NERA
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# Cost of Equity for SPT in RIIO-T2

## Report for Scottish Power Transmission plc

19 April 2019

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# Executive Summary

Scottish Power Transmission (SPT) commissioned NERA Economic Consulting (NERA) to estimate the cost of equity for RIIO-T2 price control period. We set out our estimate of the cost of equity, as well as respond to Ofgem's recent RIIO-2 framework and sector consultations. We also respond to a series of reports commissioned by Ofgem from CEPA, Indepen, and Dr Robertson, an academic consultant, and a report commissioned by UK Regulators Network (UKRN) on setting the cost of capital.

**We estimate the cost of equity using a total market return (TMR) approach**

To estimate the cost of equity, we draw on a total market return (TMR) approach. The TMR approach involves estimating the TMR and RFR directly, and calculating the ERP as the difference between the TMR less the RFR. The alternative approach is to estimate the ERP and RFR separately, which taken together provides an implied TMR. The reason for adopting a TMR approach is the inverse relationship between the RfR and ERP elements of the TMR. Estimating the two parameters separately creates the risk of combining inconsistent estimates, e.g. an RFR based on low short-term market data with a long-run historical ERP, providing an overall TMR which is biased downwards.

In its framework and sector consultation, Ofgem also proposes to adopt a TMR approach at RIIO-2, in line with recommendations from UKRN commissioned report. The difference between us relates to how we have interpreted the evidence to inform the TMR.

**Our TMR range of 6.5 to 6.8 per cent (real, RPI) draws on DMS long-run historical returns, adjusted for the RPI effect**

To estimate the TMR, we draw on long-run historical estimates of the TMR based on data from Dimson, Marsh and Staunton (DMS) database, which provides long-term time series data on returns on stocks, bonds, bills as well as inflation over the period since 1900, i.e. including 118 years of data. The DMS database is the standard reference point for UK regulators including the CMA as well as financial practitioners.

We calculate updated estimates for the TMR drawing on the estimators used by the CME NIE 2014 decision: these includes simple as well as overlapping arithmetic averages, as well as "Blume" and "JKM" estimators. These latter two provide weighted averages of arithmetic and geometric means to provide unbiased estimates of the forward-looking TMR, depending on the assumption of the typical holding period. As shown, the longer the holding period, the greater the weight on geometric means, and the lower the estimate.

**Table 1: Long-run DMS TMR estimates lie in range of 6.2 to 7.1 per cent (real, RPI-deflated) for different averaging methods and holding periods**

| | Simple | Overlapping | Blume | JKM |
|---|---|---|---|---|
| 1Y holding | 7.1 | 7.1 | 7.1 | 7.1 |
| 2Y holding | 6.6 | 7.0 | 7.1 | 7.1 |
| 5Y holding | 6.7 | 6.8 | 7.0 | 7.0 |
| 10Y holding | 6.8 | 6.7 | 7.0 | 6.7 |
| 20Y holding | 7.1 | 6.8 | 6.8 | 6.2 |

*Source: NERA calculations using DMS (February 2018), Credit Suisse Global Investment Returns Yearbook 2018 (DMS data since 1988 converted to real RPI-deflated figures for consistency with earlier data).*

We conclude that the TMR should be based on holding periods of 1 to 5 years, based on empirical evidence of typical investor holding period. However, we do not propose to place weight on the simple average method, as the number of observations is relatively limited for holding periods of 2 to 5 years (e.g. for 5 years, the TMR is based on around 20 or so observations) and the estimates are not stable over time as a result. Based on these considerations, the evidence supports a historical real TMR (RPI-deflated) of 6.8 per cent to 7.1 per cent, as shown by the highlighted cells in the Table above.

As a further step, we apply a downward adjustment to our range to reflect the methodological changes by the ONS in 2010, which led to an estimated structural increase in the measure of RPI inflation ("the formula effect"), and an increase in the RPI-CPI wedge of around 30 bps. Applying a 30 bps reduction to the derived historical TMR range, we estimate an expected TMR of between 6.5 and 6.8 per cent (real, RPI) which allows for a structurally higher measure of RPI inflation over RIIO-2.

**In Ofgem's step 1, it relies on UKRN estimate for TMR of between 6 to 7 per cent (CPI) or 5 to 6 per cent (RPI), but which we consider relies on an unreliable CPI historical series**

Ofgem adopts a three-step approach to estimating the allowed cost of equity, where step 1 involves estimating a CAPM based cost of equity. To do so, Ofgem proposes a TMR based on long run realised returns of 6.25 to 6.75 per cent (real, CPIH), based on the 2018 UKRN report range of 6 to 7 per cent (real, CPI) or 5 to 6 per cent (real, RPI). UKRN's 2018 proposed TMR in RPI terms (5 to 6 per cent) is around 150bps lower than the 2003 UKRN. According to Ofgem, the proposed range is lower because of the lower realised returns up to 2018 (c. 25bps), lower upward adjustment from geometric to arithmetic mean given revised views on returns predictability (c. 25bps) and a switch from RPI to CPI(H) inflation (c. 100bps). The UKRN report draws on a so-called CPI Millennial database, which back-cast CPI over the period from 1900 to 1989, its first official publication date.

We show that the historical inflation data labelled as CPI in the Millennium dataset does not represent a reliable measure of CPI inflation going back to 1900 and therefore should not be used to estimate the historical real TMR. Indeed, for a substantive period of the analysis, the period 1915 to 1949, the supposed CPI series is in fact identical to the official RPI series. Instead of drawing on an unreliable CPI series, the *historical* real TMR should be estimated using RPI inflation, which is the most reliable measure of UK historical inflation going back to 1900, as per our own approach.

We also show that the UKRN report assumption of returns predictability is contentious and that established TMR estimators by Blume and JKM, which also consider serial dependence, support a smaller adjustment than applied in the UKRN report to reflect long investment horizons. Correcting for these two factors, would provide a TMR (RPI deflated) based on our approach as described above.

**In Ofgem's step 2, it draws on a series of cross-checks, key among these, CEPA's DGM model which we consider relies on unsubstantiated assumptions**

In step 2, Ofgem compares its CAPM based cost of equity to a number of cross-checks. Principally, Ofgem relies on a dividend growth models (DGM) developed by CEPA which provides forward looking evidence for the TMR in a range of 4.4. to 5 per cent (RPI-deflated).

CEPA's DGM is understated, due to implausibly low assumptions around dividend growth rates, a key determinant of the implied TMR. CEPA assumes that FTSE dividends grow in line with short-term and long-term nominal growth in UK GDP. This assumption is incorrect for a number of reasons. First, FTSE All-Share companies derive over 70 per cent of their earnings from outside of the UK, which have higher forecasts of GDP growth than assumed by CEPA (and PwC) for the UK. Second, short-term UK GDP forecast growth rates are somewhat depressed (e.g. due to Brexit) and are substantially lower than independent analyst forecasts of dividend growth rates for FTSE stocks, which are used by the Bank of England as a basis of forecasting short-term dividend growth in its own DGM.

By contrast, we cross-check our long-run historical TMR estimates drawing on independent DGM by Bank of England, which supports a range of between 7 to 8 per cent, i.e. the range lies largely above our historical TMR estimated range.

We also explain that Ofgem's other cross-checks support an upward adjustment to the CAPM-based cost of equity. For example, MAR premium for two of the three publicly listed UK utility companies has been mostly negative over the last year, and the equity IRRs for OFTOs winning bidders support a cost of equity of 5.2 per cent (real, CPIH), and infrastructure discount rates support a cost of equity of 5.1 to 8.2 per cent (real, CPIH).

In a final step 3, Ofgem proposes to set the cost of equity at the bottom end of the range to allow for supposed systematic outperformance by companies. Ofgem claims that the allowed return can be set below the expected or required return as investors expect to outperform on other aspects of the control; this is termed the "informational wedge". In a separate report commissioned by the ENA, the report shows that the proposed downward adjustment goes against all previous regulatory decisions; there is no evidence of long-term systematic outperformance; and, no reason to assume outperformance over RIIO-2.

**Our estimate of the RfR is based on Ofgem's spot rate, and long-run average which mitigates risk**

We conclude an RfR of -1.68 to 1.25 per cent for RIIO-T2. The lower bound reflects Ofgem's risk-free rate assumption, based on the spot rate of the 20-year index-linked government bond on 26 October 2018.[1] We assume that risk-free rate indexation mechanism

[1] Ofgem (December 2018), RIIO-2 Sector Specific Methodology Annex: Finance, para 3.49.

that Ofgem has proposed for RIIO-2 applies, and therefore we do not apply an ex ante uplift to current market rates. However, if an RfR indexation mechanism does not apply, the short-term market evidence should be adjusted to incorporate an uplift for expected changes in rates.

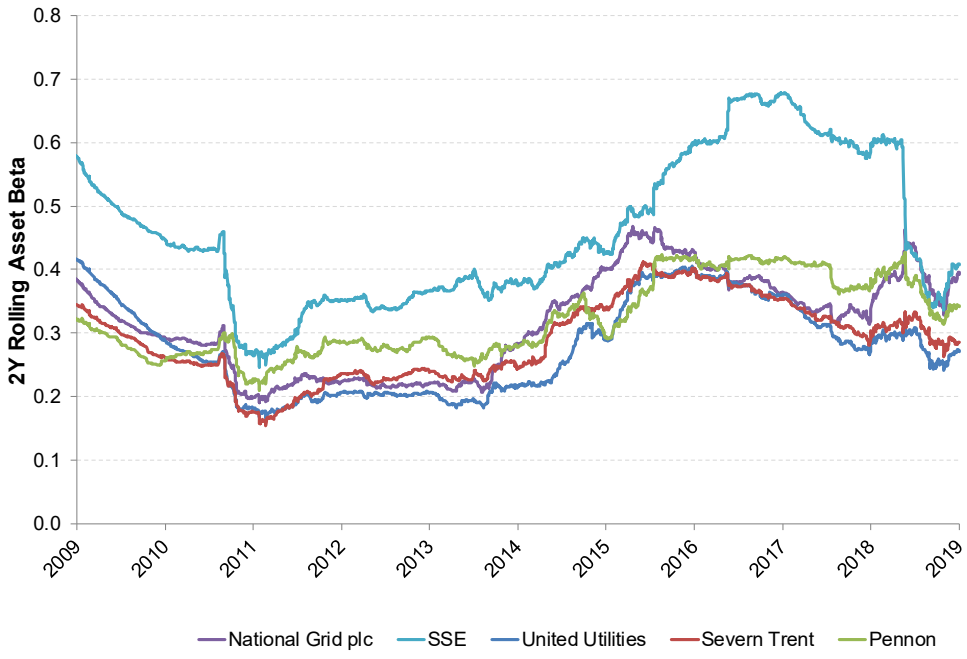
The upper bound is in line with the RfR used by the CMA in its 2015 Bristol Water determination. This approach is consistent with UK regulators' approach of placing greater weight on long-run evidence to avoid setting the allowed rate of return which varies with the business cycle which contributes itself to co-variant risk, as well as regulatory risk.

The division of the TMR into the RFR and ERP is far less material in determining the overall allowed cost of equity than the determination of the TMR itself, the critical factor.

**Empirical asset beta estimates support an increase in beta for SP at RIIO-2**

Of UK listed network companies – NG plc, United Utilities, Severn Trent, SSE and Pennon – shows that UK utility betas have increased from low levels during the time of the RIIO-1 price control, which coincided with the "flight to quality" in the aftermath of the financial crisis (see Figure ). The average two-year asset beta of networks stands at 0.34, or 0.32 if we exclude SSE. SSE is predominantly a non-network business, and its beta shows volatility over recent periods because of the effect of Brexit. The pure networks' businesses are less affected. NG plc's has a two-year asset beta toward the top-end of the range for our comparators at 0.39.

**Figure 1: 2Y rolling asset betas for UK utilities have increased since RIIO-T1, as UK emerges from the financial crisis**




*Source: Bloomberg, NERA analysis, cut-off: 21 September 2018, daily data, reference index: FTSE All Share.*

**Our comparative risk analysis suggests that SPT investors face greater risks, as supported by the empirical betas**

In recent price controls, UK regulators have set asset beta allowances in the range of 0.3 (for water) to 0.44 (for aviation: HAL and NATS). At RIIO-1, Ofgem allowed asset betas of 0.34 and 0.38 for NGGT and NGET, respectively, and higher asset betas of 0.43 for SPT and SHETL reflecting greater capex risk as measured by capex:RAV. Our comparative risk analysis suggests that energy networks face higher risk than water networks in relation to system operability risks and greater exposure to stranding risk due to government's decarbonisation plans. Our analysis also shows that TOs face greater risks than other energy networks because of the relative complexity of the investment programme, as acknowledged by Ofgem at previous reviews, competition risks from Ofgem's "competition proxy" and special purpose vehicle (SPV) models, and uncertainty over the future role of TOs due to embedded generation.

The analysis justifies a continuation of higher asset betas for TOs relative to other regulated network assets.

**NG plc's composite asset beta understates the risk associated with NG UK network assets, given lower risk US operations**

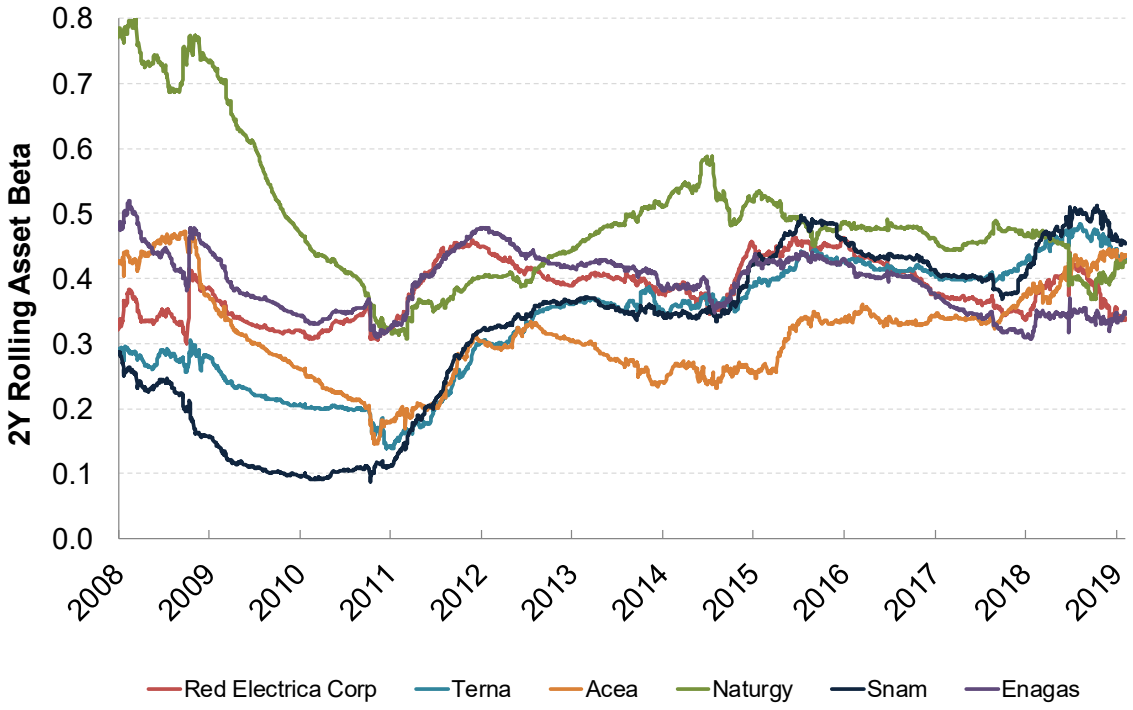
We consider that the most direct comparator for SPT is NG, as the only listed energy network. (SSE has a high weighting of generation assets.) However, NG plc's composite beta reflects the combined systematic riskiness of NG plc's UK and US operations. UK and US operations have a similar share of NG plc's overall regulated asset base, but US regulatory regimes impose lower risks on investors due to a number of factors, including: some assets are regulated under cost-plus rather than incentive regulation; objective methods for setting cost allowances; less stringent financial output incentives; and, greater investor security offered by court based proceedings which have enshrined property rights and "prudence standards" which imposes a high evidentiary bar for the disallowance of costs.

We have also derived the asset beta associated with NG plc's UK businesses by estimating the betas associated with comparator US networks. We use a sample of US only comparators as a proxy for the systematic riskiness of NG plc's US operations and solve for the implied UK beta. We find that US asset betas are below NG plc's group beta, with an average of around 0.2. Solving for NG plc's implied UK beta, we obtain a range 2-year asset beta range of 0.55 to 0.57, reflecting the greater for UK operations relative to composite NG Group asset beta estimate of 0.39.

**European empirical evidence supports an asset beta of around 0.4**

To inform SPT asset beta, we have also estimated asset betas for listed European networks operating in Italy and Spain. The empirical evidence supports an asset beta of around 0.4 over the most recent two-year period (see Figure ). Our comparative risk assessment of the Italian and Spanish regimes suggests that investors face broadly similar risks as per SPT investors, and therefore the 0.4 asset beta provides a relevant benchmark for SPT at RIIO-2.

**Figure 2: 2Y rolling asset betas for European utilities have increased since the crisis**




*Source: Bloomberg, NERA analysis, cut-off: 21 September 2018, daily data, reference index: Eurostoxx.*

**We conclude an asset beta range of 0.4 to 0.45, reflecting increased beta risk since RIIO-2**

Considering the evidence above, we conclude an asset beta range of 0.4 to 0.45. Our lower bound estimate is based on the higher-end of the range for 2-year betas for NG, and wider European evidence. We consider that SPT's asset beta should be at least as high as NG plc's beta, given that NG plc's beta is likely to understate UK energy network risk, as our decomposition analysis shows.

For our upper-bound, we determine a value of 0.45 which is the approximate mid-point between NG plc's asset beta (which is 0.38), and the decomposition of NG's plc's beta to isolate UK energy risk, which supports a value of 0.55/0.57. We have not adopted the higher values of 0.55/0.57 given the absence of wider evidence to support this assumption, e.g. from European networks. The upper-bound value is also in line with SPT's RIIO-1 decision of 0.43. Wider empirical evidence shows that beta risk has increased since T1 determination, and therefore there is no apparent rationale to determine a lower beta for SPT at RIIO-T2.

**Ofgem draws on a report by Indepen to estimate an asset beta of 0.35 to 0.37**

To arrive at an asset beta, Ofgem starts by de-leveraging a raw equity beta range of 0.6 to 0.7 (which itself draws on Indepen's recommended range) using an average of the gearing levels of the 5 comparators used by Indepen, but multiplying this average gearing by a "normal" Market-to-Asset ratio (MAR) of 1.1. This adjustment appears to be based on Indepen's recommendation that the gearing used to de-leverage and the gearing used to re-leverage

should both be on a consistent basis (i.e. it is not consistent to have actual gearing based on Debt/Enterprise Value to de-leverage and re-leverage using notional gearing based on Debt/RAB). For reasons set out in this report, Ofgem mis-interprets Indepen's approach and as a consequence understates the implied debt beta.

Ofgem arrives at an asset beta range of 0.35 to 0.36, using debt betas of 0.10 to 0.15. It then re-leverages them using a notional gearing estimate of 60 per cent, calculating a notional equity beta range of 0.65 to 0.76.

Indepen's recommended beta range, upon which Ofgem relies, fails to incorporate the evidence from the beta decomposition of National Grid, as we describe above, although Indepen states that it supports the approach conceptually. It also fails to estimate betas for European network comparators on the basis that the risk to UK energy may be dissimilar, although it draws on UK water sector beta evidence. The evidence is also weak to support a debt beta range as high as 0.10 to 0.15. For these reasons, Indepen's recommended beta range understates energy network risk.

Further, Indepen's proposed adjustment to gearing has no precedent in UK regulation and, even if we were to accept this, there is no strong evidence that adjusted MARs are significantly different from 1. In any case, Ofgem fails to correctly apply Indepen's method, leading to an understatement of asset betas and cost of equity.

**We propose a range of 55 to 60 per cent for notional gearing, relying on both empirical evidence and regulatory precedent**

Our review of empirical evidence and regulatory precedent supports a range of 55 to 60 per cent compared to Ofgem's assumed notional gearing of 60 per cent. In line with financial theory, we find that gearing does not have a material impact on the overall cost of capital.

**Overall, we estimate a cost of equity of between 5.59 and 7.49 per cent for RIIO-2 (real, RPI)**

Overall, we estimate a cost of equity of 5.59 to 7.49 (RPI deflated), higher than Ofgem's range of around 3 to 4 per cent. Our estimated range is higher mainly because of our higher TMR and beta ranges.

**Table 2: We estimate a cost of equity of 5.59 to 7.49 per cent (real RPI)**

| Parameter | Ofgem RIIO-2 Low | Ofgem RIIO-2 High | NERA lower bound | NERA upper bound |
|---|---|---|---|---|
| TMR | 5.19% | 5.68% | 6.50% | 6.80% |
| RfR | -1.68% | -1.68% | -1.68% | 1.25% |
| ERP | 6.87% | 7.36% | 8.18% | 5.55% |
| Asset Beta | 0.35 | 0.36 | 0.40 | 0.45 |
| Debt Beta | 0.15 | 0.10 | - | - |
| Gearing | 60% | 60% | 55% | 60% |
| Equity Beta | 0.65 | 0.76 | 0.89 | 1.13 |
| **Cost of Equity** | **2.75%** | **3.93%** | **5.59%** | **7.49%** |

*Source: NERA calculations*

# 1. Introduction

Scottish Power Transmission (SPT) commissioned NERA Economic Consulting (NERA) to estimate the cost of equity for RIIO-T2 price control period, which is expected to run for the period April 2021 to March 2026.

## 1.1. Methodology

Our methodology for estimating the cost of equity for SPT relies on the application of the Capital Asset Pricing Model (CAPM). The CAPM sets out that the investor's required return on equity can be calculated from two components:

- A Risk-free Rate (RfR): which compensates investors for the time value of money, i.e. the fact that they commit capital today to an investment that is expected to pay off in the future; and
- An Equity Risk Premium (ERP) – which is equal to the total market return (TMR) less the RFR. The ERP compensates investors for the fact that the future return on their equity investment is uncertain. Under the CAPM framework, the only risk that investors are compensated for is the company's non-diversifiable or systematic risk, referred to as beta risk. The premium for risk is calculated as beta times the equity risk premium, defined as the expected return on the market portfolio less the risk-free rate.

Algebraically, CAPM can be written as:

$$R_e = RfR + \beta * (TMR - RfR)$$

where $R_e$ is the return on equity, RfR is the risk-free rate, β is the measure of the systematic risk of the company's equity and TMR is the total return on the market portfolio.

The rest of the report is structured as follows:

- Section 2 sets out our estimate of the Total Market Return (TMR) and its constituent elements the RfR and the ERP;
- Section 3 sets out our estimate of the asset beta for SPT;
- Section 4 sets out our proposal for SPT's gearing; and,
- Section 5 draws conclusions on the cost of equity for SPT during RIIO-T2.

In the Appendices, we set out detailed responses to CEPA's cost of capital analysis for Ofgem[2], UK Regulators Network report on the cost of capital for price controls

[2] CEPA (February 2018), Review of Cost of Capital Ranges for Ofgem's RIIO-2 for Onshore Networks.

commissioned by Ofgem and other UK regulators[3], a report commissioned by Ofgem from Indepen[4], and Robertson[5], as well as recent relevant reports by Ofwat[6] and CAA[7].

[3] S Wright, P Burns, A Mason, D Pickford (2018), Estimating the cost of capital for implementation of price controls by UK Regulators ("UKRN Report")

[4] Indepen (December 2018) Ofgem Beta Study – RIIO-2 Main Report

[5] [Reference]

[6] Ofwat (December 2017), Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return.

[7] PwC (November 2017), Estimating the cost of capital for H7: A report prepared for the Civil Aviation Authority (CAA), link: http://publicapps.caa.co.uk/docs/33/PwC_H7InitialWACCrange.pdf.

# 2. Total Market Return, Risk-free rate and Equity Risk Premium

In this section, we set out our estimate of the total market return (TMR) for RIIO-T2 and its constituent elements the risk-free rate (RfR) and the equity risk premium (ERP).

We estimate a TMR of 6.5 to 6.8 per cent (real, RPI), drawing on realised historical returns, cross-checked against forward looking evidence. By contrast, Ofgem's estimates a TMR range of 5 to 6 per cent (real, RPI) based principally on a report by UKRN.

## 2.1. Summary of Ofgem's RIIO-2 Cost of Capital Consultations

### 2.1.1. March 2018 Framework Consultation

In March 2018, Ofgem published a Framework Consultation setting out its proposed approach to determining the RIIO-2 price controls.[8] In setting out the methodology for estimating the costs of capital at RIIO-2, Ofgem referred to the report by Wright, Burns, Mason and Pickford for the UK Regulators Network ("UKRN report")[9], which sets out recommendations to UK regulators for estimating the cost of capital at future reviews. Ofgem stated it agrees with the recommendations of the UKRN report and that it would estimate the RfR and TMR at RIIO-2 using the following methodology:[10]

- *Total market return*: Estimate TMR based on *long-run averages* as the best estimate of investors' future expectations, but also take into account forward-looking approaches considered recently by other regulators CAA and Ofwat.
- *Risk-free rate*: Estimate RfR based on *current evidence* for long dated index-linked gilts, without any adjustments to reflect expected changes in the RfR over the price control. Instead, Ofgem proposes to introduce indexation of the RfR.

Alongside its Framework Consultation, Ofgem published a report prepared by CEPA which estimates ranges for the cost of capital parameters for RIIO-2 based on *current evidence*.[11]

CEPA estimated a TMR of 5 to 6.5 per cent (real RPI-deflated), which it notes is consistent with the range used by the CMA in its NIE 2014 determination, and a RfR of -1.8 to 0.6 per cent, based on spot (lower bound) as well as forward (upper bound) rates on index-linked gilts.[12]

In relation to the TMR parameter, in addition to referring to the CEPA estimates, Ofgem also highlighted other evidence including:[13]

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8 Ofgem (March 2018), RIIO-2 Framework Consultation, Our approach to setting price controls for GB gas and electricity networks.

9 Wright, S, Burns, P, Mason, R, and Pickford, D (2018), Estimating the cost of capital for implementation of price controls by UK Regulators, An update of Mason, Miles and Wright (2003).

10 Ofgem (March 2018), RIIO-2 Framework Consultation, Our approach to setting price controls for GB gas and electricity networks, paras 7.31-7.34.

11 CEPA (February 2018), Review of Cost of Capital Ranges for Ofgem's RIIO-2 for Onshore Networks.

12 CEPA (February 2018), Review of Cost of Capital Ranges for Ofgem's RIIO-2 for Onshore Networks, section 5.1.1. and 5.1.2.

13 Ofgem (March 2018), RIIO-2 Framework Consultation, Our approach to setting price controls for GB gas and electricity networks, paras 7.40-7.44.

- The UKRN report which estimated a TMR of 5 to 6 per cent (real, RPI-deflated) based on *long-run historical averages*.
- *Forward-looking evidence* from dividend growth models derived by CEPA in a range of 4.4. to 5 per cent.
- *Regulatory precedent*, including the range of 5 to 6.5 per cent used by the CMA in its 2014 NIE determination as well as Ofwat's indicative range of 4.9 to 6.1 per cent based on forward looking approaches, noting that this is consistent with CEPA's range.

