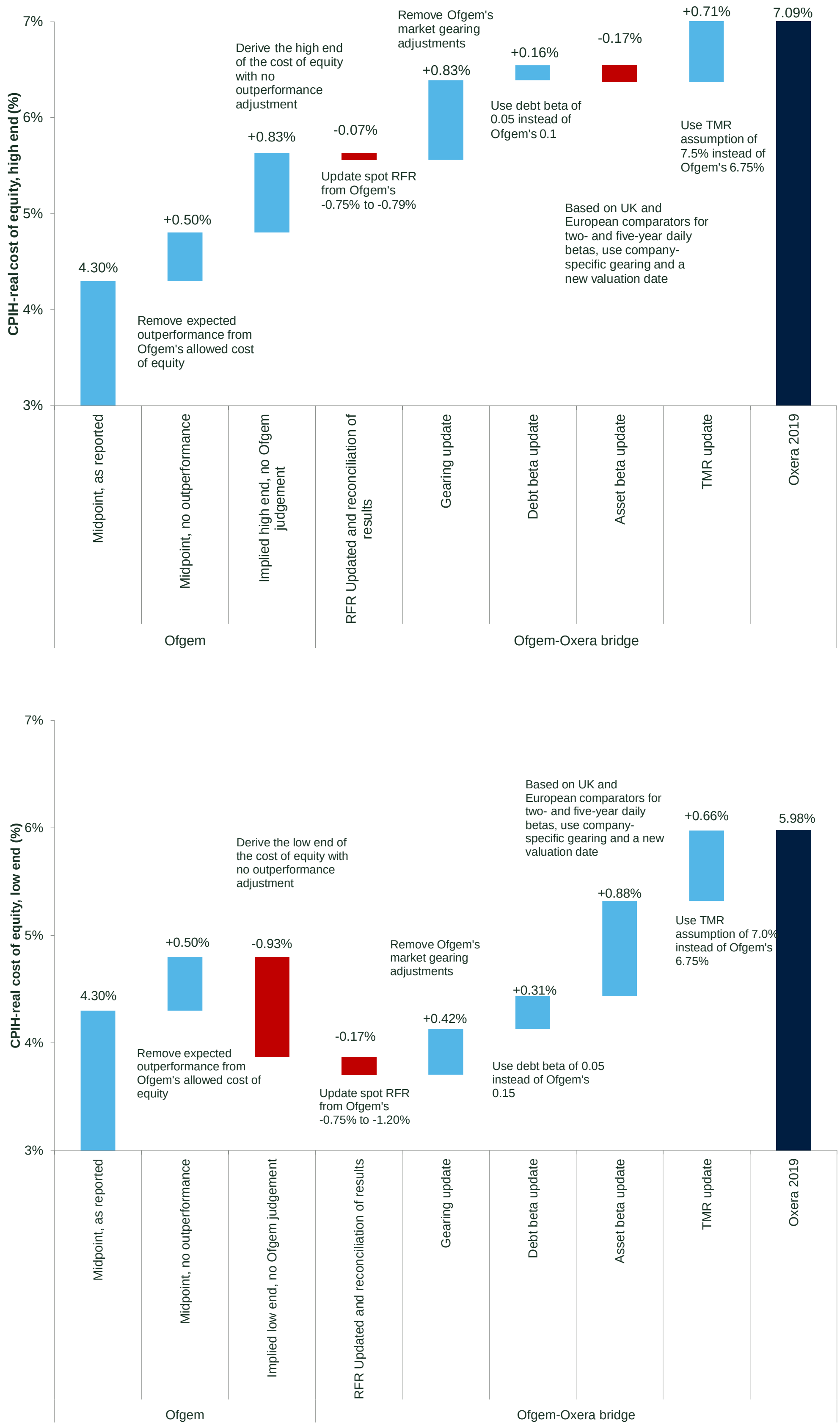
The risk of underinvestment is closely connected to the issue of regulatory stability. Given that regulated networks make investment decisions that span multiple price control periods, limiting volatility in allowed returns from one price control period to the next facilitates the securing of long-term investment. This is particularly important for RIIO-2, during the time when regulated utilities are exposed to heightened political uncertainty, which noticeably affects the perception of investors of the risks of these businesses (see section 3.4). Moderating the change in the allowed return on equity for the RIIO-2 controls compared with the RIIO-1 controls would support long-term investment decisions.

[123] Commerce Commission of New Zealand (2014), 'Amendment to the WACC percentile for price-quality regulation for electricity liens services and gas pipeline services. Reasons paper', 30 October, p. 101.

A1 Comparison to Ofgem SSMD

Figure A1.1 illustrates the reconciliation bridges between the cost of equity range presented in in this report and the allowed equity return range in Ofgem’s SSMD.

Figure A1.1 Cost of equity bridge between Ofgem and Oxera's estimates



Note: All figures are presented in CPIH-real terms. The changes depicted in the chart are cumulative, the labels indicate an incremental percentage change in cost of equity.

Source: Oxera analysis.

The far left-hand side of the figure shows Ofgem's proposed allowed equity return midpoint estimate of 4.30%. From left to right, we incrementally introduce changes to the equity return calculation, until the final bar in the chart arrives at our recommended range of 5.98–7.09%.

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