Ofgem presented CEPA's estimates of the TMR and RfR as part of its indicative range for the cost of equity for RIIO-2, although it noted that it is still very early in the process and final parameters would only be determined in 2020.[14]

In July 2018, Ofgem published its framework decision for RIIO-2, which confirmed Ofgem's proposed methodology from the Framework Consultation. Specifically, Ofgem confirmed its intention to use long run TMR, but also take account of forward looking models, as well as draw on current market evidence to inform the RFR, and develop options for indexation. [15]

### 2.1.2. December Sector Consultation

#### 2.1.2.1. Estimation of TMR

Ofgem estimates the cost of equity using a three-step methodology, as we explain below.[16]

**Step 1: CAPM evidence**

Ofgem relies on the Capital Asset Pricing Model (CAPM) for estimating cost of equity. Ofgem proposes a TMR based on long run realised returns of 6.25 to 6.75 per cent (real, CPIH), based on the 2018 UKRN report (6 to 7 per cent) as described above. UKRN's 2018 proposed TMR in RPI terms (5 to 6 per cent) is around 150bps lower than the 2003 UKRN, according to Ofgem, because of the lower realised returns up to 2018 (c. 25bps), lower upward adjustment from geometric to arithmetic mean (c. 25bps) and a switch from RPI to CPI(H) inflation (c. 100bps). [17]

Ofgem acknowledges that respondents to its framework consultation considered the UKRN TMR is a measured on an upwardly biased measure of CPI which accounts for the substantive reduction in the TMR. In response, Ofgem states that "historical measures of inflation are similar over the 20th century and the CPI did not exist in its current form for the majority of those 100 years. However, the UKRN study focuses on the expected value of real returns not the expected value of inflation." [18]

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[14] Ofgem (March 2018), RIIO-2 Framework Consultation, Our approach to setting price controls for GB gas and electricity networks, paras 7.50-7.52.

[15] Ofgem (July 2018), RIIO-2 Framework Decision, Our approach to setting price controls for GB gas and electricity networks, p.56. Ofgem did not present any updated estimates of the TMR or RfR parameters in the July 2018 Framework Decision.

[16] Ofgem (December 2018) RIIO-2 Sector Specific Methodology – Annex: Finance, p. 14

[17] Ofgem (December 2018) RIIO-2 Sector Specific Methodology – Annex: Finance, Annex 2, p.91

[18] Ofgem (December 2018) RIIO-2 Sector Specific Methodology – Annex: Finance, p. 31

Ofgem no longer relies on the CEPA estimated a TMR of 5 to 6.5 per cent (real RPI-deflated), which was the basis for its earlier framework consultation cost of capital.[19]

In its December sector consultation, Ofgem proposes a RFR based on spot market evidence. It also proposes to change to the equity allowance set at review based on the change in the RFR multiplied by a (1-beta) factor plus the TMR multiplied by beta, but where the TMR and beta are held constant during the price control review. That is, Ofgem's proposal falls back to the change in the RFR*(1-beta) as a mathematical consequence of assuming the TMR and beta are constant.[20] Ofgem proposes to rely on the 20-year RPI-linked bond yields, adjusted for the difference between RPI and CPI forecasted by OBR. The resulting CPIH-based risk-free rate should be calculated as the average over the month of October and published by 30 November.[21]

As we set out in Appendix C, we consider the UKRN report estimates of the TMR based on long-run historical data are understated, due to reliance on a flawed historical CPI measure and an unjustified downward adjustment to account for the alleged predictability of returns at long horizons. We do not consider that Ofgem has addressed these issues in its December sector consultation, as we describe in the Appendix.

We do not specifically address Ofgem's proposed RFR indexation in this report, which is addressed as a separate NERA study on behalf of the wider industry.[22]

**Step 2: Cross-checking of CAPM results**

Ofgem cross-checks CAPM-implied cost of equity against different measures, such as CEPA's DGM, with updated sensitivity analysis compared to the earlier framework consultation, Market-to-Asset Ratios (MAR), forecasts from investment managers and advisors, bids for Offshore Electricity Transmission assets ("OFTOs"), infrastructure fund discount rates.

As set out in Appendix A, we explain that CEPA's DGM model, a key component of Ofgem's step 2 cross-checks understates the expected TMR due to implausibly low assumptions around dividend growth, and we do consider that the further sensitivity analysis in the sector consultation has addressed our concerns.[23]

In Appendix B, we also explain that the other cross-check methodologies support an upward adjustment to the CAPM-based cost of equity, as opposed to supporting a lower TMR as Ofgem assert. For example, MAR premium for two of the three publicly listed UK utility companies has been mostly negative over the last year, and the equity IRRs for OFTOs

[19] CEPA (February 2018), Review of Cost of Capital Ranges for Ofgem's RIIO-2 for Onshore Networks, section 5.1.1. and 5.1.2.

[20] Ofgem (March 2018), RIIO-2 Framework Consultation, para. 7.64.

[21] Ofgem (December 2018), RIIO-2 Sector Specific Methodology Annex: Finance, para 3.47.

[22] NERA (March 2019) Cost of equity indexation using RFR, A report for the ENA

[23] In Appendix A, we also consider that other evidence provided by CEPA in its earlier report for Ofgem is unreliable, e.g. unjustified reliance on geometric averages to calculate historical realised returns. We also find that CEPA's (as well as Ofgem's) interpretation of the CMA 2014 NIE range of 5 to 6.5 per cent is incorrect, given the CMA stated that the *weight of evidence* supported a range between 5.5 and 6.5 per cent. CMA (March 2014) op. cit., para. 13.38.

winning bidders support a cost of equity of 5.2 per cent (real, CPIH), and infrastructure discount rates support a cost of equity of 5 to 8.2 per cent (real, CPIH).[24]

**Step 3: Expected versus allowed returns**

Ofgem proposes to apply a distinction between Expected Return (ER) and Allowed Return (AR) for RIIO-2 in light of companies' outperformance in previous price controls, which it draws on to set a proposed cost of equity towards the lower end of its CAPM range, as set out in Table 2.1.

We do not address Ofgem's step 3 analysis as part of this report, as this is addressed in a separate industry wide study.[25]

Table 2.1 shows Ofgem's preliminary CAPM-based cost of equity for RIIO-2 following step 1. Ofgem has proposed a cost of equity of 4 per cent (real CPIH), towards the bottom end of the range, as it considers the allowed rate of return should be set below the expected rate of return (as provided by the CAPM under its step 1), to reflect investors' expectations of outperformance.[26]

We address Ofgem's beta estimates in section 3.

**Table 2.1: Preliminary CAPM-based Cost of Equity Assumptions for RIIO-2**

| | RPI | | CPI | | Nominal | |
|---|---|---|---|---|---|---|
| | **Low** | **High** | **Low** | **High** | **Low** | **High** |
| Notional equity beta | 0.646 | 0.762 | 0.646 | 0.762 | 0.646 | 0.762 |
| Total Market Return (TMR) | 5.189% | 5.684% | 6.25% | 6.75% | 8.417% | 8.928% |
| Risk-free rate (RFR) | -1.68% | -1.68% | -0.69% | -0.69% | 1.34% | 1.34% |
| **CAPM-implied cost of equity** | **2.76%** | **3.93%** | **3.79%** | **4.98%** | **5.91%** | **7.12%** |

*Ofgem (December 2018), RIIO-2 Sector Specific Methodology Annex: Finance, Table 13: CAPM-implied cost of equity range.*

### 2.1.3. Conclusions

We agree with Ofgem's proposed methodology to estimate the TMR based on long-run historical averages as the best available evidence on investors' future expectations, using forward-looking approaches as a cross-check. This is also the approach we use in estimating the TMR in this report (as discussed in the following sections). However, we do not agree with the specific TMR estimates presented by Ofgem based on the studies commissioned from UKRN and CEPA, as we explain the Appendices. In the Appendices, we also address reports commissioned by other sector regulators, Ofwat and CAA.[27]

[24] Ofgem (December 2018), RIIO-2 Sector Specific Methodology Annex: Finance, para 3.141.

[25] Frontier Economics (March 2019) Adjusting Baseline Returns for Anticipated Outperformance

[26] Ofgem (December 2018), RIIO-2 Sector Specific Annex: Finance, p.53.

[27] As we explain in Appendix D and Appendix E, we also consider the estimates presented by Ofwat as well as the CAA, drawing on their advisors' analysis of forward-looking evidence, rely on flawed assumptions and analysis and that there is no evidence supporting the assumption that expected equity returns have fallen as a result of the low RfR environment.

As we set out in the following sections, and explain further in Appendix F, we show that updating the evidence base considered by the CMA in its NIE 2014 determination shows no reduction in the TMR since 2014 and supports the conclusion that the TMR for RIIO-T2 should be at least as high as 6.5 per cent (real, RPI) as per the CMA's 2014 NIE determination.

## 2.2. We use a TMR approach to estimate the cost of equity in line with Ofgem and CMA precedent

There are two principal approaches to estimating the RfR and ERP components of the CAPM: (i) estimate the risk-free rate and ERP parameters separately, and in combination derive the market cost of equity; (ii) estimate the TMR directly, and the risk-free rate, and derive the ERP as the residual (referred to as the "TMR approach"). We adopt the second approach, consistent with the approach used by the CMA and other UK regulators.

The reason for adopting a TMR approach is the inverse relationship between the RfR and ERP elements of the TMR. Estimating the two parameters separately creates the risk of combining inconsistent estimates, e.g. an RfR based on low short-term market data with a long-run historical ERP, providing an overall TMR which is biased downwards.

Finance theory explains that the negative relationship between the RfR and the ERP is associated with increased risk aversion and the so called "flight to safety" effect during periods of economic and financial crisis. At times of economic uncertainty, investors dispose of risky assets such as equity in favour of risk-free assets such as government bonds. This reduces the price of equities and increases the premia for holding risk while reducing yields on risk free assets, giving rise to the negative correlation between the ERP and the RfR.[28] Empirically, a number of studies find a positive relationship between volatility and expected equity returns and a negative relationship between the RfR and ERP while the TMR remains stable over time.[29] As an example, some of the most compelling evidence is provided by Siegel (1998), who analysed 200 years of US stock market data, which shows a remarkable degree of stability in equity returns over time, in contrast to the risk-free rate and by extension the ERP:[30]

> *"the growth of purchasing power in equities not only dominates all other assets but* ***is remarkable for its long-term stability****. […] This remarkable stability of long-term real returns is a* ***characteristic of mean reversion****, a property of a variable to offset its short-term fluctuations so as to produce far more stable long-term returns. […] As*

[28] See for example: (1) Campbell and Cochrane (1999), By force of habit: A consumption-based explanation of aggregate of stock market behaviour, Journal of Political Economy, 107, 205-51; (2) Wright, S. et al. (September 2006), Report on the Cost of Capital – provided to Ofgem, Smithers & Co Ltd; (3) Harris, Robert, and Marston, Felicia (1999) , The Market Risk Premium: Expectational Estimates Using Analysts' Forecasts, Darden Business School Working Paper No 99-08; (4) Maddox, F., D. Pippert and R. Sullivan (1995), An Empirical Study of ex ante Risk Premiums for the electric Utility Industry," Financial Management, 89-95.

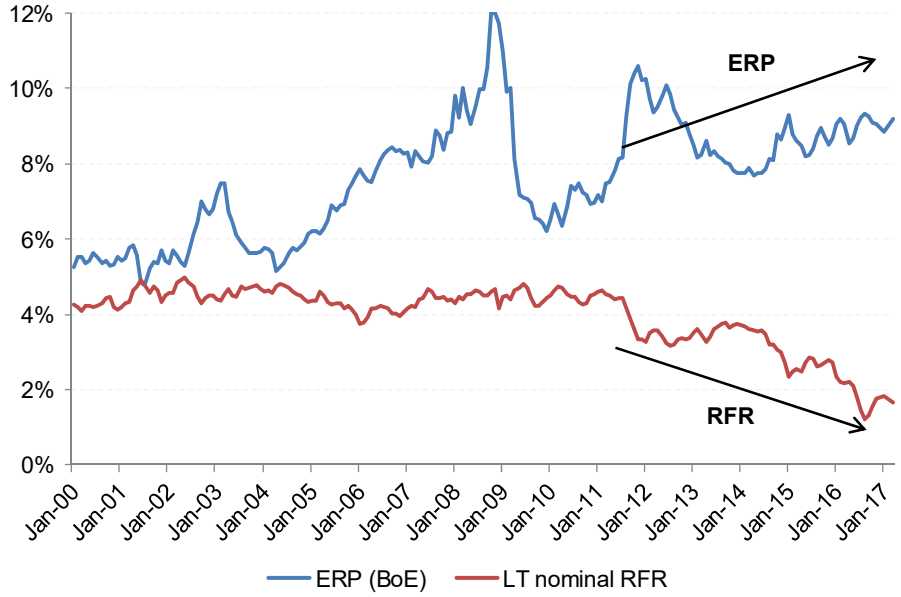
[29] See for example: (1) Graham and Harvey (2010), The equity risk premium in 2010. (2) Cochrane and Piazzesi (2008), Decomposing the yield curve, Graduate School of Business, University of Chicago. Working Paper; (3) Wright, Mason, Miles (2003), A Study into Certain Aspects of the Cost of Capital for Regulated Utilities in the UK, Smithers & Company Limited.; (4) Scruggs (1998), Resolving the puzzling intertemporal relation between the market risk premium and conditional market variance: A two-factor approach. The Journal of Finance, 53(2), 575-603.; (5) Siegel W (1998), Stocks for the Long Run McGraw Hill, Second Edition.

[30] Siegel (1998), Stocks for the Long Run. McGraw-Hill, second edition, p.11, 13.

*stable as the long-term real returns have been for equities, the* ***same cannot be said of fixed-income assets****."*

Consistent with financial literature, prominent economic institutions such as the Bank of England have recognised that low interest rates and economic uncertainty have led to increased ERPs.[31] Indeed, the Bank of England's estimates of the ERP derived from its dividend growth model (DGM) have increased markedly with the recent fall in interest rates (see Figure 2.1).

**Figure 2.1: Bank of England DGM shows reduction in RfR offset by increases in ERP over recent period**




*Source: NERA analysis of Bank of England data.*

The German Bundesbank also noted that there is a strong negative correlation between ERP and risk-free rates: [32]

*"[…] the correlation between returns from stocks and long-term government bonds is a suitable measure of risk aversion... In times of heightened risk aversion, it is therefore often possible to observe that investors demand higher equity risk premiums or undertake shifts from stocks into secure government bonds (safe haven flows). The resulting contrasting price developments of stocks and government securities are accompanied by a negative correlation."*

[31] See for example, Bank of England, (August 2016), Inflation Report, p.2, which noted: "*There remains, however, substantial uncertainty about the nature of the UK's future trading arrangement and the implications for competitiveness. This may have increased the risk premium required by investors to hold sterling-denominated assets*" or the Bank of England (May 2018), Inflation report, p.9, which states that *"[…] equity risk premia — the additional return that investors require for holding equities instead of less risky government debt — are estimated to have increased for UK-focused companies in recent years."*

[32] Deutsche Bundesbank (Nov 2007), Monthly Report.

Overall, financial literature and empirical evidence supports the theory of an inverse relationship between the RfR and the ERP, which supports the use of a TMR approach for estimating the two parameters jointly.

The use of a TMR approach is also consistent with UK regulatory precedent including the CMA's approach in its most recent reviews (NIE 2014 and Bristol Water 2015).[33] Moreover, Ofgem also proposed using the TMR approach for RIIO 2, as we describe in Section 2.1.

## 2.3. Latest evidence on the TMR

There are two principal approaches to estimating the TMR: i) to draw on long run historical evidence, or ii) to draw on forward looking estimates based on dividend growth model (DGM). We discuss current estimates of the TMR based on the two approaches in the following sections.

### 2.3.1. Long-run historical data support a TMR of at least 6.5 per cent

The most common approach to estimating the TMR is to draw on historical realised returns. This approach assumes that historical realised returns provide an unbiased estimate of the expected return over long time periods. As discussed in the previous section, the relative stability of the TMR over time supports the use of long run historical returns as a basis of estimating the expected TMR going forward.

We present long-run historical estimates of the TMR based on data from Dimson, Marsh and Staunton (DMS) database, which provides long-term time series data on returns on stocks, bonds, bills as well as inflation over the period since 1900, i.e. including 118 years of data in the latest publication.[34] The DMS database is the standard reference point for UK regulators including the CMA as well as financial practitioners.[35]

In estimating the TMR based on historical data, a key question is whether the expected return should be estimated based on arithmetic or geometric averages of historical realised returns.[36] Assuming a single period or one year investment horizon, the correct estimate of the expected return is the simple arithmetic mean.[37]

In case of investment horizons which are greater than one year, the simple arithmetic mean will be an upward biased estimate of the expected return. Blume (1974) was among the first to propose unbiased estimates of returns for investment horizons longer than a single period.[38] Blume shows that if the investment horizon (or holding period, N) is less than the

[33] CMA (March 2014), NIE Limited price determination; CMA (October 2015), Bristol Water price determination

[34] DMS (February 2018), Credit Suisse Global Investment Returns Yearbook 2018.

[35] See e.g. CMA (March 2014), NIE Limited price determination, para 13.139.

[36] The arithmetic average is calculated as the sum of the historical annual returns divided by the number of years in the historical period, while the geometric average corresponds to a constant rate of return that an investor would receive each year to achieve the same asset value as generated by the variable annual returns by the end of the period.

[37] Jacquier, Kane, Marcus (2005), Optimal Estimation of the Risk Premium for the Long Run and Asset Allocation: A Case of Compounded Estimation Risk, Journal of Financial Econometrics, vol 3, no 1, pp 37-55.

[38] Blume (1974), Unbiased Estimators of Long-Run Expected Rates of Returns, Journal of the American Statistical Association 69, p.634–663.

period for which we have historical data (T), the arithmetic mean (AM) will provide an upward biased estimate of expected returns, whereas the geometric mean (GM) will provide a downward biased estimate, and therefore an unbiased estimate will lie somewhere between the two.[39] Blume suggested a number of unbiased measures of expected returns if the holding period N is longer than one year. These include:[40]

- The "simple estimator" which is based on the arithmetic mean of returns for non-overlapping investment horizons or holding periods of N years. For example, for a holding period of 5 years, we have 20 or so observations using a hundred years of historical data series, which are then used to calculate the arithmetic mean to form the expected return.
- The "overlapping estimator" which is based on the arithmetic mean of returns for overlapping investment horizons or holding periods of N years. This approach greatly increases the number of observations relative to the simple estimator, but Blume simulations suggested the estimator was less efficient.
- The third estimator is the "adjusted unbiased" estimator which is a weighted average of arithmetic and geometric means. To calculate this estimator, the shorter the investment horizon (N) relative to the historical estimation period (T), as in our case, the greater the weight on the arithmetic mean relative to the geometric mean, as shown in the Blume formula below:

$$TMR = [\frac{T-n}{T-1}T * (1+AM)^n + \frac{n-1}{T-1} * (1+GM)^n]^{\frac{1}{n}} - 1$$

Jacquier, Kane and Marcus (JKM, 2005)[41] also derive an unbiased estimator of the expected return. As with Blume, the JKM estimator is calculated as the weighted average of the geometric and arithmetic means, with greater weight placed on the arithmetic mean the longer the historical period compared to the investment horizon.

In its 2014 NIE decision, the CMA presented historical TMR estimates based on the Blume and JKM estimators discussed above, for different investment horizons or holding periods.[42]

Table 2.2 below shows an update of the CMA calculations using data over the period 1900-2018 from the latest DMS 2018 publication.

[39] Blume (1974), op.cit., p.634–663

[40] Blume (1974), op.cit., p.634–663.

[41] Jacquier, Kane, and Marcus (2005), Optimal estimation of the risk premium for the long run and asset allocation: a case of compounded estimation risk, Journal of Financial Econometrics.

[42] CMA (March 2014), NIE Limited price determination, p. 13-27, Table 13.7.

**Table 2.2: Long-run DMS TMR estimates lie in range of 6.2 to 7.1 per cent (real, RPI-deflated) for different averaging methods and holding periods**

| | Simple | Overlapping | Blume | JKM |
|---|---|---|---|---|
| 1Y holding | 7.1 | 7.1 | 7.1 | 7.1 |
| 2Y holding | 6.6 | 7.0 | 7.1 | 7.1 |
| 5Y holding | 6.7 | 6.8 | 7.0 | 7.0 |
| 10Y holding | 6.8 | 6.7 | 7.0 | 6.7 |
| 20Y holding | 7.1 | 6.8 | 6.8 | 6.2 |

*Source: NERA calculations using DMS (February 2018), Credit Suisse Global Investment Returns Yearbook 2018 (DMS data since 1988 converted to real RPI-deflated figures for consistency with earlier data).*[43]

Table 2.2 shows that the assumed holding period is an important factor in estimating the TMR. We consider evidence supports the use of relatively short averaging periods for the following reasons:

- Roberge et al (2016) find that the average holding period in the NYSE was 8.3 months as of December 2016.[44]
- The use of short-term holding periods is consistent with evidence from a survey of equity market participants by the CFA Institute UK that suggests that the average holding period is between 1-2 years.[45]
- Helm and Tindall (2009)[46] find that most utilities are held by private equity or infrastructure funds, where the former have an average holding period of 4-5 years while the latter tend to be more long-term.

We therefore propose to draw on holding periods of 1 to 5 years. However, we do not propose to place weight on the simple average method, as the number of observations is relatively limited for holding periods of 2 to 5 years (e.g. for 5 years, the TMR is based on around 20 or so observations) and the estimates are not stable over time as a result.[47] Taking

[43] DMS (February 2018), Credit Suisse Global Investment Returns Yearbook 2018, p.214-217. We note that the 2018 DMS publication includes real returns for the UK market since 1988 which have been calculated using CPI as opposed to RPI inflation. (See DMS (February 2018), Credit Suisse Global Investment Returns Yearbook 2018, p.210.) As a result, the DMS reported historical real return for the UK market of 7.3 per cent over the period 1900-2017 should not be interpreted as a real RPI-deflated measure. To ensure consistent treatment of inflation, we have re-calculated the real UK historical returns to be based on a RPI deflated basis. This provides an estimate of historical real returns of 7.1 per cent for the UK market over the period 1900-2017.

[44] Roberge M., Flaherty J., Almeida R., Boyd A. (July 2017), Lengthening the Investment Time Horizon, p.2

[45] Kay Review of UK Equity Markets and Long-Term Decision Making, Interim Report, Feb 2012I; CFA UK response to the Kay Review of UK Equity Markets and Long-Term Decision Making – Call for Evidence.

[46] Helm and Tindall (November 2009), The evolution of infrastructure and utility ownership and implications, Oxford Review of Economic Policy, Vol 25, pp 411 – 434.

[47] For our TMR range, we do not draw on 2-year and 5-year TMR estimates using the simple average approach, as these are very volatile, depending on the cut-off date used for the calculation. For example, using the DMS 2017 dataset results in 2-year and 5-year simple average TMR estimates of 7.5 and 7.2 per cent (using data up to 2016), while the DMS 2018 dataset (using data up to 2017) shows estimates of 6.6. and 6.7 per cent respectively, a difference of 50-90 bps by adding just one year of data. We therefore do not consider that these estimates are reliable for estimating the TMR for RIIO-T2.

into account these considerations, the evidence supports a historical real TMR (RPI-deflated) of 6.8 per cent to 7.1 per cent, as per the highlighted cells in Table 2.2.

#### 2.3.1.1. Changes to the calculation of RPI, and conclusions on historical TMR

At recent reviews, UK regulators have discussed changes to how RPI inflation is measured and the implications for setting a real RPI allowed rate of return going forward. In 2010 the ONS modified the way certain clothing and footwear price indices were collected. The change in data collected raised the variation of the relevant samples and had an impact on the relative difference between RPI and CPI, because they are calculated using different formulae at the lowest level of aggregation: arithmetic and geometric means respectively. The ONS concluded that, going forward, the wedge between RPI and CPI attributed to differences in the formulae ("the formula effect") increased by about 32bps as a result of this change.[48]

We have considered whether there is a rationale for an adjustment to the real (RPI-deflated) historical TMR data to reflect the relative increase in RPI post 2010. First, we note that here are other factors which contribute to the difference between RPI and CPI ("the RPI-CPI wedge") which may have also changed following the 2010 methodology change, thus offsetting the impact of the "formula effect" estimated by the ONS at 32bps. For example, in 2015 the Office for Budget Responsibility (OBR) suggested a downward adjustment to the RPI-CPI wedge for the "weights effect" from 0 to -0.4 per cent.[49] As OBR notes, part of this difference *"represents interactions between categories, in particular between the formula and weights effect".* This shows the change in the weights effect may have potentially offset an increase in the "formula effect" arising from the 2010 changes to the method for collecting clothing, as identified by ONS as 32 bps. Second, we note that the adjustment associated with the 2010 change reflects only one of potentially many changes to the RPI methodology which could have had opposite effects and indeed the adjustment could reverse in the future.

However, on balance, we apply a 30bps downward adjustment to historical RPI-deflated returns to capture the increase in the forward looking RPI-CPI wedge. This results in a real TMR (RPI-deflated) range of 6.5 per cent to 6.8 per cent, i.e. 30 bps lower than the range of 6.8 to 7.1 per cent based on DMS data, as explained above.

### 2.3.2. Bank of England estimates forward looking TMR of 7 to 8 per cent

As an alternative to the long-run historical approach, the TMR can be calculated based on forward looking evidence, as derived using the dividend growth model (DGM). At previous reviews, the CMA as well as other regulators used evidence from the DGM as a cross-check on the TMR estimated from long-run historical data.[50]

The DGM solves for a discount rate which equates the present value of future expected dividends to the current stock price. If applied to the entire market index (e.g. FTSE All

[48] ONS (December 2010), CPI and RPI: Increased impact of the formula effect in 2010, p. 1.

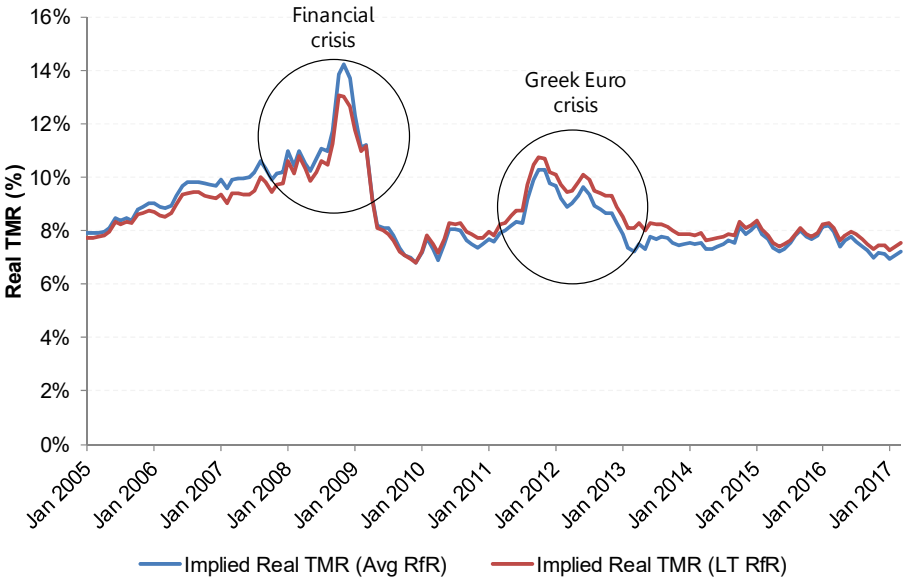
[49] OBR (March 2015), Economic and fiscal outlook, p.62.

[50] See e.g. Ofwat (January 2014), Setting price controls for 2015-20 - risk and reward guidance, section A1.4 or CMA (March 2014), NIE Limited price determination, para 13.137.

Share), the discount rate implied by the DGM reflects the expected return on the whole market (i.e. the TMR).

Figure 2.2 below shows estimates of the TMR from the Bank of England. The Bank of England estimates the TMR for the FTSE All Share index, using equity analyst estimates of short-term dividend growth and a long-run dividend growth assumption based on long-run GDP growth estimates for the different regions from which FTSE All Share companies derive their earnings.

**Figure 2.2: Bank of England DGM shows TMR has been relatively stable, with elevated values during GFC and Greek Euro crisis**




*Note: The Bank of England estimates the DGM using a time varying risk-free rate for all maturities (where available) and a long-run risk-free rate assumption. We calculate a TMR as the sum of the Bank of England's reported ERP and an i) average of the real risk-free rate for all available maturities and 2) the real risk-free rate at the longest maturity available.*
*Source: NERA analysis of Bank of England (2017), An improved model for understanding equity prices, Quarterly Bulletin 2017Q2, p.94 and Bank of England yield curve data.*

As can be seen from Figure 2.2, the TMR estimate from the DGM has been relatively stable over time, apart from the global financial crisis period as well as the Greek euro crisis period where it showed elevated values. The relative stability of the TMR supports the theory that the recent reductions in the risk-free rate have been offset by increases in the ERP resulting in a stable TMR over time (as discussed in Section 2.2).

Table 2.3 below shows the estimates of the TMR based on Bank of England DGM data. To smooth for volatility in equity markets, we present evidence of the forward-looking TMR for spot (March 2017 in line with latest data from the BoE) as well as 1 and 5 year historical averaging periods.

**Table 2.3: Bank of England DGM supports a real TMR of 7.2 to 8.1 per cent**

| | Spot (Mar 2017) | 1Y average (Mar 2017) | 5Y Average (Mar 2017) |
|---|---|---|---|
| BoE TMR (average RfR) | 7.2 | 7.3 | 7.8 |
| BoE TMR (LT RfR) | 7.6 | 7.6 | 8.1 |

*Note: The Bank of England estimates the DGM using a time varying risk-free rate for all maturities (where available) and a long-run risk-free rate assumption. We calculate a TMR as the sum of the Bank of England's reported ERP and an i) average of the real risk-free rate for all available maturities and ii) the real risk-free rate at the longest maturity available.*
*Source: NERA analysis of Bank of England (2017), An improved model for understanding equity prices, Quarterly Bulletin 2017Q2, p.94 and Bank of England yield curve data using March 2017 as cut-off date (later data from BoE on the TMR not available.*

Depending on the averaging period, the forward-looking estimates of the real TMR based on the Bank of England's DGM lie in a range between 7.2 and 8.1 per cent. The forward-looking estimates are therefore higher compared to the historical estimates presented by CMA at NIE 2014, as shown in Table 2.2 and discussed in Appendix F.

## 2.4. We conclude a TMR of 6.5 to 6.8 per cent

In deriving the TMR for the RIIO-T2 period, we rely on long-run historical averages as the primary source of evidence, with forward looking estimates based on the DGM used only as a cross-check. We consider forward looking evidence should be treated with caution, given the relative sensitivity of the results to the long-term dividend growth assumption, for which there are no independent analyst forecasts. The use of historical evidence as a measure of the expected TMR is supported by the stability of the TMR over time as documented in financial literature.

We recommend a TMR in the range between 6.5 and 6.8 per cent for RIIO-T2, in line with our estimates based on historical data. Forward looking evidence supports a higher TMR estimate between 7.2 and 8.1 per cent.

We note that the bottom end of our TMR range is consistent with CMA TMR at the 2014 NIE and 2015 Bristol water determinations.[51] As we discuss in Appendix F, our update of the different approaches the CMA considered in determining the TMR at the 2014 NIE and 2015 Bristol water determinations show a slight increase in the estimates using latest available data compared to the evidence presented by the CMA in the 2014 NIE and 2015 Bristol water determinations. This supports our conclusion that the TMR for RIIO-T2 should be no lower than 6.5 per cent.

## 2.5. Division of TMR between RfR and ERP

There are two broad approaches used by UK regulators to estimate the RfR (and therefore ERP) components of the TMR: i) relying on long-run historical averages or ii) relying on short-run market evidence, such as spot or forward rates.

[51] CMA (March 2014), NIE Limited price determination, p. 13-39, Table 13.11 and CMA (October 2015), Bristol Water plc, A reference under section 12(3)(a) of the Water Industry Act 1991, Report, p.332, para 10.186.

### 2.5.1. Long-run estimates

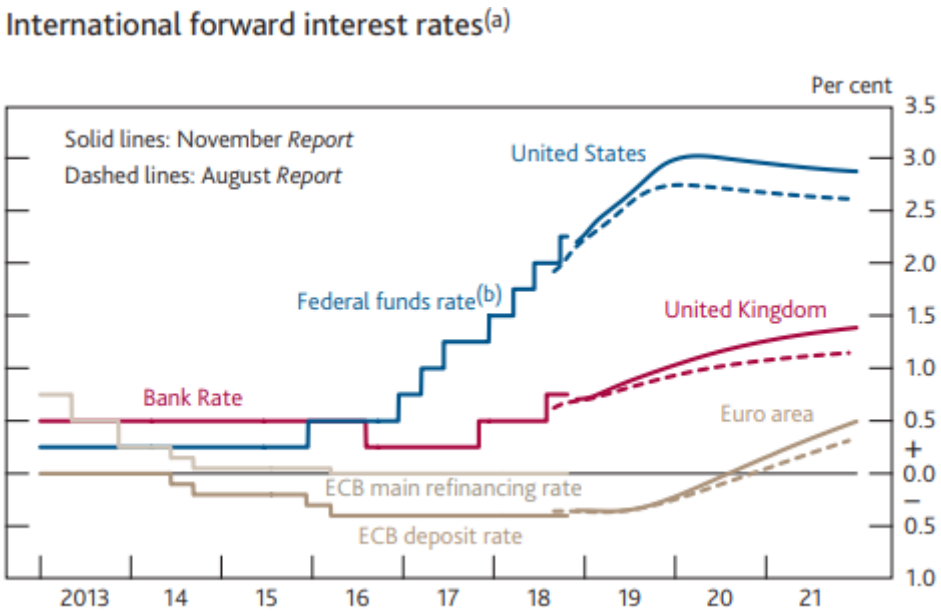
Long-run estimates of the RfR based on UK government bonds yields as calculated by DMS over the period 1900-2017 suggest a long-run RfR estimate for the UK of 2.4 per cent (real, RPI).[52]

### 2.5.2. Short-run market evidence

Government bond yields in the UK and internationally have fallen since the global financial crisis, reflecting the impact of central banks' unconventional monetary policy and quantitative easing aimed at stimulating economic recovery. In the UK, government bond yields have fallen further following the Brexit vote in 2016 and the Bank of England's reaction by further loosening of monetary policy, resulting in yields reaching historical lows around negative 2 per cent (real) in summer 2016 (see Figure 2.4).

Since then, in November 2017, the Bank of England implemented the first increase in the base rate since 2007 from 0.25 to 0.5 per cent, and further increased the base rate from 0.5 to 0.75 per cent in August 2018.[53] Current market expectations suggest increases in yields in the UK and internationally, as shown in Figure 2.3 below.

**Figure 2.3: Bank of England data shows markets expect further base rate increases in the lead up to RIIO-T2**




*Source: Bank of England, (November 2018), Inflation Report, p.6.*

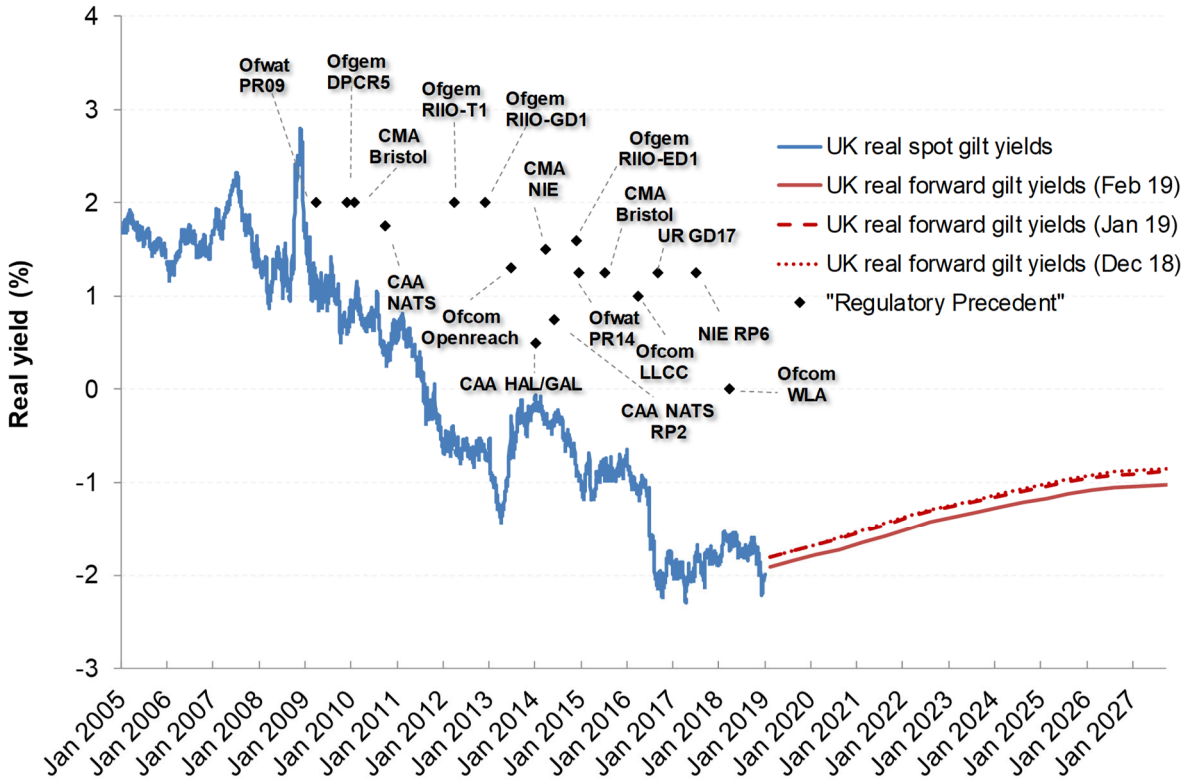
Our own evidence from forward gilt rates suggests markets are expecting real yields to increase in the run-up to and during the RIIO-T2 period. As shown in Figure 2.4 below, forward rates indicate that the market expects an increase in yields over RIIO-2, and by

[52] Calculated based on DMS bond returns data, adjusted post 1988 deflated using RPI inflation. See footnote 43 for details.

[53] Bank of England (August 2018), Inflation report.

around 60 bps to the mid-point (i.e. 2022/23), higher than Ofgem's estimate of around 30 bps.[54]

**Figure 2.4: Forward rate evidence supports expected increase in gilt rates during RIIO-T2**




*Note: We calculate historical yield using 10Y UK implied real spot curve. For forward yields, we use a 10Y gilt yield deflated using HM Treasury inflation forecast.*
*Source: NERA analysis of Bloomberg data, Bank of England data, HM Treasury data and regulatory precedent, cut-off date 12 February 2019.*

As can be seen from Figure 2.4 and Table 2.4, at recent reviews, UK regulators including the CMA at NIE 2014 and Bristol water 2015 determinations, generally placed greater weight on long-run evidence on the RfR, with some downward adjustment to long-run data to reflect the lower spot and forward yield evidence.

[54] See: Ofgem (December 2018), RIIO-2 Sector Specific Methodology Annex: Finance, Table 4 and Table 5.

**Table 2.4: Regulators have not generally drawn on low spot and forward yield evidence at recent reviews**

| Decision | Date | Real RfR |
|---|---|---|
| Ofwat PR09 | April 2009 | 2.0% |
| CMA Bristol | February 2010 | 2.0% |
| Ofgem RIIO-T1 | December 2012 | 2.0% |
| CMA NIE | March 2014 | 1.5% |
| Ofgem RIIO ED1 | November 2014 | 1.6% |
| Ofwat PR14 | December 2014 | 1.25% |
| CMA Bristol | October 2015 | 1.25% |
| UR GD17 | September 2016 | 1.25% |
| UR NIE RP6 | June 2017 | 1.25% |

*Source: NERA analysis of regulatory determinations.*

We conclude an RfR of -1.68 to 1.25 per cent for RIIO-T2. The lower bound reflects Ofgem's risk-free rate assumption, based on the spot rate of the 20-year index-linked government bond on 26 October 2018.[55] We assume that risk-free rate indexation mechanism that Ofgem has proposed for RIIO-2 applies, and therefore we do not apply an ex ante uplift to current market rates. However, if an RfR indexation mechanism does not apply, the short-term market evidence should be adjusted to incorporate an uplift for expected changes in rates.

The upper bound is in line with the RfR used by the CMA in its 2015 Bristol Water determination. This approach is consistent with UK regulators' approach of placing greater weight on long-run evidence to avoid setting the allowed rate of return which varies with the business cycle which contributes itself to co-variant risk, as well as regulatory risk.

## 2.6. Conclusions on TMR and decomposition

Table 2.5 summarises our recommendations on the TMR and how this should be decomposed between the RfR and ERP components.

**Table 2.5: We recommend a TMR of 6.5 to 6.8 per cent, with a RfR of -1.68 to 1.25 per cent and an implied ERP of 8.18 to 5.55 per cent (real, RPI)**

| Parameter | Ofgem Low | Ofgem High | NERA lower bound | NERA upper bound |
|---|---|---|---|---|
| TMR | 5.19% | 5.68% | 6.50% | 6.8% |
| RfR | -1.68% | -1.68% | -1.68% | 1.25% |
| ERP | 6.87% | 7.36% | 8.18% | 5.55% |

*Source: NERA calculations and CEPA (February 2018), Review of Cost of Capital Ranges for Ofgem's RIIO-2 for Onshore Networks, p.71*

[55] Ofgem (December 2018), RIIO-2 Sector Specific Methodology Annex: Finance, para 3.49.

By contrast, Ofgem estimates a TMR range of 5.19 to 5.68 per cent, based principally on UKRN report, which proposes a TMR of 5 to 6 per cent (RPI real). As we explain in Appendix C, we consider that the UKRN's TMR estimate draws on a flawed backcast of the CPI inflation measure, and if it were to draw on established RPI historical series, its conclusion on TMR would be around 100 bps higher (in both RPI and CPI deflated terms), as per our own analysis.

As we explain in Appendix B, we also consider that Ofgem's cross-checks do not support its TMR conclusions. Notably, CEPA's DDM model draws on implausible ranges for FTSE dividend growth; the alternative cross-checks, OFTO and survey evidence, support a higher TMR than UKRN estimate.

Finally, as we explain in Appendix F, drawing on the different methods considered by the CMA in the 2014 NIE determination, the evidence does not support Ofgem's assertion that the TMR has declined over time. The CMA NIE determination of 6.5 per cent real (RPI-deflated) TMR should therefore be considered as a lower bound for the TMR for RIIO-T2.

# 3. Beta

In this section, we set out our estimate for the beta risk of SPT at RIIO-T2. We first present a summary of Ofgem's RIIO-2 decision before setting out our own evidence for beta risk.

We recommend an asset beta range of 0.4 to 0.45 compared to Ofgem's range of 0.35 to 0.36 (with a debt beta range of 0.10 to 0.15). Our range draws on up-to-date evidence for NG's and European network betas, the SPT beta decision of 0.43 for RIIO-T1, and empirical evidence that beta risk has increased since RIIO-T1 decision.

## 3.1. Summary of Ofgem RIIO-2 Consultations on Beta

### 3.1.1. March Framework Consultation

In its Framework Consultation in March 2018, Ofgem proposed to estimate betas by looking at historical correlations between prices of regulated utilities and a reference index, while also making use of sophisticated (GARCH) econometric techniques mentioned in the UKRN report. It provides evidence from CEPA and the UKRN report, both pointing that RIIO-1 equity betas are likely to be too high.[56]

Alongside the Framework Consultation, Ofgem also published CEPA's report. However, despite Ofgem's suggestion of using the techniques mentioned in the UKRN report, CEPA estimates betas using the more traditional methods, even though it acknowledges the value of the methods proposed in the UKRN report.[57] CEPA's report initially estimated a 0.25 to 0.35 asset beta range, as the starting point. It relied essentially on four comparators (National Grid, Pennon, United Utilities and Severn Trent)[58] and considers a range of different beta estimation approaches (daily vs weekly, 2-year vs 5-year). Moreover, CEPA considers that the possible additional systematic risk coming from future large investment programmes justifies setting a broader range, and thus concludes on a 0.25 to 0.4 asset beta range.[59]

In July 2018, Ofgem published its Framework Decision, where it confirmed the approach set out in the March Consultation, mentioning that it would consider the estimation of beta for network companies, based on issues highlighted in the UKRN report.[60]

We consider that CEPA puts unnecessary weight on a period when betas were depressed as a result of the financial crisis and fails to account for the risk differences between both energy and water networks and NG's UK and US operations. By placing more weight in current evidence, analysing more thoroughly the relative riskiness of the energy sector, including evidence on European comparator networks and decomposing NG's beta in a UK and US

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56 Ofgem (March 2018), RIIO-2 Framework Consultation, Our approach to setting price controls for GB gas and electricity networks, p.84 and p.87-89.

57 CEPA (February 2018), Review of Cost of Capital Ranges for Ofgem's RIIO-2 for Onshore Networks, p.51.

58 CEPA does not consider SSE to be a reliable comparator given their low proportion of revenues originating from UK regulated entities.

59 CEPA (February 2018), Review of Cost of Capital Ranges for Ofgem's RIIO-2 for Onshore Networks, p.50-54.

60 Ofgem (July 2018), RIIO-2 Framework Decision, Our approach to setting price controls for GB gas and electricity networks, p.56.

component, we arrive at an asset beta range of 0.4 to 0.45, higher than CEPA's proposed range.

In Appendix G we comment in detail on CEPA's beta evidence.

### 3.1.2. Sector Specific Methodology

In December 2018, Ofgem published its RIIO-2 sector specific methodology, which contains an updated notional equity beta range of 0.65 to 0.76.[61] To arrive at this range, Ofgem commissioned two reports, from Dr Donald Robertson and Indepen. The first report, by Robertson, discusses issues around the use of GARCH and OLS, the use of different data frequencies and impact of using different estimation windows.

However, in estimating a notional equity beta range, Ofgem relies on Indepen's report, which presents only raw equity beta estimates, drawing on GARCH, OLS and Least Absolute Deviations (LAD) models, using high-frequency data (daily data) over different estimation windows and relying on 5 comparators (United Utilities, National Grid, SSE, Pennon and Severn Trent). Indepen estimates a raw equity beta range of 0.55 to 0.7, and a narrower range of 0.57 to 0.65.[62] In Appendix H, we comment in detail on Indepen's beta recommendations.

To arrive at an asset beta, Ofgem starts by de-leveraging a raw equity beta range of 0.6 to 0.7 (which is said to be consistent with Indepen's recommended range) using an average of the gearing levels of the 5 comparators used by Indepen, but multiplying it by a "normal" Market-to-Asset ratio (MAR) of 1.1.[63] This adjustment appears to be based on Indepen's recommendation that the gearing used to de-leverage and the gearing used to re-leverage should both be on a consistent basis (i.e. it is not consistent to have actual gearing based on Debt/Enterprise Value to de-leverage and re-leverage using notional gearing based on Debt/RAB)[64] but as we show in Appendix H Ofgem mis-applies Indepen's approach.

Ofgem arrives at an asset beta range of 0.35 to 0.36, using debt betas of 0.10 to 0.15. It then re-leverages them using a notional gearing estimate of 60 per cent, calculating a notional equity beta range of 0.65 to 0.76.

We consider that Indepen does not provide strong enough evidence to estimate equity betas without de-leveraging and re-leveraging and further fails to take into account the evidence from the beta decomposition of National Grid, and evidence from international comparators. We note that Indepen's proposed adjustment to gearing has no precedent in UK regulation and, even if we were to accept this, there is no strong evidence that adjusted MARs are significantly different from 1. Moreover, Ofgem fails to correctly apply Indepen's method, and instead applies an adjustment to actual gearing, leading to an understatement of asset betas and cost of equity.

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61 Ofgem (18 December 2018), RIIO-2 Sector Specific Methodology Annex: Finance, Section 3, pp.39-40.

62 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 5, pp.45 and 46.

63 Market to Asset ratio is defined as Market Value of the company over the RAB.

64 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 4, pp.31-34.

In Appendix H we comment in more detail on Indepen's and Ofgem's beta approach. In Appendix I we also review the use of a GARCH estimation model by Indepen.

In the following sections, we present our estimate for the asset beta of SPT. Section 3.2 sets out our methodology. In Section 3.3 we present beta evidence on UK networks and complement it in Section 3.4 with a relative risk assessment. In Section 3.5 we present evidence on EU comparator networks, including a relative risk assessment. Finally, in Section 3.6 we present our conclusions.

## 3.2. Empirical beta analysis

### 3.2.1. We draw on OLS methods, and prefer high frequency data and short time periods

Our overall approach is to use ordinary least squares (OLS) statistical techniques, and to draw on relatively high frequency data and recent (e.g. 2 year) estimation periods.

The estimation period (e.g. 1, 2, 5 years) and frequency of data (daily, weekly, monthly) should be considered together to ensure sufficient observations in the regression to lead to precise estimates, i.e. estimates with relatively low standard errors.

In terms of the estimation period, the more recent the time period the more relevant the beta estimate to the risks faced by investors over the control period. The period also has to be sufficiently long to provide the requisite number of observations to estimate statistically robust betas. We consider that a 2-year period and daily observations provides both relevant and robust beta estimates.

The only reason not to draw on daily observations is for stocks that are infrequently traded, and illiquid. For such stocks, daily stock returns are likely to exhibit serial correlation, where the returns on successive days are not independent, and which weakens the efficiency of the beta estimates.[65] For these stocks, weekly or monthly data may be justified. However, in our case, the comparators considered in this report have liquid stocks (based on bid-ask spreads), and hence we use daily return data, which provide statistical robust estimates in combination with 2-year estimation periods.

Our approach is in line with standard UK regulatory practice. UK regulators have often relied on relatively short estimation windows combined with daily data. Ofcom, for example, only considered one-year and two-year estimation windows in its Business Connectivity Market Review. It finally decided to use a two-year window, because it "*provides the most appropriate balance between a short enough estimation period to remain relevant on a forward-looking basis, whilst having enough data points to be sufficiently statistically robust*".[66] This is also in line with the risk associated with rapid technological change in the telecoms sector.

[65] We look at bid-ask spreads as a proxy for the liquidity of the listing. We consider stocks with bid-ask spreads below 1 per cent are sufficiently liquid/ frequently traded, based on UK and European regulatory approaches. See for example, NERA (2016) Update of the Equity Beta and Asset Beta for BT, A report for Ofcom. Section A4, p. 58-59. Link: https://www.ofcom.org.uk/__data/assets/pdf_file/0028/97039/annex_31.pdf.

[66] Ofcom (2016), Business Connectivity Market Review, Annex 30, p.80.

In the recent past, investors in UK energy networks have seen an increase in both technology-related risk and political risk (especially regarding political interference), and we expect that this will be reflected in the more recent market data. Given these developments, we prefer to rely on shorter estimation windows, e.g. of around two-years, but also report the wider set of estimation windows (1, 2, 5, and 10 years).

#### 3.2.1.1. MPW, Indepen and Dr Robertson recommendations

As we set out in a separate report,[67] three of the UKRN report authors, Mason, Pickford and Wright (MPW) recommend estimating betas using a methodology which substantially departs from common regulatory practice and the approach we adopt in this report. Specifically, they recommend betas should be estimated using very long-run estimation periods going back to 2000; aggregated or low frequency data (e.g. quarterly returns); and statistical models from the GARCH family for estimating betas.

As we explain in our report, we disagree with MPW's recommendations. Estimating betas over long horizons going back to 2000 ignores material changes in companies' business and financial risk, changes in market conditions, as well as changes in the regulatory regime, resulting in beta estimates that fail to reflect regulated companies' risk profile at RIIO-T2. The use of low frequency quarterly data requires extending the estimation period to ensure sufficient observations, leading to very long estimation periods that are not relevant in terms of risk profile, as noted above. The use of quarterly intervals results in less precise beta estimates, e.g. as measured by the standard errors.

Indepen addressed some of our issues with the MPW recommendations, namely by supporting the use of high frequency data (and specifically, estimate their recommended equity beta range using daily data) and addressing the choice of specific GARCH model (by testing different models to see which fit the data better).[68] However, Indepen, while acknowledging the existence of structural breaks, still relies on data going as far back as 2000 to inform its recommended equity beta range.[69]

Dr Robertson provides a similar view to our own, noting that higher frequency data provides more precision in the estimation of equity betas and presenting equity beta estimates in the form of daily data.[70] Robertson, similar to Indepen and our view, also recognises that the existence of structural breaks provides an argument against the use of very long run data.[71]

In terms of estimation technique, we show that if we use daily data and recent time periods, then beta estimates are similar irrespective of whether GARCH or standard OLS statistical models are used. Given the substantial increase in complexity associated with the use of GARCH models, we consider that GARCH methods are less justified compared to standard OLS in the regulatory context, and hence our focus on established OLS methods in this

[67] NERA (2018), Review of UKRN report recommendations on beta estimation.

[68] Indepen (December 2018), Ofgem Beta Study – RIIO-2 Main Report, Final, Section 2 and Section 5, pp. 10, 11 and 45.

[69] Indepen (December 2018), Ofgem Beta Study – RIIO-2 Main Report, Final, Section 2 and Section 5, pp. 5-7 and 45.

[70] Donald Robertson (April 2018), Estimating β, pp. 3, 39 and 40.

[71] Donald Robertson (April 2018), Estimating β, p.36.

report. We provide a detailed commentary on the choice of the estimation model in Appendix I.

### 3.2.2. Levering the beta

The systematic risk of a company is measured by the asset beta of the firm, which takes into account all the assets of the firm. Unlike the equity beta, the asset beta is not affected by the firm's capital structure. The asset beta is estimated by de-levering the equity beta for the listed companies, using each company's gearing. The asset beta must then be "levered" back to an equity beta using the gearing assumption for the sector as whole. In levering the beta, we use the so-called Miller formula which is the standard approach in GB regulation, i.e. used by CMA.[72,73]

- Miller: $\beta_e = \beta_a * (1 + D/E)$

For de-levering equity betas, we use net debt to market capitalisation of the respective companies.

#### 3.2.2.1. MPW proposed approach

As with the wider estimation techniques, MPW provide an alternative view on how to estimate the beta for a notionally geared efficient network. MPW argue that the use of a notional gearing to re-lever the asset beta is incorrect and that the most reliable equity beta is the raw estimation.

We do not consider the MPW approach has merit. The use of an unadjusted equity beta reflecting companies' actual gearing would be inconsistent with the notional weights used to calculate the weighted average cost of capital. Alternatively, if the regulator were to determine the cost of capital based on listed companies' actual capital structure decisions, this would undermine incentives to optimise capital structure and minimise financing costs, and would tie the sector to the capital structure decisions of the few listed companies.

The use of de-leveraging and re-leveraging the equity beta to reflect the regulator's notional structure has also been adopted by CMA, Ofgem and Ofwat, and therefore our approach is consistent with wider regulatory practice. [74,75]

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[72] CMA (2015), Bristol Water plc - A reference under section 12(3)(a) of the Water Industry Act 1991, p.333; CMA (2014), Northern Ireland Electricity Limited price determination - A reference under Article 15 of the Electricity (Northern Ireland) Order 1992, p.13-40.

[73] An alternative is to use the so-called Modigliani-Miller: $\beta_e = \beta_a * (1 + \{1\text{-Tax Rate}\}*D/E)$. The Miller formula assumes that the capital structure of the firm is constant, or in other words the firm pursues a target capital structure and it rebalances its debt and equity constantly towards its target. By contrast, the Modigliani-Miller formula assumes that the debt *level* of the firm is constant, whilst the capital structure can change. See: Brealey and Myers (2011), Principles of Corporate Finance, 10th edition, p.484-486.

[74] Ofwat (September 2016), Water 2020: consultation on the approach to the cost of debt, p. 16. Ofwat states: Ofwat cites the following reasons to support a notional approach. These were: *"Customers should not be responsible for funding inefficient financing structures of debt costs"; "Companies are free to choose their actual capital structure and the debt instruments raised, but customers will only face the efficient cost of debt for a notionally structured company."*

[75] The CMA also supported a notional approach to capital structure and cost of debt in Bristol Water appeal. The CMA states the following: "*In addition, we support Ofwat's use of a notional cost of embedded debt in the context of a multi-company framework. As well as being consistent with other regulators (e.g. Ofgem), this has the benefits of allocating*

#### 3.2.2.2. Indepen's proposed approach

Indepen, while not estimating notional equity betas (opting to present raw equity betas), points to an inconsistency in the leveraging process if observed equity betas are de-leveraged using their actual gearing value (based on an enterprise value gearing), it is inconsistent to then re-leverage them using a RAB-based notional gearing estimate.

Indepen acknowledges that this would not be an issue if Market to Asset ratios are close to 1, i.e. enterprise value and RAB gearing are close.[76] However, for the cases where MAR is different from 1, Indepen recommends the use of a notional enterprise value level of gearing which is calculated as D/(RAB*MAR).

Having set the formula for calculating a notional enterprise value level of gearing, Indepen also considers the MAR value to use. Given the issues surrounding the use of the actual MAR, Indepen opts for using a "normal" MAR of 1.1 as a starting point, based on evidence from the UKRN report, including the fact that recent MAR's for water pure-plays are around 1.1 and last 20 years average MAR's for energy and water networks is close to 1.2.[77] The choice of a MAR above 1 implies that the new notional gearing measure will be lower, which will be reflected in lower re-leveraged equity betas.

We do not believe that such adjustments are required in principle and current estimates of MARs are not significantly different from 1, which means that, even if we were to accept Indepen's adjustment, it should have no effect in gearing. Moreover, Indepen's "adjusted" notional gearing has no precedent in UK regulation.

Meanwhile, Ofgem continues to estimate a notional equity beta, but de-leveraging the raw equity betas by adjusting the actual gearing of companies using Indepen's normal MAR adjustment, overstating the actual gearing level.[78] This is not consistent with Indepen's approach, as Indepen applies its adjustment to the notional gearing estimate, and not to the actual gearing levels. When de-leveraging betas, the objective is to remove the financing effects from the comparators to obtain a measure of business risk, which is accomplished by using the firm's actual capital structure, and not some measure adjusted to reflect a notional level. This adjustment leads to an understatement of the asset betas and, consequently, the cost of equity.

We present a detailed commentary on this issue in Appendix H.

### 3.2.3. Debt beta

The debt beta captures the degree of correlation between the returns to debt-holders and the broader economy, analogous to the equity beta which captures correlated risk for equity-

*risk/reward to the people best able to manage it (i.e. management), incentivising efficient methods and timings of raising debt, and removing incentives to obfuscate actual debt costs through complex arrangements and capital structures."*
Source: CMA (2015) Bristol Water price determination, p. 304. Link: https://assets.publishing.service.gov.uk/media/56279924ed915d194b000001/Bristol_Water_plc_final_determination.pdf

[76] Market to asset ratios is defined as Market Value of the company over the RAB.

[77] Indepen (December 2018), Ofgem Beta Study – RIIO-2 Main Report, Final, Section 4, pp.32-34.

[78] Ofgem (18 December 2018), RIIO-2 Sector Specific Methodology, Annex: Finance, Section 3, pp. 39 and 40.

holders. Under standard corporate finance theory, both quantities are needed to obtain the asset beta, a measure of business risk which removes the effect from leverage (i.e. quantifies correlated volatility as if the company had no debt), as per the following formula:

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

where

$\beta_a$ is the unlevered beta ("asset beta");

$\beta_d$ is the debt beta;

$\beta_e$ is the equity beta; and

g is the gearing level (Debt/Debt + Equity).

Ofgem has assumed a debt beta range of 0.1 to 0.15, the same as Indepen's recommendation, based on the analysis of regulatory precedent and academic evidence.[79]

We do not consider Indepen's range is well-supported, with most regulators assuming a zero debt beta. For example, Ofwat and Ofgem used a zero debt beta in estimating cost of equity at PR14 and the recent RIIO reviews.[80] CEPA also assumes a zero debt beta for its recent report to Ofgem, and the UKRN report provides empirical evidence that the debt beta for UK energy networks is likely to be close to zero when using daily data.[81]

The assumed debt beta has a negligible impact on the equity beta and cost of capital, assuming de-leveraging and leveraging is undertaken correctly as confirmed by the CMA.[82,83] In line with common regulatory practice, we assume a zero debt beta in our analysis.

## 3.3. Empirical evidence from UK networks

Figure 3.1 shows the evolution of asset betas for listed UK networks comparators – National Grid plc, SSE, UU, Severn Trent and Pennon – over the past 10 years. We observe noticeable movement around June 2018, the date where the Brexit referendum effect falls out of our sample, especially for SSE, which shows a steep drop in its asset beta. The movement

[79] Ofgem (18 December 2018), RIIO-2 Sector Specific Methodology, Annex: Finance, Section 3, pp. 39 and 40; Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 3, pp.26-29; Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Appendices D-H, Appendix E, pp.4-10.

[80] Ofgem (December 2012), RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas - Finance and uncertainty supporting document; Ofgem (December 2012), RIIO-GD1: Final Proposals - Finance and uncertainty supporting document; Ofgem (July 2014), RIIO-ED1: Draft determinations for the slow-track electricity distribution companies – Financial Issues; Ofwat (December 2014), Setting price controls for 2015-20 Final price control determination notice: policy chapter A7 – risk and reward, p.41, 42.

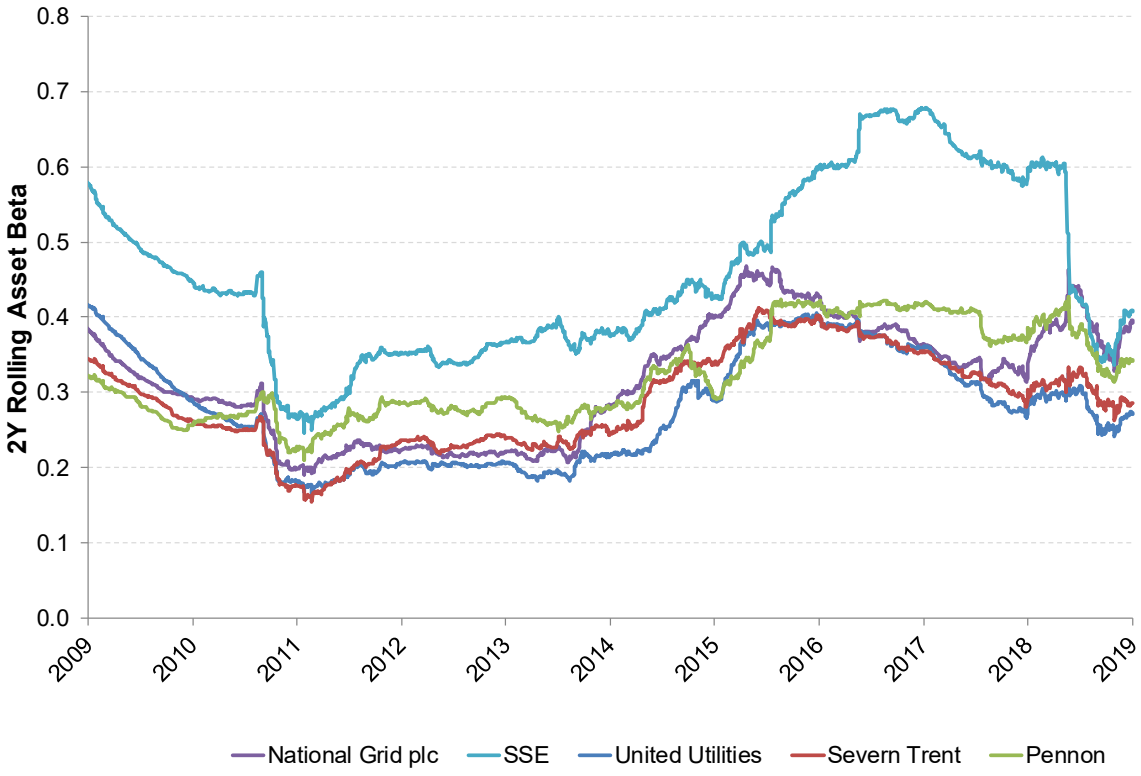
[81] CEPA (February 2018), Review of the cost of capital ranges for Ofgem's RIIO-2 for onshore networks, p.51; S Wright, P Burns, A Mason, D Pickford (2018), Estimating the cost of capital for implementation of price controls by UK Regulators ("UKRN Report"), p55.

[82] The assumed debt beta affects the notional cost of equity only to the extent that leverage for the comparators differs from the notional assumption. If empirical leverage is the same as notional and consistent debt betas are used for un-levering and re-levering, there is no impact on the re-levered cost of equity.

[83] For example, at the BW 2015 appeal, the CMA assumed a debt beta of zero, noting that debt beta has very little impact on the overall cost of capital as BW's notional gearing level was similar to the comparators.

is less obvious for other utilities, since they are defensive stocks and did not co-move as much with the stock market on the Brexit date, while SSE's larger proportion of generation and non-regulated activities[84] explains its higher systematic risk during periods of increased market uncertainty. CEPA also comments on SSE, mentioning that their low percentage of revenues from UK regulated activities makes it a non-reliable comparator.[85] The asset betas for NG plc and other comparators have increased considerably since the height of the financial crisis in Europe (2011-2012), and the RIIO-T1 determination in 2013, as can be seen in Table 3.1.

**Figure 3.1: 2Y rolling asset betas for UK utilities have increased since RIIO-T1, as a consequence of UK emerging from the financial crisis**




*Source: Bloomberg, NERA analysis, cut-off: 8 February 2019, daily data, reference index: FTSE All Share.*

[84] In FY2017/2018, SSE derived only about 4% of its total revenues from regulated network activities (electricity transmission and distribution). The largest share of SSE's revenues came from wholesale activities (74%, including generation activities), followed by retail activities (22%). See Annual report for FY2017/2018, p. 158.

[85] CEPA (February 2018), Review of Cost of Capital Ranges for Ofgem's RIIO-2 for Onshore Networks, p.50-51.

**Table 3.1: Empirical asset betas were considerably lower at RIIO-T1 compared to today**

| | Cut-off: 17 December 2012 | | | Cut-off: 8 February 2019 | | |
|---|---|---|---|---|---|---|
| | 1Y | 2Y | 5Y | 1Y | 2Y | 5Y |
| National Grid | 0.21 | 0.22 | 0.28 | 0.33 | 0.39 | 0.38 |
| SSE | 0.32 | 0.36 | 0.41 | 0.39 | 0.41 | 0.55 |
| United Utilities | 0.17 | 0.20 | 0.26 | 0.24 | 0.27 | 0.33 |
| Severn Trent | 0.22 | 0.24 | 0.26 | 0.25 | 0.29 | 0.34 |
| Pennon | 0.26 | 0.29 | 0.27 | 0.28 | 0.34 | 0.38 |
| Average | 0.24 | 0.26 | 0.30 | 0.30 | 0.34 | 0.39 |
| **Average (excl. SSE)** | **0.22** | **0.24** | **0.27** | **0.27** | **0.32** | **0.35** |

*Source: Bloomberg, NERA analysis, daily data, reference index: FTSE All Share.*

Table 3.2 shows updated beta estimates using the CMA approach from the Bristol Water appeal,[86] where the betas are estimated based on various data frequencies and estimation windows, with the CMA taking an average of the regression results over different periods. The CMA then determined a beta range based on the 25$^{th}$ and 75$^{th}$ percentiles (interquartile range) based on the sixteen different approaches. Reproducing the CMA approach, we estimate an asset beta range of 0.36 to 0.42 based on the interquartile range for our set of comparators (Pennon, Severn Trent, United Utilities, National Grid plc and SSE). If we exclude SSE, this range becomes 0.33 to 0.40. As mentioned in Section 3.2, we prefer to use

[86] CMA (October 2015), Bristol Water price determination.

2-year daily data for our estimates, which provides us with slightly lower ranges: 0.34 to 0.36 (if we include SSE) and 0.32 to 0.33 (if we exclude SSE).

**Table 3.2: CMA approach supports a range of 0.3 to 0.4 (excluding SSE)**

| | Averaging Period | | | |
|---|---|---|---|---|
| Estimation period | **Today** | **Last Year** | **Last 2 Years** | **Last 5 Years** |
| **All comparators** | | | | |
| 2-year daily | 0.34 | 0.36 | 0.36 | 0.38 |
| 2-year weekly | 0.41 | 0.43 | 0.43 | 0.40 |
| 5-year weekly | 0.41 | 0.41 | 0.40 | 0.33 |
| 5-year monthly | 0.41 | 0.44 | 0.42 | 0.30 |
| **All comparators (excl. SSE)** | | | | |
| 2-year daily | 0.32 | 0.33 | 0.32 | 0.34 |
| 2-year weekly | 0.40 | 0.43 | 0.42 | 0.39 |
| 5-year weekly | 0.39 | 0.39 | 0.38 | 0.32 |
| 5-year monthly | 0.39 | 0.43 | 0.41 | 0.28 |
| **Pennon** | | | | |
| *2-year daily* | 0.34 | 0.37 | 0.31 | 0.34 |
| *2-year weekly* | 0.49 | 0.49 | 0.47 | 0.42 |
| *5-year weekly* | 0.43 | 0.42 | 0.42 | 0.36 |
| *5-year monthly* | 0.42 | 0.41 | 0.37 | 0.29 |
| ***UU*** | | | | |
| *2-year daily* | 0.27 | 0.28 | 0.29 | 0.32 |
| *2-year weekly* | 0.33 | 0.34 | 0.36 | 0.35 |
| *5-year weekly* | 0.35 | 0.36 | 0.35 | 0.29 |
| *5-year monthly* | 0.35 | 0.40 | 0.39 | 0.26 |
| ***SVT*** | | | | |
| *2-year daily* | 0.29 | 0.30 | 0.31 | 0.34 |
| *2-year weekly* | 0.37 | 0.41 | 0.41 | 0.39 |
| *5-year weekly* | 0.37 | 0.38 | 0.38 | 0.33 |
| *5-year monthly* | 0.38 | 0.46 | 0.46 | 0.31 |
| ***NG*** | | | | |
| *2-year daily* | 0.39 | 0.38 | 0.36 | 0.38 |
| *2-year weekly* | 0.41 | 0.47 | 0.43 | 0.39 |
| *5-year weekly* | 0.39 | 0.40 | 0.39 | 0.29 |
| *5-year monthly* | 0.41 | 0.44 | 0.40 | 0.25 |
| ***SSE*** | | | | |
| *2-year daily* | 0.41 | 0.47 | 0.54 | 0.53 |
| *2-year weekly* | 0.44 | 0.43 | 0.49 | 0.47 |
| *5-year weekly* | 0.49 | 0.49 | 0.48 | 0.40 |
| *5-year monthly* | 0.50 | 0.48 | 0.47 | 0.38 |

*Source: NERA analysis of Bloomberg data, including Pennon, UU, SVT, NG and SSE. We assume zero debt beta. Information date is 8 February 2019 (weekly returns we used 1 February 2019; for monthly returns, we used 31 January 2019). Asset beta is calculated using gearing based on net debt.*

### 3.3.1. Explaining trend in NG plc's beta risk over time

We have conducted an empirical analysis of systematic risk, using stock and index return data to estimate betas for NG plc and other listed UK networks.

Figure 3.2 shows NG plc's equity beta (red line) over the period 2007 to 2019, including a decomposition of the beta into its two components, the relative volatility of the stock return to that of the market (blue line) and the correlation of the stock return with the market (green line).

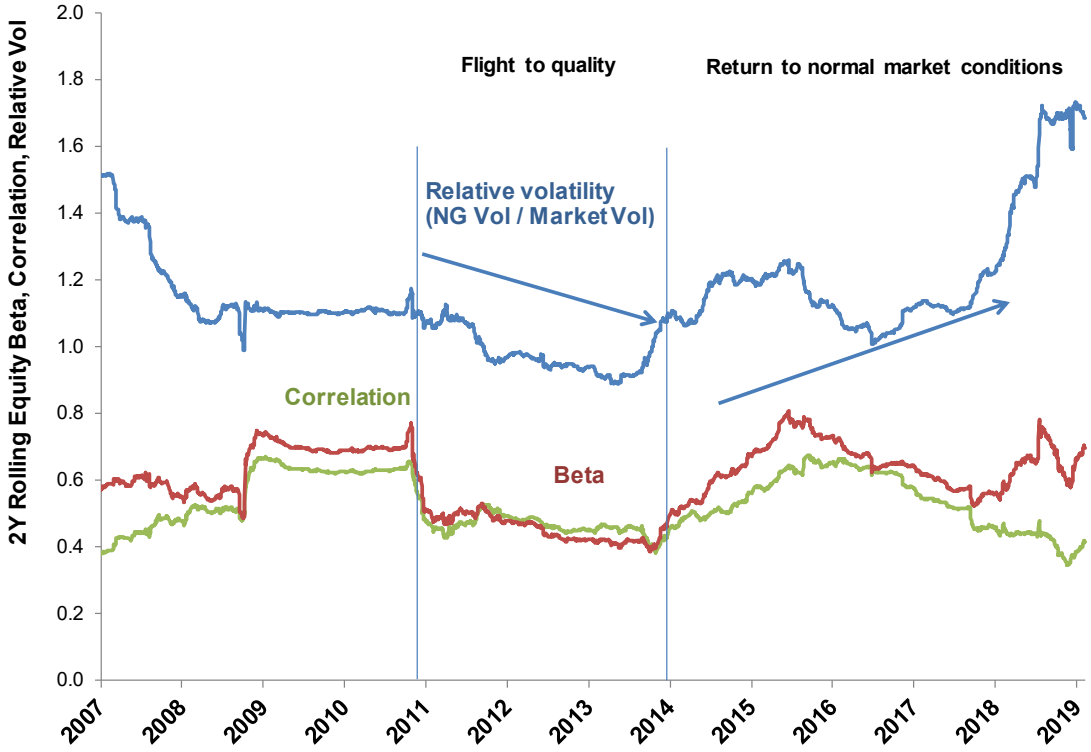
Under the OLS CAPM, the equity beta derived from market data can be decomposed into correlation of the stock return with the market, and relative volatility of the stock return to that of the market:

$$equity\ \beta = \rho_{stock,\ market}\ x\ \frac{\sigma_{stock}}{\sigma_{market}}$$

As with other "defensive" stocks, NG plc's equity beta fell in the aftermath of the financial crisis due to higher market volatility relative to NG plc's volatility, and reduced correlation (which was relatively suppressed due to NG plc being a defensive stock). However, NG plc's equity beta has returned back to normal market conditions and pre-crisis levels.

Initially, both the correlation component and relative volatility increased, followed by a decrease. In recent months, relative volatility has increased considerably. This could be a result of increased political risk (e.g. regarding political interference in utility regulation) as well as increased risks with regard to technological developments, e.g. relating to uncertainty over the future role of TO networks. This trend of higher relative volatility can also be observed for the listed water companies.

**Figure 3.2: Increase in NG plc's equity beta mainly a result of increase in relative volatility**




*Source: Bloomberg, NERA analysis, cut-off: 8 February 2019, daily data, reference index: FTSE All Share.*

### 3.3.2. NG group beta decomposition

We have considered how National Grid's non-UK regulated businesses affect its asset beta, and analyse it more thoroughly in Appendix G. Here, we present a summary of our findings.

The decomposition of NG plc's beta is done through the following equation:

$$\beta_{National\ Grid} = \frac{Regulated\ assets\ in\ UK}{Total\ regulated\ assets} * \beta_{UK} + \frac{Regulated\ assets\ in\ US}{Total\ regulated\ assets} * \beta_{US}$$

$$\beta_{National\ Grid} = 59\% * \beta_{UK} + 41\% * \beta_{US}$$

To estimate the US beta, we rely on a set of 20 US network comparators, who mainly engage in regulatory energy network, retail, or generation activities. Furthermore, we consider that 3 of these comparators provide a more accurate representation of the risk to which NG's US assets are exposed, given that they operate in the same states and hence are exposed to similar regulatory regimes. These companies are Consolidated Edison, Unitil Corp and Eversource Energy. In Table 3.3 and Table 3.4 we present the implied UK asset betas based on the reduced comparator set and the full set. Overall, it supports a range 2-year asset beta range of 0.55 to 0.57, higher than the 2-year asset beta estimate of NG plc (0.38).

**Table 3.3: We estimate NG's UK beta of 0.57/0.49 based on three most direct comparators operating in same/similar states**

| | NG overall | US | UK |
|---|---|---|---|
| Share of regulated assets | | 41% | 59% |
| 2Y beta | 0.39 | 0.13 | **0.57** |
| 5Y beta | 0.38 | 0.21 | **0.49** |

*Source: Bloomberg, NERA analysis.*

**Table 3.4: Solving for NG UK beta – full set of comparators**

| | NG overall | US | UK |
|---|---|---|---|
| Share of regulated assets | | 41% | 59% |
| 2Y beta | 0.39 | 0.16 | **0.55** |
| 5Y beta | 0.38 | 0.26 | **0.46** |

*Source: Bloomberg, NERA analysis.*

### 3.3.3. Indepen's Conceptual Questions on Beta Decomposition

Indepen considers that, while a strong case can be made for decomposing the asset betas of some listed UK networks (including National Grid), there is still uncertainty around the assumptions required and thus it does not recommend relying on results obtained through a beta decomposition until these issues are resolved. Indepen's concerns are centred around three issues:

a. Should it [the decomposition] be applied to equity or asset betas?

b. If applied to asset betas, should a group average, group actual or industry specific gearing be used?

c. Are net assets the right way of measuring the weights? [87]

In our view, there is enough support behind the assumptions required by Indepen to justify the use of the National Grid's beta decomposition in the estimation of betas for RIIO-2.

In finance theory, a beta decomposition approach is relatively frequent, being commonly referred to as a "bottom-up beta".[88] The evidence from finance theory allows us to answer Indepen's three conceptual questions. First, the decomposition should be done using asset betas because these are the correct measures of a segment's business risk, without introducing financing decisions into the beta. Second, the gearing used for de-leveraging the comparators' equity betas should reflect the actual gearing of the comparators', while the gearing used for re-leveraging the estimated asset beta should be a notional gearing level.

[87] Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 4, pp.36 to 39.

[88] See for example Damodaran, A (2012), Investment Valuation: tools and techniques for determining the value of any asset, Chapter 8, p.197.

Finally, the weights used should be based on the present value of future cash-flows, which, in our view, can be proxied by the proportion of regulated assets out of total regulated assets.

Beta decomposition is also relatively common in UK regulatory determinations. For example, Ofcom and the then Competition Commission, now Competition and Markets Authority have applied asset beta decompositions in their determinations.[89]

Indepen, in their National Grid beta decomposition example, estimates a beta for the UK segment higher than for the US segment, which is also consistent with our results present in the previous section.

We present a more detailed commentary in Appendix G and Appendix H.

### 3.3.4. Conclusions on UK networks empirical asset betas

Listed networks' asset betas have increased since RIIO-T1, as the UK economy emerged from the financial crisis.[90] As set out in Table 3.2, the average two-year asset beta of networks stands at 0.34 (0.32 if we exclude SSE), with NG plc's having an higher asset beta (0.39), due to the average being driven down by the presence of water companies (we discuss additional risks faced by energy networks relative to water networks in Section 3.4). Moreover, we also show that NG plc's composite beta understates the risks associated with its UK operations, as the composite beta in part reflects lower risk US operations.

Reasons for the increase in asset betas are related to an increase in correlation with the stock market, and most notably (and recently) an increase in the relative volatility of stocks. This can be seen for NG plc in Figure 3.2.

## 3.4. Relative risk assessment

### 3.4.1. Energy compared to other networks

We have compared the risks faced by SPT relative to other UK networks against a range of risk factors. Table 3.5 summarises our risk assessment relative to a wider set of UK network regulatory regimes.

In general, the regulatory regimes in energy and water are closely aligned, although energy networks face greater risk from the longer regulatory review period, and from the cost of debt indexation mechanism which increases the pro-cyclicality of returns relative to a fixed ex ante allowance.[91] Water companies potentially face greater risk from the treatment of pensions relative to energy networks, where water companies can recover 50 per cent of

[89] Ofcom (28 03 2018): Wholesale Local Access Market Review: Statement, Annexes 17-27, pp.76 and 115-136.; Competition Commission (28 September 2007), BAA Ltd, A report on the economic regulation of the London airport companies (Heathrow Airport Ltd and Gatwick Airport Ltd), Appendix F, pp.F-7, F-8 and F-28 to F-31.

[90] It should be noted that the nature of NG plc.'s UK business changed when the company sold a majority stake (61%) in its gas distribution business on 31 March 2017. This sale increased the share of regulated assets located in the US by about 5 percentage points from 36% to 41%.

[91] However, we note that Ofgem and its advisers did not accept that the cost of debt indexation method increased the procyclicality of returns. See for example, FTI (2012) A report for Ofgem (2012) Cost of capital study for the RIIO-T1 and GD1 price controls, p. 96. Link: https://www.ofgem.gov.uk/ofgem-publications/53728/riio-t1-cost-capital-study-riio-t1-and-gd1.pdf.

deficits as at PR09.[92] By contrast, energy networks can recover the established deficit as at 2013 with triennial revaluation to allow for changes in the value of the deficit, but face risk on post-establishment deficits.[93]

However, Ofwat intends to introduce a cost of debt indexation mechanism albeit for new debt only at PR19.[94] In its RIIO-2 framework consultation, Ofgem also proposes to reduce the length of price control form 8 years to 5 years.[95] Therefore, there may be further alignment between energy and water following RIIO-2 and PR19 price control reviews.

In addition to differences in the regulatory framework, our comparative analysis suggests that investors in SPT face higher risk than investors in water networks for the following reasons:

- Greater system operability risks associated with TOs;
- Greater exposure to stranding risk due to uncertainty over the future role of SPT in a decarbonised energy sector with prospects for decentralised generation

By contrast, SPT bears somewhat lower risk than companies in the aviation sector (HAL and NATS). Whereas energy companies have higher incentives with regard to cost and output, aviation companies are exposed to material within-period volume and competition risks, given their price cap regime.

[92] At PR09, Ofwat determined the price control allowance for pension deficit repair costs associated with companies defined benefit pension schemes assuming a 10- to 15-year deficit repair period starting in 2009 or 2010. Ofwat allowed companies to recover about 50 per cent of pension deficit repair costs from customers from PR09, with the rest dealt with by management action or shareholder contributions. Source: Ofwat (October 2013), IN 13/17: Treatment of companies' pension deficit repair costs at the 2014 price review. Link: https://0980a19b0bb02fe4a86d-0df48efcb31bcf2ed0366d316cab9ab8.ssl.cf3.rackcdn.com/wp-content/uploads/2015/11/prs_in1317pr14pension.pdf

[93] Ofgem (17 December 2012), RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas - Finance Supporting Document, Appendix 5.

[94] Ofwat (December 2017) Delivering Water 2020: Our final methodology for the 2019 price review, Link: https://064f1d25f5a6fb0868ac-0df48efcb31bcf2ed0366d316cab9ab8.ssl.cf3.rackcdn.com/wp-content/uploads/2017/12/Final-methodology-1.pdf

[95] Ofgem (March 2018), RIIO-2 Framework Consultation, para 4.20.

## Table 3.5: Relative risk assessment: SPT faces greater risk in terms of size of capex and asset stranding

| | SPTL (T1) | Gas Distribution | Electricity Distribution | Water | Heathrow | NATS (air traffic control) |
|---|---|---|---|---|---|---|
| **Form / length of control** | • Revenue-cap<br>• 8-years | • Revenue-cap<br>• 8-years | • Revenue-cap<br>• 8-years | • Revenue-cap<br>• 5-years | • Price-cap<br>• 5-years | • Part revenue part price-cap<br>• 5-years |
| **Setting cost allowances** | • Expert review of totex<br>• DB pension deficit recovery over 15yrs with 3Y re-valuation (but risk on post-2012 liabilities)<br>• Re-openers for some costs | • Comparative benchmarking of totex (UQ efficiency)<br>• DB pension deficit recovery over 15yrs with 3Y re-valuation (but risk on post-2012 liabilities)<br>• Re-openers for some costs | • Comparative benchmarking of totex (UQ efficiency)<br>• DB pension deficit recovery over 15yrs with 3Y re-valuation (but risk on post-2012 liabilities)<br>• Re-openers for some costs | • Comparative benchmarking of totex (UQ efficiency)<br>• 50% sharing of pension deficit repair costs with customers | • Opex based on benchmarking & capex agreed with airlines<br>• Pass-through of pension deficit costs | • Opex based on benchmarking & capex agreed with airlines<br>• DB pension deficit allowance and 80% pass through of savings / overspend within period |
| **Outturn cost risk & incentives** | • TIM<br>• Uncertainty/pass-through of non-controllables<br>• Disapplication of price control | • TIM<br>• Uncertainty/pass-through of non-controllables<br>• Disapplication of price control | • TIM<br>• Uncertainty/pass-through of non-controllables<br>• Disapplication of price control | • Totex sharing<br>• Pass-through of non-controllables<br>• IDoK/SAE clause | • Full risk on opex and pass-through of efficient actual capex (s.t. delay penalties) | • 5-year opex roller and pass-through of efficient capex |
| **- Capex/opening RAB** | • 15% (T1)/ 7% (T2) | • 6% | • 11% | • 6-8% (WaSC-WOC) | • 4% | • 10% |
| **- Totex/opening RAB** | • 17% (T1) | • 13% | • 15% | • 13-22% (WaSC-WOC) | • 11% | • N/a |
| **- Totex sharing factor** | • 50% (T1) | • 62-64% | • 53-58(70)% | • 50-57% | • 100% opex, 0% capex | • 5-year opex roller, 0% capex |
| **Financing cost risk** | • COD update = 10Y trailing average iBoxx | • COD update = 10Y trailing average iBoxx | • COD update = 10-20Y trailing average iBoxx | • Fixed at weighted average of industry embedded and new forecast COD | • Fixed at weighted average of HAL embedded and new forecast COD | Fixed at weighted average of NERL embedded and new forecast COD |
| **Quality of Service/Output incentives** | • Performance incentives : +0.9/-1.4% of RORE | • Performance incentives : +1.3/-0.7% of RORE | • Performance incentives : +2.2/-2..8% of RORE | • Performance incentives (SIM,ODI): +0.8/-2.1% of RORE | • Service quality: asymmetric -7% penalty.+2% reward of airport charges | • Delays: +/-1% revenue |
| **Stranding/ competition / regulatory risk** | • Uncertainty over future role and operation of system from distributed generation | • Uncertainty over future gas flows (domestic heat decarbonisation) | | • Competition in NHH retail; future competition for water/ bioresources | • Competition from other London/UK and European hub airports | • No competition in immediate future |

*Source: Bloomberg, NERA analysis*

### 3.4.2. TO's face greater risks than other energy networks

For reasons of the complexity of investment, competition risks, and asset stranding risk, TOs are likely to face higher risks than most other energy networks.

**Complexity of investment**

At RIIO-T1, Ofgem considered both the scale and complexity of investment as risk factors. Ofgem took into account factors such as the size of the project, the number of projects, interlinkages with other projects and the projects' bespoke nature when assessing the complexity of networks' investments.[96]

At RIIO-T1, Ofgem's analysis shows that SPT's capital investment projects (and electricity TOs more generally) were more complex than those of gas transmission and distribution networks. Ofgem concluded that electricity TOs have larger and more complex investment projects, and a greater number of major linked projects.

**Competition risks**

In January 2016, DECC (now BEIS) published a policy proposal with the aim of "extending competitive tendering in the GB electricity transmission network", which is intended to follow a similar framework to the Offshore Transmission Owner (OFTO) regime.[97] As a consequence of a delay to the necessary statutory changes to introduce the competitively appointed TO or CATO) regime, Ofgem recently published proposals to introduce competition proxy model (CPM) and special purpose vehicle (SPV) models, which can proceed ahead of the legislative change[98], and has identified a number of projects which it expects to subject to CPM or SPV approach.

We consider that overall the SPV/CPM model is likely to expose TOs to greater risk. For example:

- *Construction risks will be greater under CPM*. Ofgem states that construction and delivery risk will remain largely with the TO but with "*sharing factor for underspend and efficient overspend*".[99] Thus, Ofgem intends to subject over-spends to efficiency test, which increases regulatory risk relative to the RIIO counterfactual where there is no such qualification.
- *Operational risk is greater under CPM*: TO is exposed to a higher level as operational and maintenance cost allowance set over the contract period as opposed to subject to periodic review. The CPM/SPV approach thereby exposes the TO greater risk from asset failure that increase cost, and unexpected increases in the cost itself.[100]

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96 Ofgem (2012), RIIO-T1: Final proposals for National Grid Electricity Transmission and National Grid Gas – Finance support document, Table 3.3

97 DECC (January 2016), Extending competitive tendering in the GB electricity transmission network, IA No: DECC 3088(1)

98 Ofgem (2018), Impact Assessment on applying the PSV and CPM to future new, separable and high value projects, p. 14

99 Ofgem (July 2018) Hinkley-Seabank project: decision on delivery model, Appendix 3.

100 Ofgem (July 2018) Hinkley-Seabank project: decision on delivery model, Appendix 3

- *Incomplete contract risks:* It is difficult to design long-term contracts that accommodate all contingencies over the life of the contract; by contrast, the RIIO process provides for established periodic reviews. The incompleteness of the contract may also heighten investor risk relative to the RIIO counterfactual, and increases the cost of capital. [101]

These risks should be compensated for in any determination of the cost of capital for CPM/SPV projects, but otherwise through the RIIO-2 process. In any case, the CPM/SPV expose TOs to greater uncertainty over future capex and funding allowances, and the potential for unrecoverable costs, e.g. in relation to developing SPV models.

**Asset stranding**

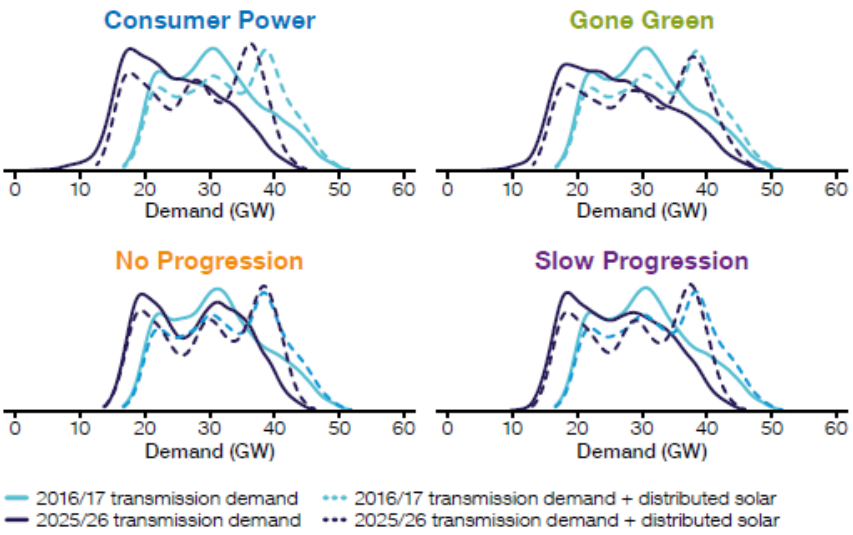
The government's decarbonisation agenda is driving significant changes in the energy supply market with traditional sources of energy supply replaced with divergent mix, with material yet uncertain implications for TOs.

The potential for increased levels of embedded generation and storage at the distribution level may lead to changes in the use of transmission networks at T2 and beyond. FES modelling shows that due to the potential for embedded generation there is the prospect for a reduction in peak demand, and prolonged periods of low demand on electricity TO networks, shown by growth in left hand tail of the relevant distributions (see Figure 3.3). For example, according to Future Energy Scenarios (FES) 2017, under the scenario "Consumer Power", as many as 33 GW of solar panels could be connected to electricity system, with a majority connected at distribution level, including "behind the meter".[102]

[101] For a discussion of incomplete contract risks in the context of PFO, see: NERA (March 2018), Why PFI holds no lessons for utility regulation, 4

[102] NG (2017), FES. Link: http://fes.nationalgrid.com/media/1253/final-fes-2017-updated-interactive-pdf-44-amended.pdf.

**Figure 3.3**
**Change in demand profile, and increase in left side tail of distribution as demand declines on electricity TOs from embedded generation**



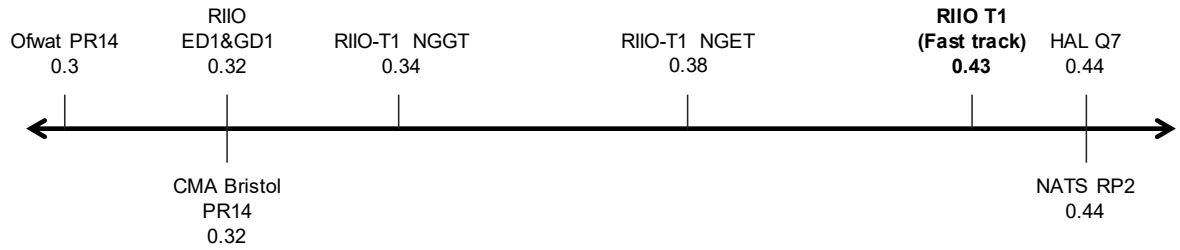

*Source: National Grid (2016) System Operability Framework, p21.*

### 3.4.3. Regulatory decisions are aligned with our view that TOs face greater risks

As set out above, energy networks face greater risks than water networks. TOs also face greater risks than most other energy networks from the complexity of projects, competition models, and uncertain energy flows from distributed generation.

Our relative risk analysis is in line with Ofgem's decision to set asset betas for SPT (and SHETL – Fast Track) above water, but below aviation at RIIO-T1, as shown in Figure 3.4. It also shows a higher asset beta compared to NGET, NGGT as well as distribution networks which is in line with Ofgem's view that these networks faced lower cash flow risk than SPT at RIIO-1.[103]

**Figure 3.4: Our relative risk assessment suggests that SPT's asset beta risk lies between water and aviation, in line with regulatory precedent**




*Source: NERA calculations based on regulatory decisions.*

[103] Ofgem (17 December 2012), RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas, Finance Supporting Document, p.19-22.

As can be seen from Figure 3.1 above, the most recent regulatory asset beta determinations as shown in Figure 3.4 corresponded to a time when the empirical betas of UK networks were considerably lower than they are today and therefore the absolute level of recent historical regulatory decisions are not relevant to RIIO-T2. As Table 3.1 shows, NG plc's two-year asset beta was 0.22 at the time of the RIIO-T1 Final Proposals (17 December 2012).[104] In contrast, the current two-year asset beta is much higher at 0.38.

Similarly, the empirical asset betas of water companies were considerably lower at RIIO-T1 than today. The average (all comparators, excluding SSE) asset beta was 0.24 at RIIO-T1, compared to 0.32 now. This increase in empirical betas since RIIO-T1 indicates that there has been an increase in the market view of equity risk, which should be taken into account at RIIO-T2.

Table 3.6 shows how Capex/Opening RAB for SPT in RIIO-T1 compares to the forecast for RIIO-T2. Given Ofgem's methodology, which states that a higher ratio implies higher riskiness, the updated results would imply a lower risk for SPT in T2. Nonetheless, and as recognised by Ofgem, cost risk also depends on expected capex/totex variability and this result should be taken into account with the other evidence presented.[105]

**Table 3.6: Capex to Opening RAB is projected to decline for SPT in RIIO-T2**

| Capex/Opening RAB | RIIO-T1 | RIIO-T2 |
|---|---|---|
| SPT | 15% | 7% |

*Source: NERA calculations based on SPT and Ofgem PCFM data.*

## 3.5. Beta Evidence from European comparator networks

In this section, we present empirical beta evidence for listed European networks. We also present a comparative risk analysis for SPT versus the principal European regimes.

### 3.5.1. Empirical evidence from European energy networks

Indepen argues that the use of international comparators is not helpful given issues such as the comparability of regulatory regimes.[106] In our view, provided that a relative risk analysis is undertaken, there is value in estimating betas for international comparators, as these can provide an appropriate benchmark for a UK regulated network. Moreover, we note that there is UK regulatory precedent in using betas from other countries in determinations. For example, the CAA in its 2014 price review for Heathrow and Gatwick estimated an asset beta

[104] Ofgem (17 December 2012), RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas.

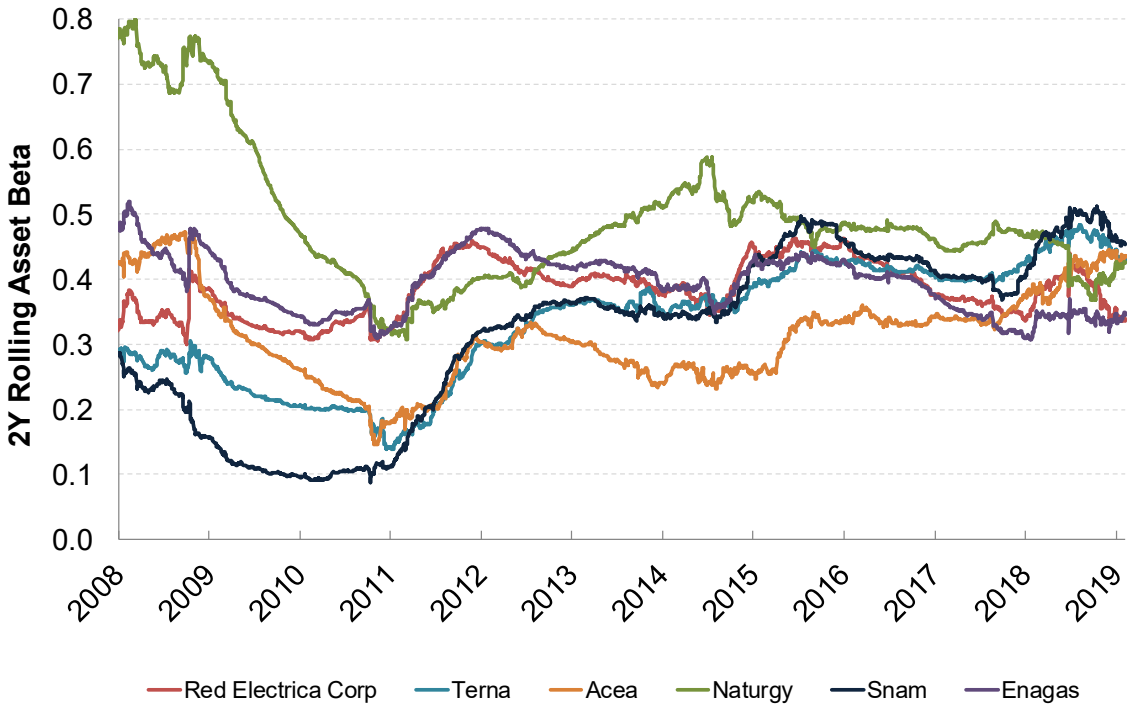
[105] Ofgem (17 December 2012), RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas, p.14-16

[106] Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 3 and Section 5, pp.23, 24 and 42.

by reviewing evidence from airports from countries such as Germany (Fraport) and France (ADP).[107]

Figure 3.5 presents the two-year asset betas of listed European comparators (i.e. Italian and Spanish transmission and distribution networks) over the past 10 years.[108] As with the UK listed networks, asset betas for these networks have generally increased since the financial crisis. There seems to be some movement around the Brexit date falling out of the sample (as in Section 3.3), although the drop is reverted quickly.

**Figure 3.5: 2Y rolling asset betas for European utilities have increased since the crisis**




*Source: Bloomberg, NERA analysis, cut-off: 8 February 2019, daily data, reference index: Eurostoxx.*

Table 3.7 below provides the most recent asset beta estimates for these comparators, for a range of estimation windows. This evidence supports an asset beta of around 0.4 over the most recent 2-year period.[109]

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[107] CAA (2014), Estimating the cost of capital: technical appendix for the economic regulation of Heathrow and Gatwick from April 2014: Notices granting the licenses, pp.39-43

[108] There are other listed European network companies (e.g. Elia, Fluxys), but their stocks have generally been illiquid and are hence not included in this analysis.

[109] Our estimates are also in line with Oxera's recent range proposed in its Report for ENA. Oxera estimate asset betas for both UK and European utility comparators, and concluded that 0.38 to 0.42 is an "appropriate assumption" for RIIO-2 based on the empirical betas of the same sample of European network comparators. Oxera's range reflects a debt beta assumption of 0.05. Assuming a debt beta of zero, in line with our approach, Oxera's range would be 0.36 to 0.40, which falls within our proposed range. See Oxera (28 February 2018), The cost of equity for RIIO-2 - Prepared for

**Table 3.7: Empirical asset beta estimates for listed European utilities[110]**

| | Country | 1Y | 2Y | 5Y |
|---|---|---|---|---|
| Snam (GT) | Italy | 0.38 | 0.45 | 0.44 |
| Terna (ET) | Italy | 0.35 | 0.43 | 0.43 |
| Acea (ED) | Italy | 0.35 | 0.44 | 0.36 |
| Enagas (GT) | Spain | 0.30 | 0.35 | 0.36 |
| Red Electrica (ET) | Spain | 0.23 | 0.34 | 0.39 |
| Naturgy (GD) | Spain | 0.42 | 0.43 | 0.47 |
| **Average** | | **0.34** | **0.40** | **0.41** |

*Source: Bloomberg, NERA analysis, cut-off: 8 February 2019, daily data, reference index: Eurostoxx.*

### 3.5.2. Risk assessment relative to European comparators

We have also compared SPT to the listed European comparators with regard to the systematic risks that investors face when investing in these companies.

Table 3.8 summarises our risk assessment for these markets, relative to SPT. We find that in general, SPT faces similar risks as Italian and Spanish networks.

**In Italy**, networks are regulated under a hybrid of a price cap (on opex) and a rate of return regime (on capex). Due to a periodic true-up, only a very small share of opex is subject to volume risk (around 5 per cent).[111] Moreover, opex cost risk is partially mitigated through a 50 per cent sharing factor. Italian networks face very little capex risk given that capex is effectively passed through.

Whereas the Italian networks face relatively low risk based on volume and cost risk considerations, the regulator has announced its intention to introduce a RIIO-like incentive based framework. This will increase the systematic risk of these networks, and is likely to be reflected in the current beta estimates (see Section 3.5.1). Given the expected change to the regime, we consider the Italian networks face a similar risk to SPT.

**In Spain**, transmission networks are regulated under revenue caps, as is SPT. On the cost side, they are subject to a 50 per cent sharing factor on capex, but bear the full cost risk on opex. Naturgy (GD) is subject to a revenue cap, based on opex and capex volume drivers. There is no sharing of opex and capex out or underperformance which indicates that it faces greater cost risk than UK networks, although this is mitigated by annual updates to the

Energy Networks Association, p.42-48. We use the Miller formula to solve for the implied asset beta: $\beta_{assets} = \beta_{equity} * (1 - gearing) + \beta_{debt} * gearing$.

110 Where there is more than one relevant comparator, we draw conclusions based on the average beta estimate for the comparator set, to take into account all relevant information.

111 See for example Aeegsi, Decision 514/2013/R/gas (Tariff regulation for gas transport for RP4), Article 13.

allowance in line with volume drivers and unit costs.[112] As with the Italian regime, we consider that investors in SPT face a similar degree of risk as investors in Spanish networks.

Based on our relative risk analysis, we consider that the Italian and Spanish networks face broadly similar risks to SPT, supporting an asset beta around 0.4, the two-year asset beta average.

[112] **Gas**: Ley 18/2014, https://www.boe.es/boe/dias/2014/10/17/pdfs/BOE-A-2014-10517.pdf; **Electricity**: Ley 24/2013 (https://www.boe.es/boe/dias/2013/12/27/pdfs/BOE-A-2013-13645.pdf), Royal Decree 1047/2013 (https://www.boe.es/boe/dias/2013/12/30/pdfs/BOE-A-2013-13766.pdf) and Royal Decree 1048/2013 (https://www.boe.es/boe/dias/2013/12/30/pdfs/BOE-A-2013-13767.pdf).

## Table 3.8: Relative risk assessment shows that SPT bears similar risks as listed European comparators

| | GB | Italy | Spain | |
|---|---|---|---|---|
| | SPT | Snam (GT),Terna (ET), Acea (ED) | Enagas (GT), Red Electrica (ET) | Naturgy (GD) |
| **Form / length of revenue period** | • Revenue-cap<br>• 8 years [5 years in RIIO-2] | • Hybrid of price cap (opex) and cost plus/pass through (capex), but virtually no volume risk on opex as a result of true up<br>• 4 years (8 years under discussion) | • Revenue-cap<br>• 6 years<br>• Volume drivers for GT revenues based on outturn demand | • Revenue-cap (s.t. volume drivers)<br>• Volume drivers/unit costs can be updated every 6 years |
| **Setting cost allowances** | • Expert review of totex<br>• DB pension deficit recovery over 15yrs with 3Y re-valuation (but risk on post-2012 liabilities)<br>• Re-openers for some costs<br>• COD update = 10Y trailing average iBoxx | • Based on actual opex in base year, updated annually according to CPI-X formula. | • Allowances set based on "standard" costs for capex and opex (review of historical data & technical input)<br>• Standard costs revised at the start of every regulatory period and every 3 years for GT | • Revenues not linked to RAB but based on base year costs (2002) rolled forward with volume drivers (demand and customer number growth) |
| **Outturn cost risk & incentives** | • TIM<br>• Uncertainty/pass-through of non-controllables<br>• Disapplication of price control | • Opex: 50% sharing factor, limited volume risk<br>• Ex-post recognition of actual capex spent<br>• Additional WACC for some investments (e.g. security of supply) | • Opex: no sharing factor<br>• Capex: 50% sharing factor; profit from underspend capped at 12.5% of costs (ET only) | • No explicit sharing of out or underperformance |
| **Quality of Service/Output incentives** | • Performance incentives: +0.9/-1.4% of RORE | • Quality of service premiums/penalties (mainly technical, e.g. interruptions) | • ET: Availability incentive (of minor importance, capped) | |
| **Other** | • Uncertainty over future role of system from distributed generation | • Risks from prospective regulatory reforms (longer controls, outputs based regime) | | • Higher remuneration for some assets |

*Sources: **Italy**: Aeegsi, Decision 514/2013/R/gas (Tariff regulation for gas transport for RP4), Aeegsi, Decision 654/2015/R/EEL (Tariff regulation for electricity transmission); **Spain**: Gas: Ley 18/2014, https://www.boe.es/boe/dias/2014/10/17/pdfs/BOE-A-2014-10517.pdf; Electricity: Ley 24/2013 (https://www.boe.es/boe/dias/2013/12/27/pdfs/BOE-A-2013-13645.pdf), Royal Decree 1047/2013 (https://www.boe.es/boe/dias/2013/12/30/pdfs/BOE-A-2013-13766.pdf) and Royal Decree 1048/2013 (https://www.boe.es/boe/dias/2013/12/30/pdfs/BOE-A-2013-13767.pdf).*

### 3.5.3. Conclusions on European evidence

We have estimated asset betas for listed European networks in Italy and Spain. The empirical evidence supports an asset beta of around 0.4 over the most recent 2-year period. While Indepen casts doubt on the value of international comparators, our comparative risk assessment of the Italian and Spanish regimes suggests that investors face broadly similar risks as per SPT investors, and therefore 0.4 asset beta provides a relevant benchmark for SPT plc's UK networks.

## 3.6. Conclusion on Beta

In this section, we summarise our findings on the asset beta evidence.

Regarding UK networks, we find evidence supporting a 0.3 to 0.4 range, where the betas for water networks are concentrated towards the low end of the range and NG, the closest comparator for SPT, in the upper end. Furthermore, by updating the CMA approach, we find a range of 0.33 to 0.4, consistent with our initial range for UK networks (drawing on 2-year daily data), although slightly higher.

On the other hand, by decomposing NG's beta into a UK and a US component we obtain an asset beta range for NG's UK component of 0.55 to 0.57 (based on a 2-year window), considerably higher than our ranges mentioned above.

Drawing on our relative risk analysis, we conclude that SPT's beta should lie above the water betas, but below the airport determinations. We also show that SPT faces greater risks than other energy networks, in relation to complexity of investment, competition, and asset stranding risks from uncertainty over future flows on transmission networks.

We also introduced evidence from European comparators, estimating betas and performing a relative risk analysis. We find that SPT faces similar risks to Italian and Spanish networks, whose average asset beta is around 0.4.

Taking into account the evidence above, we propose an asset beta range of 0.4 to 0.45 where the lower bound is based on the higher-end of the range for 2-year betas for NG, and wider European evidence. We consider that SPT's beta should be at least as high as NG plc's beta, given that NG plc's beta is likely to understate UK energy network risk, as our decomposition analysis shows. For our upper-bound, we determine a value of 0.45 which slightly lower than the mid-point between NG plc's asset beta (which is 0.39), and the decomposition of NG's plc's beta to isolate UK energy risk, which supports a value of 0.55. We do not adopt the higher value of 0.55 given the absence of wider evidence to support this assumption (e.g. from European networks), and the scope for statistical error in decomposing composite betas into their constituent elements. The upper-bound value is also in line with SPT's RIIO-1 decision of 0.43. Wider empirical evidence shows that beta risk has increased since T1 determination, and therefore there is no apparent rationale to determine a lower beta for SPT at RIIO-T2.

# 4. Gearing

In this section, we set out our view of the gearing level to use for the RIIO-T2 period. We start by presenting a summary of Ofgem's approach to determining gearing and then provide our evidence on an appropriate gearing range.

We recommend a range of 55 to 60 per cent for gearing, based on both empirical evidence and regulatory precedent.

## 4.1. Summary of Ofgem RIIO-2 Consultation on Gearing

### 4.1.1. March and July Framework Consultation

Ofgem's March 2018 Framework Consultation set out its proposed approach for determining the RIIO-2 price controls, where it proposed investigating the appropriate measures of gearing.[113]

Alongside the consultation, Ofgem also published a report prepared by CEPA which estimates plausible ranges for the cost of capital parameters for RIIO-2. In this report, CEPA provides an estimate for a notional gearing level using evidence from RIIO-1 determinations and estimates of net debt/RAV for Gas distribution networks, Distribution network operators and Transmission owners and system operators, alongside with empirical gearing for the same comparator set as in beta (National Grid, United Utilities, Severn Trent and Pennon). CEPA concludes on a 50 to 65 per cent range, where the lower end is based on regulated utilities gearing evidence and the upper end is drawn from previous regulatory decisions.[114]

In July 2018, Ofgem published its framework Decision for RIIO-2, where it confirmed the proposed methodology from the Framework Consultation and proposed to conduct further research into the relationship between beta and gearing.[115]

### 4.1.2. Sector Specific Consultation

In its latest consultation, the sector specific methodology, Ofgem has determined a notional gearing level of 60 per cent for the purpose of re-leveraging asset betas.[116] As discussed in Section 3.2.2, Indepen had recommend the use of a "adjusted" notional gearing level, but Ofgem incorrectly applied this adjustment to the actual gearing level, which is used to de-leverage raw equity betas.

## 4.2. Empirical evidence on gearing in regulated industry

In this section, we consider the actual capital structure observed in the comparable regulated industries, namely the GB transmission operators, European energy networks and GB water and sewerage companies. Table 4.1 presents the evidence on actual gearing for GB Transmission Operators (TOs), including National Grid Electricity Transmission (NGET),

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113 Ofgem (March 2018), RIIO-2 Framework Consultation, Our approach to setting price controls for GB gas and electricity networks, para 7.33.5

114 CEPA (February 2018), Review of Cost of Capital Ranges for Ofgem's RIIO-2 for Onshore Networks, section 6.1

115 Ofgem (July 2018), RIIO-2 Framework Decision, Our approach to setting price controls for GB gas and electricity networks, para 6.41

116 Ofgem (18 December 2018), RIIO-2 Sector Specific Methodology, Annex: Finance, Section 3, pp. 39 and 40.

Scottish Power Transmission (SPT) and Scottish Hydro Electric Transmission (SHET). We calculate a gearing range of 55 to 59 per cent, with SPT at the lower end of the range.

**Table 4.1: Actual gearings for GB TOs lie between 55 and 59 per cent, with an average of 57 per cent**

| | Actual gearing (Net Debt / RAV) |
|---|---|
| NGET | 58% |
| SHET | 59% |
| SPT | 55% |
| **Average** | **57%** |

*Source: NGET Regulatory Account Statements 2017/2018 (p.84); computed as net debt/RAV for SHET based on Directors report and regulatory financial statements, year ended 31 March 2018 (p.2 and p.35); and computed as net debt/RAV using net debt in SP Transmission Corporate report and regulatory accounts for the year ended 31 March 2017 (p.3) and RAV in SP Transmission Annual Performance Report 2016/17 (p.25).*

Table 4.2 shows the gearing of European energy networks, which supports a range of 39 to 57 per cent, and an average of 50 per cent, slightly lower than those obtained for GB TOs.

**Table 4.2: Actual gearings for European networks range from 39 to 57 per cent, with an average of 50 per cent**

| | Actual Gearing (Net Debt / RAV) |
|---|---|
| Snam | 57% |
| Terna | 51% |
| Acea | 49% |
| Enagas | 57% |
| Red Electrica | 46% |
| Naturgy | 39% |
| **Average** | **50%** |

*Note: Gearing computed as Net debt over RAB based on data as of February 2019. When RAB is not publicly available or it is not an accurate representation of invested capital, we use Net debt over Fixed Assets, as per Moody's rating methodology for energy networks. See Moody's (16 March 2017), Rating Methodology, Regulated Electric and Gas Networks, p.18*
*Source: NERA analysis of Bloomberg data*

## 4.3. Regulatory precedent on notional gearing

Table 4.3 shows the recent regulatory determinations for notional gearing levels. The majority of regulatory precedent on gearing lie in the range of 55 to 65 per cent, with the exception of the CMA NIE (2014) value of 45 per cent.

**Table 4.3: Regulatory precedent shows gearing range of 45 to 65 per cent**

| | Notional gearing |
|---|---|
| CC Bristol (2010) | 60% |
| RIIO GD1 (2012) | 65% |
| RIIO T1 NGGT (2012) | 62.5% |
| RIIO T1 NGET (2012) | 60% |
| RIIO T1 SPT and SHET (2012) | 55% |
| CAA Heathrow (2014) | 60% |
| CAA Gatwick (2014) | 55% |
| CMA NIE (2014) | 45% |
| RIIO ED1 (2014) | 65% |
| Ofwat PR14 (2014) | 62.5% |
| CMA Bristol (2015) | 62.5% |

*Source: NERA analysis of regulatory determinations*

## 4.4. Conclusion on gearing

We recommend a gearing range of 55 to 60 per cent for SPT over the RIIO-T2 regulatory period, based on the evidence from actual gearing of comparable sectors and regulatory precedent. Our lower end is consistent with the RIIO-T1 determination, as well as actual gearing of SPT. The upper end reflects current gearing levels observed from the wider comparable industry, including the GB TOs and European energy networks.

We note that established finance theory explains that the WACC is broadly unaffected by the level of gearing (referred to as the capital structure irrelevancy). The theory explains that increasing the level of gearing increases the share of relatively cheaper debt in the WACC, but this is offset by the increase in cost of equity due to higher equity risk caused by greater financial leverage, leaving the overall WACC broadly unchanged.

This conclusion is consistent with the position of the CMA. In the 2010 Bristol Water appeal, the CMA analysed the impact on WACC of gearing changes in a range between 50 and 80 per cent and concluded that the cost of capital is not sensitive to the level of gearing:

"*[…] while a level of gearing above the company's actual gearing may lead to a lower WACC, the effect does not seem likely to be large […] our analysis suggests that, after taking account of the tax effect, the WACC is not sensitive to the level of gearing"*[117]

[117] CMA (February 2010), BRISTOL WATER plc Notice of Reference: Determination of Adjustment Factor for the period 2010- 2015, Appendix N para 30 and 32.

# 5. Conclusion on Cost of Equity

Table 5.1 sets out our estimates for the cost of equity of 5.59 to 7.49 per cent (RPI deflated). This is higher than Ofgem's range of around 3 to 4 per cent. In terms of the key components, we draw the following conclusions:

- For the TMR, the evidence supports a range of 6.5 to 6.8 per cent, higher than Ofgem's range of 5.2 to 5.7 per cent. We believe that UKRN study's TMR estimate, Ofgem's principal source, is incorrect as its relies on a flawed backcast of CPI inflation and fails to make a full adjustment for the difference between geometric and arithmetic returns. Instead, we use the established RPI series to calculate the historical long run average TMR. Ofgem's cross-check are also not valid: CEPA's DGM model relies on implausibly low dividend yields; otherwise two of its cross-checks support a higher cost of equity than its proposed range.
- For the RFR, we propose a range of -1.68 to 1.25 per cent, where our lower value is equal to Ofgem's proposed spot market value. Our top-end of the range draws on previous regulatory decisions and acknowledges that there is value in setting an RFR on a consistent long-run historical basis over price controls, as per Ofgem's intention with the TMR.

  We calculate the ERP as the residual, as does Ofgem. However, the decomposition of the TMR into RFR and ERP is relatively unimportant in the determination in the overall cost of equity, relative to the value of the TMR itself.
- For the asset beta we propose a range of 0.4 to 0.45, which is higher than the 0.35 to 0.36 range proposed by Ofgem. The bottom end of the range draws on NG and European energy network empirical betas, as the closest comparators to SPT. The upper-end is supported by our decomposition of NG plc's beta to identify UK network beta risk. Indepen appears to support our approach to decomposition in principle, but then does not rely on it in its conclusions.
- We propose a range of 55 to 60 per cent for notional gearing, relying on both empirical evidence and regulatory precedent similar to Ofgem's point estimate of 60 per cent.

**Table 5.1: We estimate a cost of equity of 5.59 to 7.49 per cent (real RPI)**

| Parameter | Ofgem RIIO-2 Low | Ofgem RIIO-2 High | NERA lower bound | NERA upper bound |
|---|---|---|---|---|
| TMR | 5.19% | 5.68% | 6.50% | 6.80% |
| RfR | -1.68% | -1.68% | -1.68% | 1.25% |
| ERP | 6.87% | 7.36% | 8.18% | 5.55% |
| Asset Beta | 0.35 | 0.36 | 0.40 | 0.45 |
| Debt Beta | 0.15 | 0.10 | - | - |
| Gearing | 60% | 60% | 55% | 60% |
| Equity Beta | 0.65 | 0.76 | 0.89 | 1.13 |
| **Cost of Equity** | **2.75%** | **3.93%** | **5.59%** | **7.49%** |

*Source: NERA calculations*

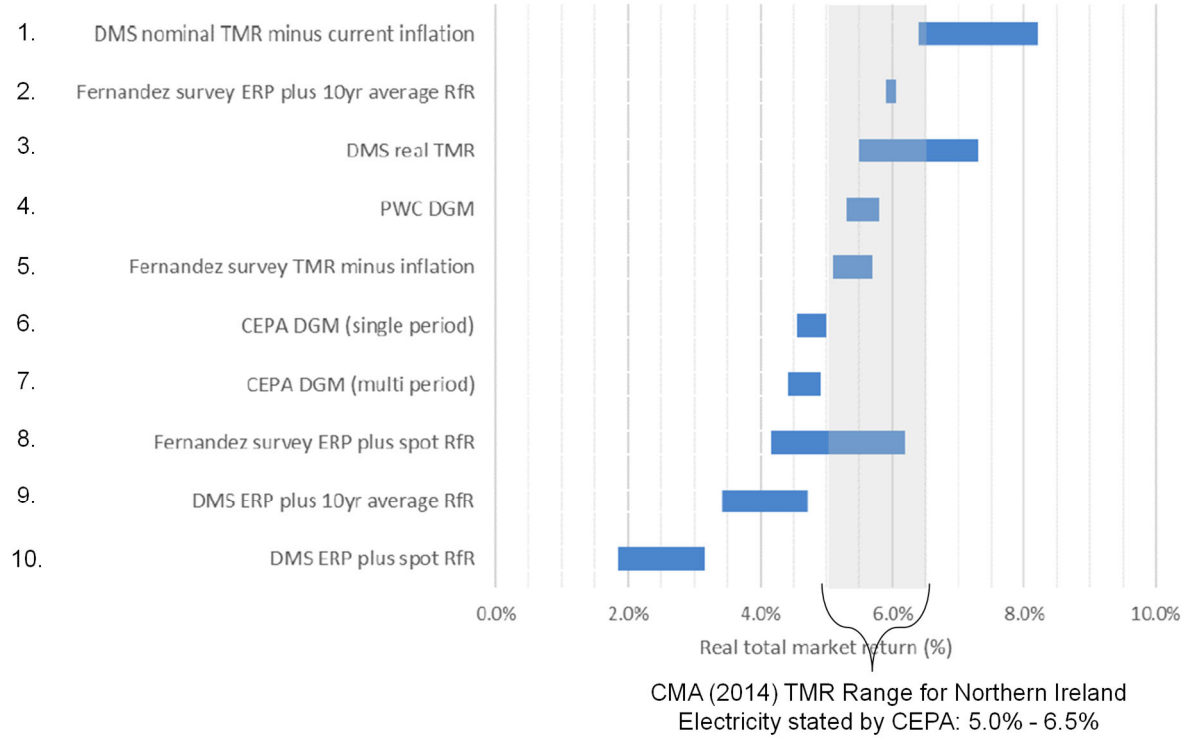
# Appendix A. Review of CEPA evidence on TMR

In this appendix, we review the evidence presented by CEPA in its report for Ofgem on estimating the cost of capital for RIIO-2.[118] As we explain in detail below, we find that much of the evidence presented by CEPA is flawed and leads to a substantial understatement of the TMR for RIIO-T2.

## A.1. Summary of CEPA's evidence and recommendations

In its report, CEPA presents a range of evidence on the TMR, including historical realised returns as well as forward looking evidence. The different estimates presented by CEPA in its report are summarised in Figure A.1 below.

**Figure A.1: CEPA presents a wide range of TMR estimates based on different sources and approaches (real, RPI-deflated)**




*Source: CEPA (February 2018), review of cost of capital ranges for Ofgem's RIIO-T2 for onshore networks, Figure E.7, p.113.*

CEPA's evidence on the TMR can be divided into three categories:

- **Historical TMR evidence**: This includes estimates based on historical realised returns from the DMS database. CEPA presents estimates based on historical nominal returns deflated with current inflation as well as historical real returns, using geometric and arithmetic averages as a basis of generating its TMR range (approaches 1 and 3 in Figure A.1).

[118] CEPA (February 2018), Review of cost of capital ranges for Ofgem's RIIO-2 for onshore networks.

- **Forward looking TMR evidence**: This includes estimates based on DGM models from PwC (based on PwC's report for Ofwat) and CEPA's own DGM analysis as well as survey evidence on the TMR (approaches 4-7 in Figure A.1).
- **Evidence on ERP and RfR parameters estimated separately**: This includes TMR calculated as a combination of ERP from various sources (historical and survey evidence) combined with current estimates of the RfR (spot and 10-year averages) (approaches 2, 8-10 in Figure A.1).

CEPA also refers to a TMR range of 5 to 6.5 per cent (real, RPI-deflated), which it states is the range adopted by the CMA in its 2014 NIE determination (as indicated in grey in Figure A.1 above).[119]

CEPA concludes that it is appropriate to consider both historical and forward-looking evidence to estimate the TMR and **recommends a range of 5 to 6.5 per cent (real, RPI-deflated) for the TMR**, which it states is in line with the CMA's 2014 NIE determination. CEPA notes that it does not consider the weight of available evidence points to an estimate outside of this range (with the exception of its own DGM estimate, approaches 6 and 7 in Figure A.1, but CEPA acknowledged that reflects only one source of evidence). CEPA further suggests that the lower end of its range is consistent with forward looking evidence and cross-checks from competitive benchmarks while historical evidence and regulatory precedent would support a TMR towards the top end of the range.[120] Finally, CEPA also notes that the UKRN report supports an upper bound of 6 per cent (real, RPI deflated) based on historical realised returns, due to adjustments by UKRN to historical inflation estimates relative to the DMS.[121]

In the next sections, we explain that most of the TMR evidence presented by CEPA is flawed and leads to a substantial understatement of the TMR for RIIO-T2. In Appendix F, we show that updating the evidence base considered by the CMA in its NIE 2014 determination supports a higher range than that identified by CEPA, supporting the conclusion that the TMR for RIIO-T2 should be at least as high as 6.5 per cent (real, RPI) as per the CMA's 2014 NIE determination.

## A.2. CEPA's historical TMR evidence based on geometric averages understates expected TMR

CEPA presents historical estimates of the TMR in the range of 5.5 to 7.3 per cent (real, RPI deflated), based on historical real TMR figures from DMS (approach 3 in Figure A.1), and a range of 6.4 to 8.2 per cent (real, RPI-deflated), based on historical nominal TMR figures from DMS, deflated using CEPA's current inflation forecasts (approach 1 in Figure A.1).[122] The bottom end of CEPA's range is based on geometric averages of historical returns whereas the top end is based on arithmetic averages.

[119] CEPA (February 2018), Review of cost of capital ranges for Ofgem's RIIO-2 for onshore networks, p.48.

[120] CEPA (February 2018), Review of cost of capital ranges for Ofgem's RIIO-2 for onshore networks, p.49-50.

[121] CEPA (February 2018), Review of cost of capital ranges for Ofgem's RIIO-2 for onshore networks, p.72.

[122] Real values calculated based on information in CEPA (February 2018), Review of cost of capital ranges for Ofgem's RIIO-2 for onshore networks, Table E.4; subtracting inflation of 3 per cent from CEPA's nominal values reported (appears consistent with figures in CEPA's Figure E.7).

We consider that the use of geometric averages in CEPA's lower bound is not appropriate for estimating the expected TMR for RIIO-T2, because the geometric average is a downward biased estimator of the expected return.

As we explain in section 2.3.1, the appropriate averaging method to calculate the TMR from historical data depends on the investment horizon (or holding period). For a single period or one year investment horizon, the unbiased estimator of the expected return is the arithmetic average. For longer holding periods, the arithmetic average is an upward biased estimator of the expected return, while a geometric average is downward biased. Several methods have been developed in theoretical literature to derive an unbiased estimator of the expected return for investment horizons longer than one year: for example by Blume (1974)[123] or Jacquier, Kane and Marcus (2005)[124]. These unbiased estimators lie between the arithmetic and geometric averages.

As we show in section 2.3.1, applying these estimators to the historical data and taking into account the relevant investment horizon, we derive a TMR in a range of between 6.8 and 7.1 per cent (real, RPI-deflated) using historical data over the period 1900 to 2017, or 6.5 to 6.8 per cent net of the "RPI effect". Our estimated range is materially higher than CEPA's lower bound of its cited range of 5.5 or 6.3 per cent.

We therefore conclude that CEPA's range for the TMR is downward biased, due to relying on the geometric average as the lower bound, which is a downward biased estimator of the expected return.

## A.3. CEPA's forward looking evidence is understated compared to independent DGM evidence from the Bank of England

### A.3.1. March Framework Consultation

CEPA presents forward looking estimates on the TMR, drawing on its own DGM as well as PwC's DGM analysis for Ofwat for the upcoming PR19 review (discussed in Appendix D.2). CEPA's DGM estimates provide a range for the TMR of 4.5 to 5 per cent and 4.4 to 4.9 per cent (real, RPI-deflated), based on CEPA's single period and multi period models respectively (approaches 6 and 7 in Figure A.1) and 5.3 to 5.8 per cent (real, RPI-deflated) based on PwC's DGM (approach 4 in Figure A.1).[125]

**CEPA's estimates are substantively below independent estimates from the Bank of England, due to implausibly low assumptions on dividend growth**

CEPA's DGM evidence, based on its own as well as PwC's DGM specification is substantially below independent estimates of the TMR from the Bank of England's DGM, which the CMA relied on in its 2014 NIE determination. As discussed in section 2.3.2, independent estimates of the TMR from the Bank of England support a range of around 7 to 8 per cent (real, RPI-deflated), substantially above the evidence presented by CEPA.

123 Blume (1974), Unbiased Estimators of Long-Run Expected Rates of Returns, Journal of the American Statistical Association 69, p.634–663.

124 Jacquier, Kane, and Marcus (2005), Optimal estimation of the risk premium for the long run and asset allocation: a case of compounded estimation risk, Journal of Financial Econometrics.

125 Real values calculated based on information in CEPA (February 2018), Review of cost of capital ranges for Ofgem's RIIO-2 for onshore networks, Table E.4; subtracting inflation of 3 per cent from CEPA's nominal values reported (appears consistent with figures in CEPA's Figure E.7).

CEPA's (and PwC's) DGM is understated, due to implausibly low assumptions around dividend growth rates, a key determinant of the implied TMR. CEPA (and PwC) assume that FTSE dividends grow in line with short-term and long-term nominal growth in UK GDP, but provide no basis for the assumption that UK GDP forecast growth rates are a good proxy for investors' expectations of dividend growth rates. This assumption is incorrect, for a number of reasons. First, FTSE All-Share companies derive over 70 per cent of their earnings from outside of the UK, which have higher forecasts of GDP growth than assumed by CEPA (and PwC) for the UK.[126] Second, short-term UK GDP forecast growth rates are somewhat depressed (e.g. due to Brexit) and are substantially lower than independent analyst forecasts of dividend growth rates for FTSE stocks, which are used by the Bank of England as a basis of forecasting short-term dividend growth in its DGM.[127]

As a result of understating dividend forecasts for both the short-term and the long-term relative to the independent estimates by the Bank of England (as summarised in Table A.1), CEPA's and PwC's DGM substantially understate the TMR.[128]

**Table A.1: CEPA's and PwC's nominal dividend growth assumptions are understated compared to Bank of England**

| | Bank of England | CEPA | PWC |
|---|---|---|---|
| Short-term dividend growth (nominal) | Around 8% (analyst forecasts) | Around 4% (UK GDP growth) | 3.7% (UK GDP growth) |
| Long-term dividend growth (nominal) | Around 6% (weighted average GDP growth for countries from which FTSE companies derive earnings) | 4.5% (UK GDP growth) | 4.0% (UK GDP growth) |

*Note: Reflects forecasts for October 2016 DGM results.*
*Source: Bank of England (2017), An improved model for understanding equity prices, Quarterly Bulletin 2017Q2, p.90-91, Chart 3 and 7, (approximate values based on BoE summary charts) ; CEPA (January 2018), Review of cost of capital ranges for new assets for Ofgem's network division, p. 77 Figure A.2 and PwC (June 2017), Refining the balance of incentives for PR19, Appendix D, Table 24, p.102*

### A.3.2. December Sector Consultation

In the sector consultation, Ofgem provides further evidence on CEPA's approach to the DGM. As explained in the sector consultation, the estimation of a multi-stage DGM requires three critical assumptions:

[126] For example, the weighted average long-run GDP growth rate for the different regions from which FTSE companies derive their earnings as of October 2016 is around 5.9% (nominal), while the UK long-run GDP growth rate assumed by CEPA and PwC is 4.5 and 4.0 per cent (nominal). Source: Bank of England (2017), An improved model for understanding equity prices, Quarterly Bulletin 2017Q2, p.91, Chart 7; CEPA (January 2018), Review of cost of capital ranges for new assets for Ofgem's network division, p. 77 and PwC (June 2017), Refining the balance of incentives for PR19, Appendix D, Table 24, p.102.

[127] Bank of England (2017), An improved model for understanding equity prices, Quarterly Bulletin 2017Q2, p.90, Chart 3; CEPA (January 2018), Review of cost of capital ranges for new assets for Ofgem's network division, p. 76-77 and PwC (June 2017), Refining the balance of incentives for PR19, Appendix D, Table 24, p.102.

[128] The DGM estimates a discount rate which equates the forecast dividends to the current value of the FTSE all share index, which is observable. If dividend forecasts are understated, the DGM will "compensate" for this by producing a lower discount rate (i.e. TMR) to equate the lower dividend forecasts to the same observed value of the market index.

- Total Equity Yield, measured as the sum of the dividend yield and the share buyback
- Short-term growth rate
- Long-term growth rate

Regarding the total equity yield, in the sector consultation Ofgem states that its advisers, CEPA, use a dividend yield assumption of 3.5 per cent (nominal). However, Ofgem does not clarify if this assumption reflects a spot value or a historical average. CEPA's yield seems too low given the past year total equity yield is 4.6 per cent. The longer-estimation period of 5 years supports a figure of 3.6 per cent, in line with CEPA. However, it is incorrect to use a long-run historical figure combined with a current market capitalisation value and current dividend growth forecasts used elsewhere in the DGM.

Regarding the short-term growth rate assumption, Ofgem uses UK GDP forecasts from OBR,[129] which we have already commented on in Appendix A.3.1 However, the results are less sensitive to this parameter than to long-term growth assumptions, as informed also by Ofgem.[130]

Regarding the long-term growth rate assumption, in RIIO-2 sector consultation document Ofgem presents different sensitivities to the long-term growth based on CEPA's analysis. CEPA has considered three different measures for the long-term growth assumption:

- Midpoint: UK historic GDP growth (4.5 per cent, calculated as the sum of the 2.5 per cent real UK GDP growth since 1950 plus a CPIH inflation rate of 2 per cent)
- Lower bound: UK historic dividend growth (3.1 per cent, calculated as the sum of the 1.1 per cent real dividend growth since 1950 plus a CPIH inflation rate of 2 per cent)
- Upper bound: International GDP growth (5.3 per cent, based on the weighted average of UK and International GDP growth considering that 70 per cent of the revenues of UK companies come from overseas)

We consider only the upper bound value to be a reliable estimate of the TMR. However, CEPA's methodology to calculate the international GDP growth appears to understate expected growth, as it applies an uplift calculated as the difference between the short-term international and UK GDP growth rates, and added this to the long-run UK GDP growth rate of 4.5 per cent, which provides a long-term growth assumption of 5.3 per cent.[131] It is not clear to us why CEPA did not draw directly on long-run global growth rates, and weighted for the source of FTSE revenues, consistent with the approach followed by Bank of England.[132] The Bank of England calculated a weighted average long-run GDP growth rate

[129] Ofgem (December 2018), RIIO-2 Sector Specific Methodology Annex: Finance, p.93.

[130] Ofgem (December 2018), RIIO-2 Sector Specific Methodology Annex: Finance, p.94.

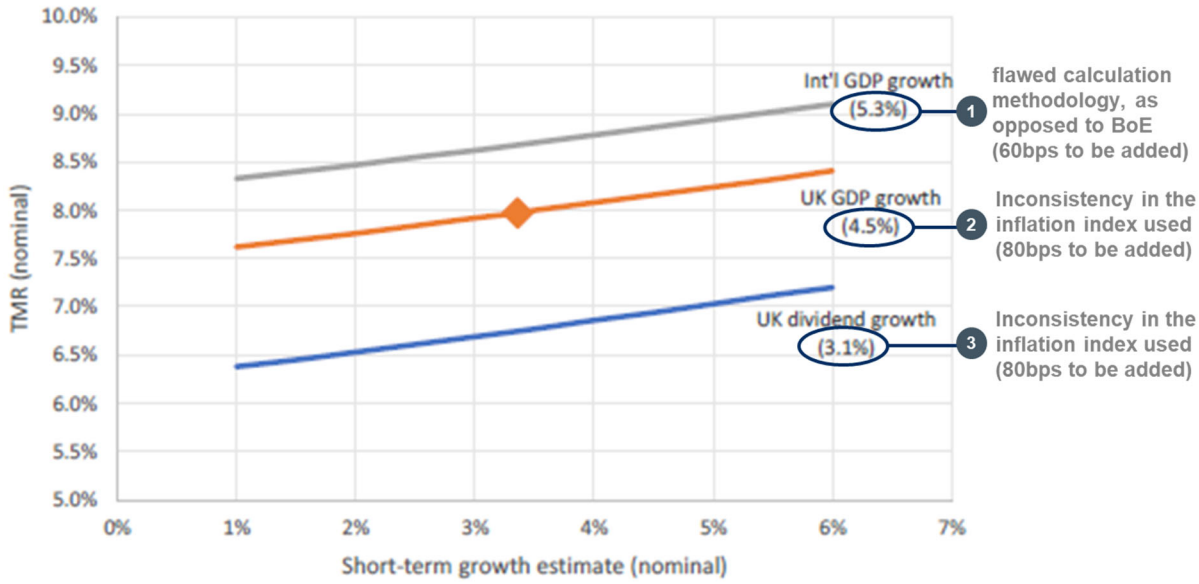
[131] Ofgem state that CEPA calculated the long term international growth rate of 5.3 per cent based on "*difference between the IMF's short-term advanced economies GDP growth forecasts and the OBR's short-term GDP growth forecasts to the long-term UK GDP growth figure of 4.5%".* Source: Ofgem (2018) RIIO-2 Sector Specific Methodology Annex: Finance, p. 94

[132] Source: Bank of England (2017), An improved model for understanding equity prices, Quarterly Bulletin 2017Q2, p.91, Chart 7

for the different regions from which FTSE companies derive their earnings as of October 2016 of around 5.9 per cent (nominal).[133]

For the midpoint estimate, CEPA's (and Ofgem's) decision to inflate the real UK GDP growth of 2.5 per cent using CPIH of 2 per cent understates expected nominal growth. CEPA's historical real growth rate would have been derived based on RPI outturn inflation, and therefore the forecast nominal growth should be derived based on an RPI forecast. CEPA's incorrect use of CPI understates expected nominal growth by at least 80 bps, the historical difference between RPI and CPI.[134] Similarly, in the low scenario, CEPA's real dividend growth assumption has been derived using RPI outturn inflation, and hence the nominal forecast must be derived by applying an RPI forecast instead of CPI (and again is likely to be downwardly biased by around 80bps).

**Figure A.2: Only International GDP Growth Provides Reasonable Basis for DDM; In all Cases CEPA's DDM-based TMR Scenarios Are Downwardly Biased**




## A.3.3. Correcting for CEPA's errors

In a separate report for the ENA[135], we have corrected CEPA's DGM TMR for the dividend growth assumptions, to identify the materiality of the different effects:

- We use the weighted average GDP growth for countries from which FTSE companies derive earnings as the measure of long-term dividend growth, consistent with the Bank of England.
- As a second step, we use analyst forecasts for the short-term period, given the absence of any up-to-date evidence on optimism bias.

133 Source: Bank of England (2017), An improved model for understanding equity prices, Quarterly Bulletin 2017Q2, p.91, Chart 7

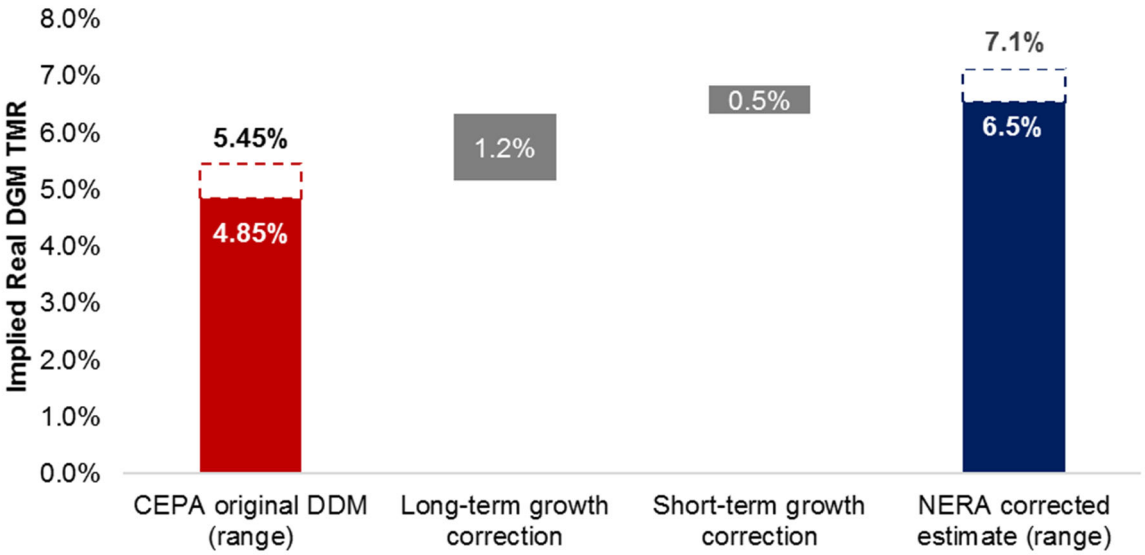
134 Based on ONS' data since 1988. Source: ONS website, https://www.ons.gov.uk/economy/inflationandpriceindices, visited on 11 February 2019.

135 ENA (November 2018) Further evidence on the TMR, section 3.2

Otherwise, we retain CEPA's assumptions, notably around the starting point total equity yield measured as the sum of the dividend yield and the share buyback

Figure A.3 shows that the correction of CEPA's dividend growth assumptions implies a real forward-looking TMR of around 6.8 per cent (mid-point), and a range of 6.5 to 7.1 per cent. The most material change relates to the correction for the use of weighted average GDP growth for countries from which FTSE companies derive earnings, which increases CEPA's DGM TMR by around 120 bps, with the use of analyst forecasts increasing CEPA's estimate by around 50 bps.[136] The relative magnitude of these effects is explained by the relative short period for which analyst forecasts are available relative to the DGM modelling period.

**Figure A.3: Correcting CEPA's DGM for Use of Global GDP Increases TMR by 120 bps, and Further 50 bps if Use Analyst Forecasts**




*Source: NERA analysis of CEPA's Bank of England's data*

## A.4. CEPA's investor survey evidence is unreliable

CEPA also presents survey evidence on TMR of between 5 and 6 per cent (real, RPI-deflated).[137] However, we do not recommend relying on survey evidence to estimate the TMR, given issues around the respondents' understanding of the question being asked (e.g. are they supposed to provide an estimate in real or nominal terms). The CMA criticised the use of survey evidence of in its 2014 NIE determination, where it noted:

> *"[…] the results of such surveys tend to depend on the identity and outlook of the respondents and how they interpret the questions being asked. Some surveys do not clarify the time frame over which the parameters are to be estimated (the long-term equilibrium ERP or a shorter-term estimate); whether an arithmetic or geometric*

[136] We have replicated CEPA's DGM TMR based on spot market and 2-year historical evidence, which forms its estimate in the range of 4.85 to 5.45 per cent. Based on this model, we estimate the impact of using global GDP as the long-run growth forecast of around 120 bps, and the impact of using analyst forecasts over the short-term of around 50 bps.

[137] Real values approximated based on CEPA (February 2018), Review of cost of capital ranges for Ofgem's RIIO-2 for onshore networks, Figure E.7.

*averaging approach should be used; or whether the ERP is over bonds or bills or some other instrument."*[138]

## A.5. CEPA's estimates based on combining ERP and RfR over different periods is unreliable

CEPA also presents a number of estimates based on combining ERP and RfR parameters from different sources and periods. Specifically, CEPA combines historical estimates from the DMS as well as forward looking survey evidence on the ERP with spot and 10-year average risk-free rate estimates based on Bank of England data. This provides a wide range of estimates of the TMR between 2 and 6 per cent (real, RPI deflated).[139]

We do not consider that CEPA's estimates of the TMR based on combining ERP and RfR from different sources and periods represents reliable evidence on the TMR for RIIO-T2.

As we explain in section 2.2, finance literature as well as prominent financial institutions such as the Bank of England or the German Bundesbank support a negative relationship between the RfR and ERP over time, which implies the two parameters should be estimated on a consistent basis to avoid biased TMR estimates. This is also supported by UK regulatory precedent of adopting a "TMR approach", which involves joint estimation of the total market return parameter first with the ERP derived as a residual. CEPA itself recommends the use of a TMR approach for RIIO-T2[140] and it is therefore not clear why it combined separate estimates of ERP and RfR from different sources and time periods, contrary to its recommendations.

While CEPA does not appear to support a full 1-to-1 relationship between the RfR and ERP, it quotes estimates of the correlation which are close to 1.

*"PwC, on behalf of Ofwat, analysed the movement in DDM estimates over two horizons to estimate this coefficient, finding for 2000-2016 that the coefficient was [-0.76] and for 2010-16 the coefficient moved to [-0.88]. Alternatively, looking at DMS evidence on TMR and the risk-free rate provides another point of evidence to utilise. A report by Harris and Marston (2013) found that the coefficient between the risk-free rate and ERP was [-0.79] based on US evidence between 1986 and 2010."* [141]

Estimating the RfR and ERP parameters separately, as CEPA does, can result in biased estimates if inconsistent sources and periods are combined, without taking the correlation of the two parameters into account. This concern applies in particular to CEPA's estimates of the TMR based on combining long-run historical ERP from DMS with spot and 10-year averages of the risk-free rate, which ignores the negative relationship between the two

[138] CMA (March 2014), Northern Ireland Electricity price determination, Final Determination, para. 13.156, p.13-31 and para 13.32.

[139] Real values approximated based on CEPA (February 2018), review of cost of capital ranges for Ofgem's RIIO-2 for onshore networks, Figure E.7.

[140] CEPA (February 2018), Review of cost of capital ranges for Ofgem's RIIO-2 for onshore networks, section E.1.2, p.101.

[141] CEPA (February 2018), Review of cost of capital ranges for Ofgem's RIIO-2 for onshore networks, p.59.

parameters and leads to implausibly low estimates of the TMR of as low as 2 per cent (real, RPI-deflated).

## A.6. Updating CMA NIE 2014 evidence supports a TMR at least as high as NIE for RIIO-2

Based on the above evidence, CEPA concludes on a TMR of 5 to 6.5 per cent (real, RPI-deflated), which it states is consistent with the CMA range considered in its 2014 NIE determination.

First, we note that CEPA's interpretation of the CMA NIE decision is erroneous. Although the CMA determined 5 per cent as a lower bound figure, it concluded that the evidence for 5 per cent was not well-supported, and the *weight of evidence* supported a range between 5.5 and 6.5 per cent.[142] In addition, given that the only the Bank of England DGM approach supported the lower bound of 5 per cent, and updated studies from the Bank of England support a value of 7 to 8 per cent, CEPA's 5 per cent lower-bound is not a reasonable interpretation of the CMA NIE approach.

Second, as we set out in Appendix F, drawing the different methods considered by the CMA in the 2014 NIE determination, the evidence does not support the conclusion that the TMR has fallen since 2014 and indeed supports an increase in the CMA's NIE preferred range of 5.5 to 6.5 per cent with both the historical ex post and DGM methods supporting values above the higher-bound value of 6.5 per cent.

The CMA NIE determination of 6.5 per cent real (RPI-deflated) TMR should therefore be considered as a lower bound for the TMR for RIIO-T2.

## A.7. Conclusions on CEPA's TMR estimate

CEPA's presents a wide range of evidence for the TMR, although ultimately concludes that the CMA NIE 2014 range is relevant for RIIO-2 – which it interprets as 5 to 6.5 per cent. As set out above, the CMA concluded the weight of evidence supported a lower-bound of 5.5 per cent, and not 5 per cent as CEPA state. In addition, our update of the CMA's analysis for NIE shows that in most cases the evidence supports a higher TMR than the value of 6.5 per cent determined by the CMA in 2014, with a marked increase in the Bank of England's DGM based TMR relative to 2014. We therefore conclude that, drawing on the CMA NIE approach, the TMR for RIIO-T2 should be at least as high as the 2014 NIE decision of 6.5 per cent.

CEPA also presents historical TMR based on geometric means, which provides a downwardly biased estimate of investors' required returns, as confirmed by the financial literature. CEPA also presents evidence that combines RFR and ERP from time periods, although all GB regulators accept that the inverse relationship between the two parameters necessitates an approach based on estimating the TMR directly. It also presents its own DGM estimates, which are far below independent Bank of England estimates because of implausibly low assumptions on dividend growth rates. However, CEPA does not appear to directly draw on these approaches in its TMR for RIIO-2.

[142] CMA (March 2014) op. cit., para. 13.38.

# Appendix B. Other Cross Checks Employed by Ofgem

We have addressed CEPA's DGM in the previous Appendix. In this Appendix, we address the other cross-checks employed by Ofgem under its step 2 in estimating cost of equity, namely, market-to-asset ratios (MARs), investment managers' surveys, bids for OFTOs and infrastructure discount rates.

We note that the two of Ofgem's methodologies under step 2 (bids for OFTOs and infrastructure discount rates) suggest a cost of equity higher than 4 per cent (real, RPI), and therefore support an upward adjustment to Ofgem's cost of equity range of 3 to 4 per cent estimated in Step 1. Otherwise, we show that MAR values do not provide any reliable evidence on investors' cost of capital given the other factors that affect MARs.

## B.1. Market-to-Asset Ratio (MAR)

Ofgem considers the ratio of the market price to the Regulated Asset Value (RAV) to assess whether the expected returns exceeds the cost of capital, indicated by a MAR greater than 1.[143] Ofgem presents MARs for three UK utility companies (Pennon, Severn Trent, and United Utilities), and concludes that investors' expected returns exceed their cost of capital, given that the MARs is greater than 1 (i.e. companies traded at premium) for the majority of the last 9 years.[144]

We have shown in a separate paper that it is necessary to make sizeable and uncertain adjustments to be able to make any inferences about investors' cost of capital from market capitalisation data.

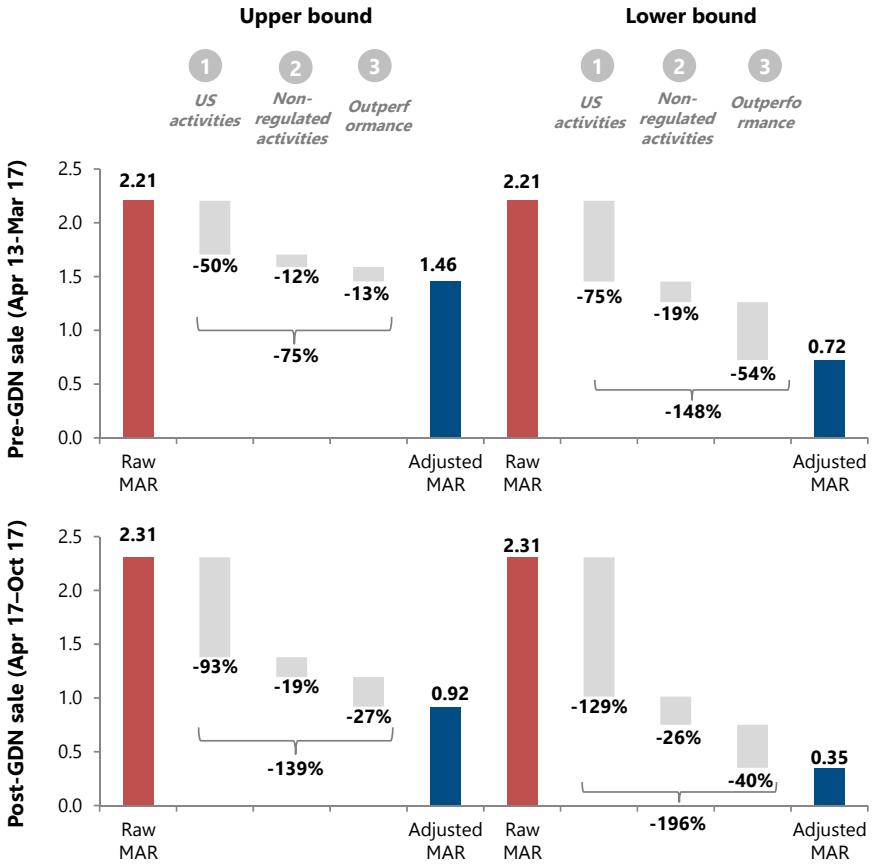
For example, NG's market capitalisation reflects NG's substantive US regulated and non-regulated assets, and these assets need to be excluded to derive an adjusted market capitalisation value and MAR that relates to NG's UK regulated T&D assets only.[145] We have previously shown that the relevant MAR for NG's UK T&D business lies in the range of 0.35 to 1.46 based on independent analyst valuations of NG's non-UK regulated activities, which demonstrates the implausibility of drawing on MAR evidence for NG to inform investors' expected cost of equity. Nevertheless, we found no evidence that the adjusted MAR for NG's UK T&D business is greater than 1. (See Figure B.1).

143 Ofgem (December 2018), RIIO-2 Sector Specific Methodology Annex: Finance, para 3.119.

144 Ofgem (December 2018), RIIO-2 Sector Specific Methodology Annex: Finance, para 3.123.

145 NERA (December 2017) Implications of Observed Market to Asset Ratios for Cost of Equity at RIIO-2. https://www.nera.com/content/dam/nera/publications/2017/171201_MAR_report_final.pdf

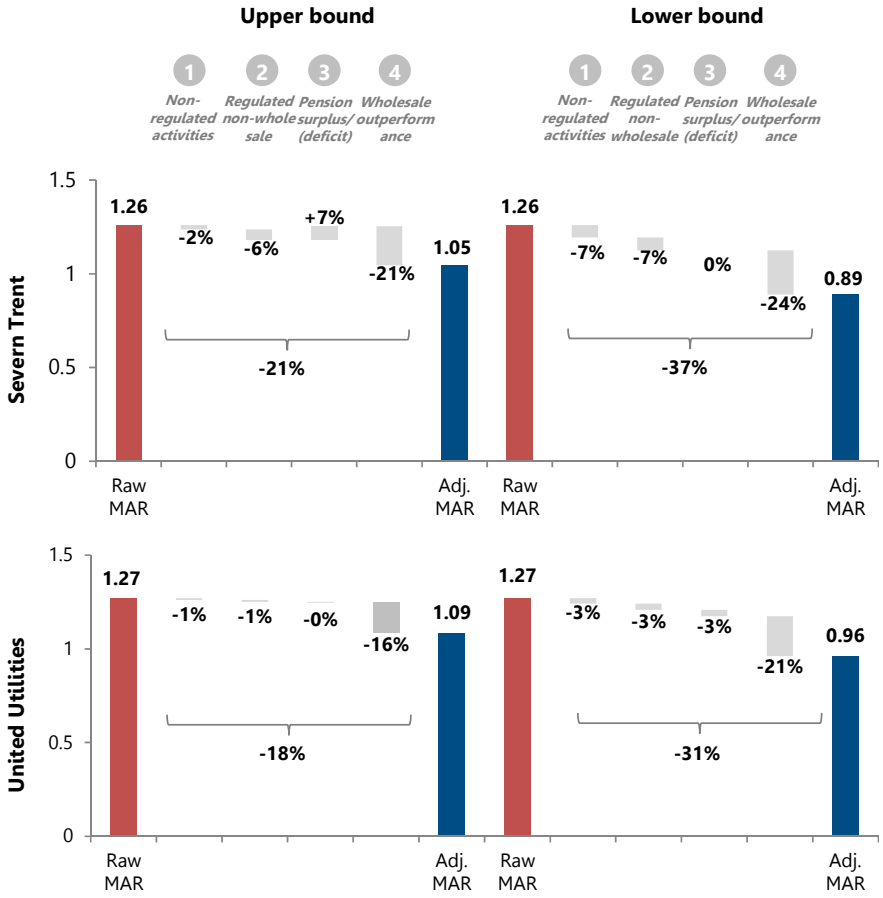
**Figure B.1: Total value of adjustments based on analyst estimates (75 to 148 per cent pre-GDN sale and 139 to 196 per cent post-GDN sale) more than explains the observed RAB premium for NG**




*Source: NERA (December 2017) Implications of Observed Market to Asset Ratios for Cost of Equity at RIIO-2, p. 6*

We have also shown that while the required adjustments are less acute in water, they are still material and uncertain. For the two UK listed companies, United Utilities and SVT, we show that the MAR is approximately 1 having made adjustments for non-regulated, non-wholesale businesses, outperformance opportunities and pension deficit (surplus), suggesting that there is no evidence the investors' expected cost of equity is lower than the allowed returns for the water sector, and therefore providing no evidence that the returns are too high in energy.

**Figure B.2: Total value of adjustments based on analyst estimates (21 to 37 per cent for SVT and 18 to 31 per cent for UU) more than explains the observed RAB premium for water companies**




*Source: NERA (December 2017) Implications of Observed Market to Asset Ratios for Cost of Equity at RIIO-2, p. 7*

## B.2. Investment Managers' surveys

Ofgem provides a selective small sample of asset managers' estimated returns, which support an average nominal TMR of 6.59 per cent.[146]

As we have set out in previous reports, survey evidence is unreliable to inform investors' expected returns.[147] For this reason, regulators should not rely on survey evidence to estimate the TMR, given issues around respondents' understanding of the question being asked. The response to the survey is highly sensitive to the framing of the question and whether the required returns are intended to be nominal or real. For similar reasons, the CMA criticised the use of survey evidence of in its 2014 NIE determination, where it noted:

*"[…] the results of such surveys tend to depend on the identity and outlook of the respondents and how they interpret the questions being asked. Some surveys do not clarify*

146 Ofgem (December 2018), RIIO-2 Sector Specific Methodology Annex: Finance, para 3.77 – 3.78.

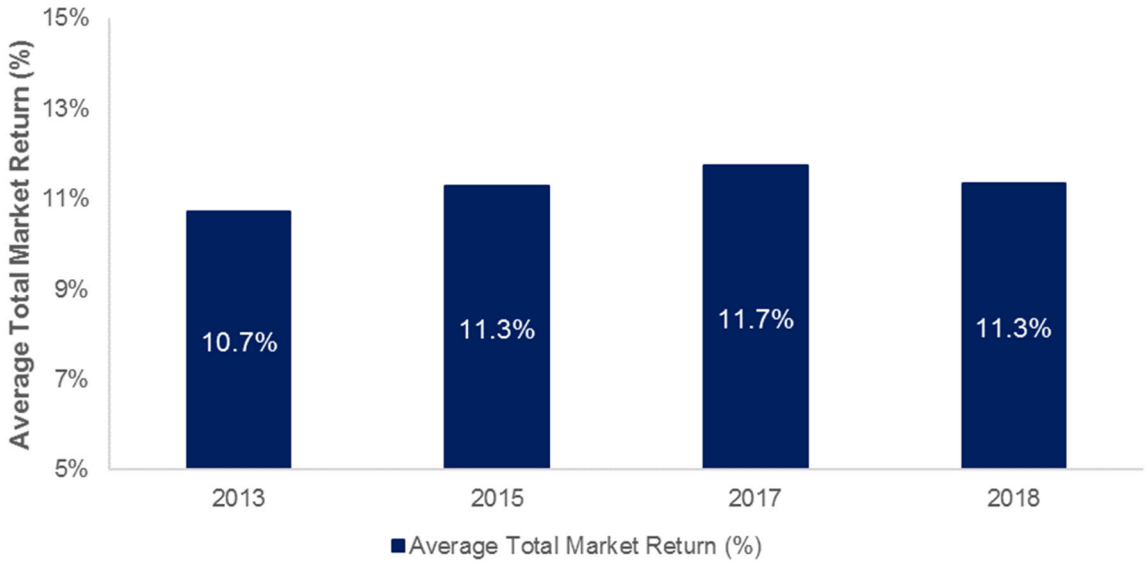
147 NERA (20 November 2018) Further Evidence on the TMR, section 2.3

*the time frame over which the parameters are to be estimated (the long-term equilibrium ERP or a shorter-term estimate); whether an arithmetic or geometric averaging approach should be used; or whether the ERP is over bonds or bills or some other instrument."*[148]

In addition, Ofgem excludes surveys carried out annually by Fernandez, which PwC relies on in its report to Ofwat for PR19.[149] Professor Fernandez et al. publish an annual study containing the statistics about the ERP used by the investor community in over 40 countries to calculate the required return on equity, and survey evidence on the TMR is available for 39 countries for the years 2013, 2015, 2017, and 2018.[150]

Reviewing the survey evidence, we find that the required return (of around 10 to 11 per cent) is substantively higher than Ofwat's survey evidence (nominal return of 6.6 per cent), and no decline in the required returns over the sample period.

**Figure B.3: Survey Evidence from Fernandez Provides for a Return Substantively Higher than Ofwat Survey Evidence[151]**




*Source: NERA analysis of Fernandez data.*

## B.3. OFTOs IRRs

Ofgem reports equity IRRs for OFTOs winning bidders as 7.2 to 10.2 per cent (nominal, RPI) or therefore 5.2-8.2 per cent (real, CPIH) or 4.2 - 7.2 (real, RPI), with the most recent round (round five), as the lower bound. These figures are far higher than Ofgem's own proposed

148 CMA (March 2014), Northern Ireland Electricity price determination, Final Determination, para. 13.156, p.13-31 and para 13.32.

149 PwC (December 2017), Updated analysis on cost of equity for PR19, p.4.

150 Source of the most recent issue of the paper: Fernandez, P., Pershin, V., and Acin, I.F. (April 2018), Market Risk Premium and Risk-Free Rate used for 59 countries in 2018: a survey

151 It is unclear to us whether the respondents are asked for their views on the TMR level in nominal or in real terms, which highlights an issue with survey evidence. See Fernandez, P., Pershin, V., and Acin, I.F. (April 2018), Market Risk Premium and Risk-Free Rate used for 59 countries in 2018: a survey, p.11.

cost of equity range of 3 to 4 per cent (real, RPI), although we acknowledge that the OFTO evidence reflects a leveraged equity return which may be higher than Ofgem's assumed notional gearing of 60 per cent, although this is not reported by Ofgem.[152] Potentially taking into account higher levels of gearing, Ofgem concludes the OFTO evidence supports a cost of equity of 4 per cent (real RPI), at the top end of its estimated range from step 1.

As we have already set out in separate reports for Scottish Power[153], OFTOs IRRs are an unreliable and an unverified estimator for cost of equity. Bidders for OFTO projects bid and are evaluated based on their proposed revenue stream over the OFTO licence period. [154] Even where equity IRRs targeted by investors for OFTO projects are stated in the bidding documents, the equity IRR is likely to understate the expected return given potential cost outperformance, tax, and financing outperformance over the operational life. In addition, the risk profile of the OFTO operational phase (under these late competition models) is lower than the risks faced by a TO undertaking a portfolio of capital projects.

## B.4. Infrastructure Discount Rates

Ofgem presents the discount rates used by infrastructure fund to value their equity investment. This evidence supports a cost of equity of 4 to 7.1 per cent (real, RPI).[155] The range is manifestly above the step 1 range of 3 to 4 per cent (real RPI) proposed by Ofgem and therefore does not provide support for its range.

Ofgem appears to draw on these data to demonstrate a decline in investors' expected returns over time, drawing specifically on HICL and 3i infrastructure. In a separate report for the ENA[156], we have considered the change in portfolio allocation by HICL over time to understand its effect on the discount rate. Our analysis shows that the change in HICL portfolio is equally likely to explain the decline in required returns. Our review of the portfolio of assets held by HICL demonstrates that only two of the noted "ten largest investments" held in 2013 are in HICL's portfolio as of March 2018. In addition, the geographic location of the asset has greatly varied, for example, with asset allocation to North America declining from 10 per cent of the asset portfolio in March 2018 to only 2 per cent in January 2013.[157]

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152 Ofgem states that the OFTOs may be as leveraged as 90 per cent at financial close, but the relevant gearing measure is the period to which the equity IRR corresponds. Source: Ofgem (December 2018) Consultation – RIIO-2 Sector Specific Methodology Annex – Finance, p. 47

153 NERA (March 2018), Review of Ofgem proposed WACC for Competition Proxy Model of delivering new onshore capacity investments

154 The bidding criteria place a 60 per cent weight on the bidders proposed revenue stream and a 40 per cent weight on quality of the underlying assumptions. See e.g. Ofgem (October 2014), Invitation to Tender Document for Tender Round 3 (TR3): Westermost Rough, p.60-62.

155 As reported in Table 15, nominal discount rates are 7.2 to 10.2 per cent. If we deflate these values using Ofgem's 3.07 per cent RPI assumption (from OBR), we obtain a range of 4.1 to 7.1 per cent (real RPI).

156 NERA (November 2018) Further evidence on the TMR, a report for ENA

157 HICL Infrastructure (January 2013), Quarterly Factsheet – January 2013; HICL Infrastructure (May 2018), Annual Results Presentation: Year to 31 March 2018.

# Appendix C. Review of UKRN report recommendations on TMR

In this appendix, we review the recommendations on estimating Total Market Return (TMR) presented in the report by Wright, Burns, Mason and Pickford in a report prepared for the UK Regulators Network ("UKRN report").[158]

## C.1. Summary of UKRN report recommendations on real TMR estimation

The UKRN report presents two key recommendations on estimating TMR at future reviews:

- ***CPI as preferred inflation index***: The UKRN report recommends that CPI inflation should be used as a basis of setting real allowed rates of return at future reviews. It also argues that historical real returns should be analysed in reference to historical CPI inflation published by the Bank of England (BoE) in the Millennium dataset, as it is more consistent over time and therefore superior to RPI over the historical period since 1900.[159]
- ***Downward adjustment to arithmetic mean to account for returns predictability***: The UKRN report argues that historical realized returns should be used as a basis of estimating the TMR. However, it applies a downward adjustment of around 1 per cent to the simple arithmetic mean of historical realized returns, to take into account predictability of returns at long horizons. Based on this, the UKRN report recommends a real (CPI-deflated) TMR of 6 to 7 per cent. [160]

We disagree with both recommendations, as we explain below.

## C.2. RPI data should be used to analyse *historical* real TMR given "CPI" BoE Millennium data unreliable

The UKRN report recommends that CPI inflation should be used both as a basis of: i) determining allowed WACC in real terms going forward; and ii) analysing historical real total market returns going back to 1900.

In principle, we agree with the UKRN report's first recommendation that *going forward* regulators may prefer to determine the allowed WACC in real terms using the same inflation index as used by the Bank of England for inflation targeting. However, when considering a change in the price control index, other factors should be considered, e.g. impact on companies' existing RPI-linked liabilities, impact on customer bills or the ability of the new inflation index to track companies' costs.

In relation to the second recommendation, the appropriateness of using BoE's Millennium CPI inflation data to calculate *historical* real TMR, depends on the reliability of this data as a measure of historical CPI inflation for the UK since 1900, given the official CPI index is only available from 1989 onwards. As we explain below, our review of the BoE Millennium dataset data shows that the "CPI" data series is not a reliable measure of CPI inflation going

[158] Wright, S, Burns, P, Mason, R, and Pickford, D (2018), Estimating the cost of capital for implementation of price controls by UK Regulators, An update of Mason, Miles and Wright (2003).

[159] Wright, Burns, Mason, Pickford (2018), op.cit., p.31 and appendix D.

[160] Wright, Burns, Mason, Pickford (2018), op.cit., appendix E.

back to 1900 and indeed that RPI data is the only reliable measure of historical inflation since 1900.

### C.2.1. BoE "CPI" data is not a reliable measure of CPI inflation since 1900 and should not be used to calculate historical real TMR

The UKRN report uses data on historical CPI inflation reported in the BoE Millennium dataset to calculate the historical real TMR.[161]

The BoE CPI data is based on a number of sources for different periods, summarised in Table C.1 below, together with the sources for the BoE alternative RPI data.

**Table C.1: Sources of BoE CPI and RPI Millennium series inflation data and RPI-CPI wedge**

| Period | RPI source | CPI source | RPI-CPI wedge |
|---|---|---|---|
| 1989-2016 | Official ONS RPI index | Official ONS CPI index | 71 bps |
| 1950-1988 | Official ONS RPI index | Modelled back series of CPI (ONS, 2013) | 28 bps |
| 1915-1949 | Implied deflator for consumers' expenditure (O'Donoghue et. Al., 2004) | Implied deflator for consumers' expenditure (O'Donoghue et. al., 2004) | 0 bps |
| 1900-1914 | Implied deflator for consumers' expenditure (O'Donoghue et.al., 2004) | Cost of living index (Feinstein, 1991) | -30 bps |

*Source: Bank of England (2017), A millennium of macroeconomic data for the UK, tab A47. Wages and prices.*

Based on our review of these different data sources, we find that the BoE "CPI" data is unreliable and inconsistent for the years before 1989 when CPI official data started being published, which represents the vast majority of the historical period over which total market returns are being analysed (since 1900). Specifically:

- For **1950-1988**, the "CPI" data is based on ONS (2013) back-estimates of "CPI" derived from the official published RPI index and the ONS (2013) paper[162] itself raises significant concerns regarding the reliability of this data:[163]

  *"The method provides only approximate results and there is no way to determine how accurate our method is as* ***sufficient data to calculate the CPI do not exist prior to 1987.****"*

[161] Wright, Burns, Mason, Pickford (2018), op.cit., p.31.

[162] ONS (2013), Modelling a Back Series for the Consumer Price index, Robert O'Neill and Jeff Ralph.

[163] *"The method provides only approximate results and there is no way to determine how accurate our method is as* ***sufficient data to calculate the CPI do not exist prior to 1987.****"* Source: ONS (2013), Modelling a Back Series for the Consumer Price index, Robert O'Neill and Jeff Ralph, p.4.

- For **1915-1949**, the BoE data for "CPI" and "RPI" is identical, based on a single series of inflation data published by O'Donoghue et. al. (2004).[164] We analysed this source and found that this series includes *RPI inflation* data after 1947 and estimates of the *RPI index* before 1947 based on data from Feinstein (1972). [165] There is therefore no CPI data available for this period and instead the BoE CPI series uses RPI inflation data.
- For **1900-1914**, the "CPI" data is based on Feinstein (1991),[166] which estimates a cost of living index for working class households only and not CPI inflation.[167] The Feinstein (1991) cost of living index is narrowly defined to focus on spending of *working class households*, whereas the CPI index has a much wider definition and covers *all private and institutional households*.[168] We conclude the Feinstein (1991) data is not a reliable measure of CPI inflation over this period.

In contrast to the UKRN report, we find that the BoE's "CPI" historical data is unreliable and inconsistent over time. Indeed, the "CPI" series includes RPI data for a substantial portion (35 years) of the historical period and the data for other historical periods is not a reliable estimate of CPI inflation historically.

We therefore conclude that the historical inflation data labelled as "CPI" in the BoE Millennium dataset does not represent a reliable measure of historical CPI inflation going back to 1900 and therefore should not be used as a basis of analysing historical real returns.

### C.2.2. Historical RPI inflation represents the most reliable and consistent source for estimating UK inflation for the period since 1900

We conclude that RPI represents the most reliable measure of UK inflation historically and therefore should be used to analyse historical real TMR for the period since 1900.

Our recommendation is consistent with the view presented in O'Donoghue et. al. (2004), which concludes that RPI data presented in the *"unofficial national accounts"*[169] from Feinstein (1972) for the period before 1947 and the official RPI data post-1947 represent the

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164 O'Donoghue, Goulding, Allen (March 2004), Consumer price inflation since 1750.

165 Feinstein (1972), National income, expenditure and output of the United Kingdom, 1855-1965, Cambridge University Press.
O'Donoghue et. al. (2004) note the following about the Feinstein (1972) data: *"During this period (1870-1947), the implied deflator for consumers' expenditure is used, derived from estimates of consumers' expenditure valued at current and constant prices. These are taken from the* ***unofficial national accounts of the United Kingdom, prepared by the Department of Applied Economics at Cambridge University (Feinstein, 1972)****. These results were put together in a form which was* ***as nearly as possible consistent in concept and definition with the then Central Statistical Office's (post-1947) official estimates of the National Accounts****."* [emphasis added] (Source: O'Donoghue, Goulding, Allen (March 2004), Consumer price inflation since 1750, p.39.)

166 Feinstein (1991), A new look at the cost of living 1870-1914; in Foreman-Peck (1991), New perspectives on the late Victorian economy: essays in quantitative economic history 1860-1914, Cambridge University Press, chapter 6.

167 Feinstein (1991) states the objective of the estimates of the cost of living index was to *"investigate one crucial aspect of these trends in living standards from 1970 to the First World War: the* ***changes in the price of goods and services purchased by working-class households****" (Source:* Feinstein (1991), A new look at the cost of living 1870-1914; in Foreman-Peck (1991), New perspectives on the late Victorian economy: essays in quantitative economic history 1860-1914, Cambridge University Press, chapter 6, p. 152.)

168 ONS (2011), History and differences between the Consumer Price Index and Retail Price Index, p.8.

169 O'Donoghue, Goulding, Allen (March 2004), Consumer price inflation since 1750, p.39.

appropriate data to be used for making *"long-run comparisons […] of consumer price inflation"*.[170] Similarly, the ONS published *Long term indicator of prices of consumer goods and services* also uses the same RPI data as O'Donoghue et. al. (2004).[171]

### C.2.3. DMS historical RPI data should continue to be considered for estimating historical real TMR

Different historical RPI inflation estimates are available from DMS and the BoE, with the BoE estimate of average RPI inflation over the period 1900 to 2017 around 20bps higher compared to DMS. The difference between the two series is driven by two factors:

- The DMS RPI (as well as equity returns) data is based on year-end values while the BoE data is based on year average values.[172]
- For the period prior to 1949, before official RPI index is available, DMS and BoE rely on different estimates of RPI inflation: DMS use an index of retail prices while the BoE relies on O'Donoghue et. al. (2004).[173] Our analysis of the data suggests the key difference between the two datasets is in the period around the Second World War, which O'Donoghue et. al. (2004) highlight as particularly unreliable: [174]

  *"Feinstein comments that there was a* ***heavy reliance on interpolation during the two wartime periods****. The year to year movements in prices during the* ***First and Second World Wars should therefore be treated with caution****."* [emphasis added]

We conclude that it is reasonable to retain DMS RPI inflation data as a basis of analysing historical real returns, given:

- the DMS data matches the timing of the nominal equity returns index (year-end values) while the BoE data does not (year average values);
- the difference between DMS and BoE is principally driven by the period around WW2, which according to the authors of the BoE inflation estimates may be particularly unreliable; and
- DMS has been the basis of estimating returns at previous reviews and represents a familiar reference point for investors.

## C.3. Evidence for return predictability is contentious and established estimators support a lower adjustment to arithmetic mean to reflect long investment horizons

The UKRN report recommends that the TMR should be based on a geometric return of 5 per cent (CPI-deflated, but based on inaccurate proxies for CPI as we explain above), plus an adjustment of 1 to 2 per cent to calculate the arithmetic return. However, the authors also argue that the case for an adjustment to arithmetic averages as large as 2 percentage points is

170 O'Donoghue, Goulding, Allen (March 2004), Consumer price inflation since 1750, p.38.

171 Available at ONS website: https://www.ons.gov.uk/economy/inflationandpriceindices/timeseries/cdko/mm23

172 NERA analysis of DMS data, BoE data and ONS RPI all items index data.

173 NERA analysis of DMS data, BoE data and ONS RPI all items index data.

174 O'Donoghue, Goulding, Allen (March 2004), Consumer price inflation since 1750, p.39.

weakened if regulators wish to set returns on a consistent basis at a relatively long (e.g. 10-year) horizon, given evidence on the predictability of returns over long horizons.

In this section, we consider the UKRN report assumption that there is predictability in returns for long-time horizons, which supports setting a TMR 1 percentage point below the simple historical arithmetic average return.

### C.3.1. Evidence on return predictability is highly contentious

The UKRN report cites evidence of the cyclically adjusted P/E ratio (or CAPE) and its supposed prediction of the end of the 1990s bull run, as the only basis for its assertion of predictability of returns.[175]

It is surprising that the UKRN report draws a firm conclusion on predictability of returns based on evidence from the 1990s, while in earlier reports in 2003 and 2013, when the evidence on the predictability of CAPE in the 1990s would have been well known, the authors considered that the evidence for predictability was contentious. Specifically:

- The Mason Miles and Wright (MMW) 2003 report concluded that predictability of returns was a contentious issue and eminent academics were divided: "*There is no clear cut empirical evidence, that we are aware of [...] Eminent academic economists have come down on both sides of the fence.*" [176]
- Similarly, Wright and Smithers (2013), in an update to the 2003 MMW paper, point out the "*evidence of predictability is contentious*" and that any evidence is "*extremely limited*".[177] In this report, the authors saw no reason to change their stance relative to their 2003 report. [178]

Our own review of studies on the topic of predictability also shows that there is a substantive body of research that contests predictability:

- Ang and Beckaert (2001)[179] argue that, although predictability of returns is often taken as a starting point for many studies, fewer studies focus on actually testing for predictability. The authors themselves find that returns are not predictable at long horizons concluding: "[returns predictability] *is not statistically significant, not robust across countries, and not robust across different sample periods. In this sense, the predictability that has been the focus of most recent finance research is simply not there"* [180]

[175] Wright, S, Burns, P, Mason, R, and Pickford, D (2018), Estimating the cost of capital for implementation of price controls by UK Regulators, An update of Mason, Miles and Wright (2003), section 4.4.3., p.39-42.

[176] Mason, Miles, and Wright (2003), A study into certain aspects of the cost of capital for regulated utilities in the UK, p.36-37, 41-42.

[177] Wright, and Smithers (2013), The cost of equity capital for regulated companies: a review for Ofgem, pp. 8 &13.

[178] Wright, and Smithers (2013), The cost of equity capital for regulated companies: a review for Ofgem, p. 10.

[179] Ang, and Beckaert (2001), Stock return predictability: is it there?

[180] Ang, and Beckaert (2001), op. cit., p.28

- Similarly, Goyal and Welch (2002)[181] classify the predictability of returns in "*the long list of great ideas in economics that ultimately failed to live up to expectations".*[182] The authors draw the same findings in further research.[183]
- In addition, papers by Boudoukh, Richardson, Whitelaw (2008), Torous, Valkanov, and Yan (2004) and Lanne (2002)[184] do not find evidence for predictability of returns at long horizons. [185]

Based on the above, we conclude that there is no evidence to support the UKRN report's assertion that the evidence base for returns predictability has strengthened and instead conclude that the evidence on returns predictability remains a highly contentious issue in financial literature, in line with the conclusions of the MMW (2003) and Wright and Smithers (2013) reports.

### C.3.2. Established methods by Blume and JKM support more modest adjustments to arithmetic mean for long investment horizons

The UKRN report authors propose an unbiased estimator of the TMR based on geometric average returns and an adjustment of 1 to 2 per cent, where the lower bound adjustment of one per cent is based on their analysis of the expected decline in variances over a 5 to 10-year investment horizon.[186]

The UKRN report ignores more established methods developed by Blume and JKM for estimating unbiased estimators of the TMR for long investment horizons, as discussed in section 2.3.1, and which also consider serial dependence:

- Blume considers the potential impact of predictability of returns on his proposed estimators. He concludes that: *"if one cannot assume independence of successive one period relatives* [returns] *or if there is even a slight change that these relatives are dependent, the simple average of N-period relatives would appear preferable* [relative to the other estimators]." [187]
- JKM also consider the impact of predictability of returns on their unbiased estimator. Although they note that the predictability as *"far from uncontroversial"*, [188] the authors find that allowing for predictability has "little effect" [189] on their estimators.

As we show in Table 2.2, the Blume and JKM estimators provide relatively modest adjustments for different holding periods relative to the simple arithmetic average of 7.1 per cent. For example, assuming a holding period or investment horizon of up to 10 years as

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181 Goyal, and Welch (2002), Predicting the equity premium with dividend ratios

182 Goyal, and Welch (2002), op.cit., p.16

183 Welch, and Goyal (2008), A comprehensive look at the empirical performance of equity premium prediction

184 Lanne (2002), Testing the predictability of stock returns

185 Torous, Valkanov, and Yan (2004), On predicting stock returns with nearly integrated explanatory variables

186 MMW report accounts for returns predictability by observing that returns predicted using a cointegrated autoregressive model (CVAR) exhibit lower volatility than they would do in case returns were random. Mason, Miles, and Wright (2003), op. cit., p.26

187 Blume (1974) op. cit. p. 638

188 Jacquier, Kane, and Marcus (2005), op. cit., p.53

189 Jacquier, Kane, and Marcus (2005), op. cit., p.39

noted by UKRN, implies only a 10 bps to 40 bps downward adjustment relative to the arithmetic mean return using a 1-year holding period. This reflects a far more modest downward adjustment to the arithmetic mean relative to magnitude of the adjustment proposed by UKRN of up to one per cent.

## C.4. Conclusions on UKRN report recommendations

In this appendix, we showed that the historical inflation data labelled as "CPI" in the BoE Millennium dataset does not represent a reliable measure of CPI inflation going back to 1900 and therefore should not be used to estimate historical real TMR. Instead, *historical* real TMR should be estimated using RPI inflation, which is the most reliable measure of UK historical inflation going back to 1900.

We also showed that the UKRN report assumption of returns predictability is contentious and that established TMR estimators by Blume and JKM, which also consider serial dependence, support a smaller adjustment than applied in the UKRN report to reflect long investment horizons.

We confirm our conclusions from section 2.4 that historical data supports a real (RPI-deflated) TMR estimate of 6.5 to 7.1 per cent, which reflects our application of the established Blume and JKM estimators for the relevant investment horizon as well as an adjustment for potential increase in the RPI-CPI wedge going forward.

# Appendix D. Review of Ofwat and its Advisors Evidence on TMR Presented at PR19

In this Appendix, we set out the evidence on the TMR presented by Ofwat in the December 2017 methodology document[190] as well as the evidence presented by Ofwat's advisors PwC in its June 2017 report (updated in December 2017)[191] and Europe Economics (EE) in its December 2017 report.[192]

## D.1. Ofwat TMR evidence presented in December 2017 methodology

### D.1.1. Summary of Ofwat's approach

In its December 2017 methodology document, Ofwat presented its "early view" on the cost of capital for PR19 including a real (RPI-deflated) TMR estimate 4.85 to 6.13 per cent with a point estimate of 5.44 per cent.[193]

Ofwat's estimate of the TMR is based on the work undertaken by its advisors PwC[194] and EE[195], as well as Ofwat's own analysis.[196]

Ofwat's early view of the TMR is substantially lower than regulatory precedent at recent reviews, including the most recent CMA decision for Bristol Water in 2015, which determined a real (RPI-deflated) TMR of 6.5 per cent.[197] This reflects Ofwat's view that equity returns have fallen due to the current low interest rate environment.

In estimating the TMR, Ofwat considers a range of evidence including "ex-post" (historical realised returns data), "ex-ante" (decomposing historical returns into expected return plus good/bad luck) and "forward-looking" approaches (e.g. evidence from dividend growth models), placing most weight on "ex-ante" and "forward looking" approaches in selecting the point estimate.[198] Ofwat notes that its point estimate of the TMR lies towards the top end of the range recommended by PwC of 4.9 to 5.4 per cent and near the bottom end of the range

190 Ofwat (December 2017), Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return.

191 PwC (June 2017), Refining the balance of incentives for PR19 and PwC (December 2017), Updated analysis on the cost of equity for PR19.

192 Europe Economics (December 2017), PR19 – Initial Assessment of the Cost of Capital.

193 Ofwat (December 2017), Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return, p.16.

194 PwC (June 2017), Refining the balance of incentives for PR19; PwC (December 2017), Updated analysis on cost of equity for PR19.

195 Europe Economics (December 2017), PR19 – Initial Assessment of the Cost of Capital.

196 Ofwat (December 2017), Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return, section 5.4.

197 CMA (March 2014) Northern Ireland Electricity price determination, para. 13.146, link: https://assets.publishing.service.gov.uk/media/535a5768ed915d0fdb000003/NIE_Final_determination.pdf

198 Ofwat (December 2017), Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return, p.32-33.

recommended by EE of 5.2 to 6.0 per cent. Ofwat also notes that its TMR lies within the range considered by the CMA for NIE in 2014 of 5.3 to 6.8 per cent.[199]

In the following sections, we comment on the analysis presented by Ofwat in the December 2017 methodology document (as well as the analysis of Ofwat's advisors PwC and EE, although we explore them in more detail in Appendix D.2 and Appendix D.3). First, we show that there is no evidence that expected market returns have fallen in the current low risk-free rate environment, due to the offsetting increase in the equity risk premium. Second, we show that Ofwat presents a selective view of the evidence on the TMR for the various methods it considers, and many of Ofwat's estimates are based on flawed assumptions.

### D.1.2. There is no evidence that equity returns are low in current low RfR environment

In its December 2017 methodology document, Ofwat argues that interest rates over PR19 are expected to remain low compared to historical standards and that this low interest rate environment will lead to low equity returns as a result. To support this statement, Ofwat presents data from DMS which shows a positive relationship between real interest rates and real equity returns from cross-country data (i.e. the lower the interest rate, the lower the equity return and vice versa).[200]

Below, we explain that there is no evidence to support Ofwat's assumption that expected equity returns have fallen as a result of the low risk-free rate environment.

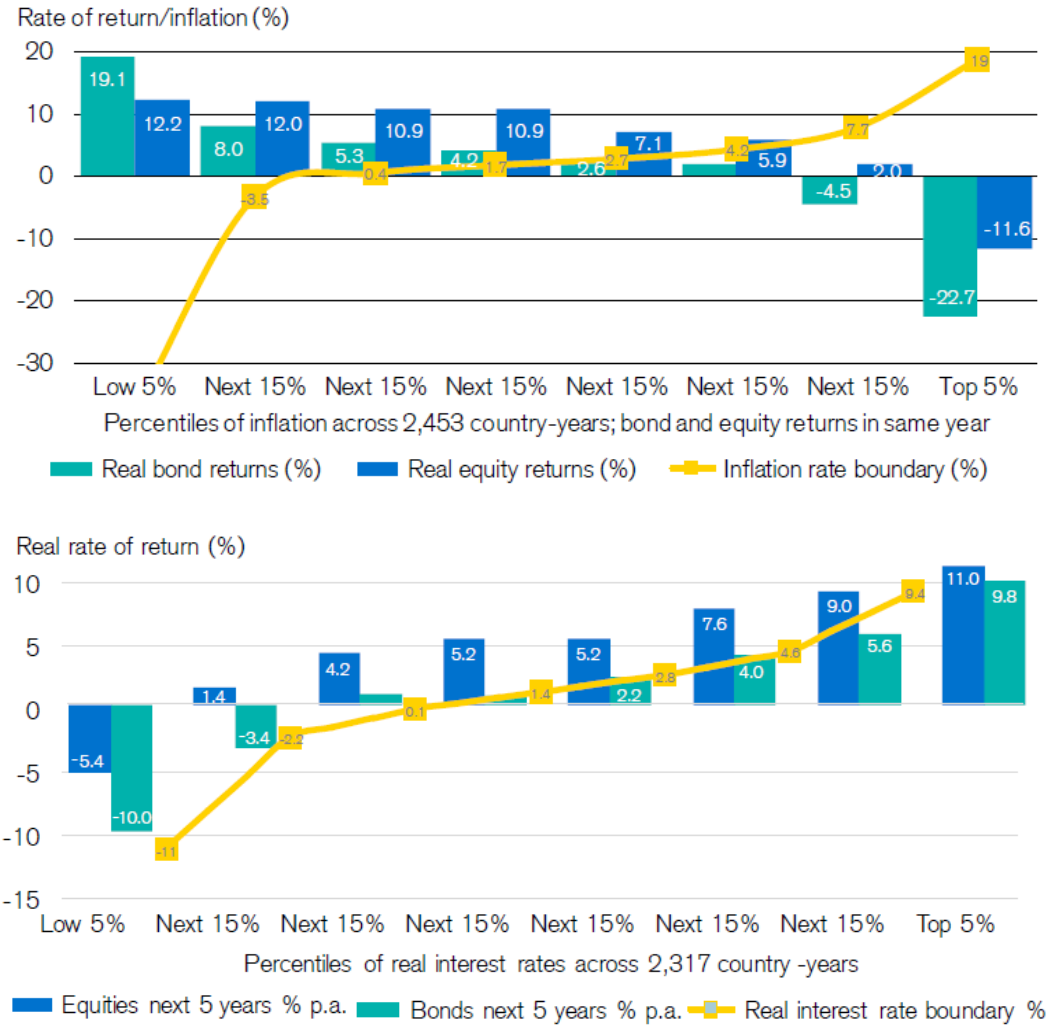
The cross-country evidence showing a positive relationship between real interest rates and real equity returns presented by Ofwat is misleading. As DMS recognise, *"historically, the bulk of the low real rates occurred **in inflationary periods**, in contrast to today's low-inflation environment".*[201] Thus, the apparent positive relationship between real interest rates and equity returns presented by Ofwat from cross-country data is in fact driven by a negative relationship between both variables and inflation. As DMS show, historically bond and equity returns have shown a negative relationship with inflation, with bond returns particularly affected compared to equities, as shown in Figure D.1. Ofwat misconstrues the DMS evidence as a positive relationship between low real bond returns and low equity returns, despite a clear statement from DMS that the relationship arises due to the relatively greater effect of high inflation on bond returns than equity.

[199] Ofwat (December 2017), Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return, p.33-34.

[200] Ofwat (December 2017), Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return., section 5.4.1.

[201] DMS (February 2018), Credit Suisse Global Investment Returns Yearbook 2018, p.20.

**Figure D.1: Bond returns react more negatively to high inflation compared to equities (LHS), giving rise to apparent "positive" relationship between low real bond returns and low equity returns (RHS)**




*Source: DMS (February 2018), Global Investment Returns Yearbook 2017 – Slide Deck, p.11 and 14.*

However, the relationship between bonds and equity returns in high inflation periods is not relevant for the assessment of the implications of the current low risk-free rate environment on equity returns, as the low risk-free rate is not driven by high inflation but is a result of loose monetary policy since the Global Financial Crisis.

As we explain in Section 2.2, there is no evidence that expected market returns have fallen in the current low risk-free rate environment, due to the offsetting increase in the equity risk premium.

We note that Ofwat appears to accept the negative relationship between the RfR and the ERP, given it reports estimates of negative correlation between the RfR and the ERP of -0.88 for the period 2010 to 2016 estimated by its advisors PwC.[202]

### D.1.3. Ofwat's evidence on the TMR is selective with many estimates based on flawed assumptions

In its December 2017 methodology document, Ofwat presents a range of evidence on the TMR based on different approaches (consistent with those considered by the CMA in its 2014 NIE determination), including i) historical "ex-post" approaches, ii) historical "ex-ante" approaches and iii) forward looking evidence (for a more detailed explanation, see Appendix F).[203]

**Historical ex-post evidence:**

Ofwat presents estimates of 4.7 to 5.7 per cent for geometric and 6.0 to 6.9 per cent for arithmetic averages using different holding periods, and incorporating a downward adjustment for RPI formula effect of 33 bps. It concludes that the true estimate lies between these two estimates.[204]

Ofwat correctly cites Blume and JKM approaches as a potential means to determine unbiased estimates for the expected TMR from long horizons, where these papers show that an unbiased estimate is a weighted average of the arithmetic and geometric mean, where the weights depend on the length of the historical time series and forecast period. However, Ofwat does not actually apply the established Blume and JKM approaches to derive unbiased estimates of the expected rate of return. As we show in Section 2.3, the application of these methods to long run historical data provide unbiased estimates for the TMR of between 6.2 and 7.1 per cent, a substantively higher range than Ofwat's cited range of 4.7 to 6.9 per cent. The explicit use of the Blume and JKM approaches to derive unbiased estimates of the expected return is consistent with the CMA approach at NIE, as we describe in Appendix F.

**Historical ex-ante evidence:**

Ofwat presents an estimate of the TMR of 4.2 per cent to 5.6 per cent using the Fama French approach applied to Barclays equity gilts study data 1990-2016 (lower bound) and 1900-2016 (upper bound).[205]

Ofwat also presents adjusted figures 5.1 per cent to 6.3 per cent which take into account volatility of share price growth versus dividend growth, in line with the approach adopted by Fama French. Ofwat correctly notes that the "*the authors recommend an uplift calculated using their proposed corrective factor of half the difference in the variances of share price*

[202] Ofwat (December 2017), Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return, p.38.

[203] Ofwat (December 2017) Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return, p.32.

[204] Ofwat (December 2017) Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return, p.40-41.

[205] Ofwat (December 2017) Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return, p.42.

*growth rate and dividend growth rate, respectively*." However, Ofwat then considers that: "*that the case for making this adjustment is greatly weakened if we consider the relative variances of total equity yield (that is dividends and share buybacks) and share price growth. PwC's analysis suggests that the former has been more volatile than the latter in almost all years since 2004 except for the last few months of 2017*".[206]

Ofwat lower bound estimate based on short run data does not provide a robust estimate. The Fama French approach, as applied by Fama and French themselves, needs to be applied to long run data given the volatility in stock market returns; Ofwat simply selects a period since 1990 which supports its view of a lower TMR. It is well established that ex-post approaches need to consider long run time series given the volatility in returns, e.g. DMS recommend the use of the longest time series available; equally ex-ante estimates of the TMR need to draw on long-time series. Hence, Ofwat's lower bound estimate is selective and not robust.

We agree with Ofwat's derivation of the upper bound estimate of 6.3 per cent when applying the Fama French approach, as calculated by us in Appendix F in replicating CMA NIE. We disagree with Ofwat's notion that the adjustment for the difference in variation between price and dividends should not apply. Ofwat's assertion that the Fama French is not required is based on selective examination of the volatility of price and dividend growth over a recent 13 year period whereas Fama French conclusions relate to examination of this issue over a much longer time period. As with its lower bound evidence, inferences made from short-term data are not robust.

We also note that the historical "ex-ante" estimates presented by Ofwat do not represent any new evidence or information on this topic, and do not demonstrate that TMR has fallen in the current low risk-free rate environment. These estimates have been fully considered by the CMA in its NIE 2014 (and Bristol Water 2015) determinations, and have been quoted by the CMA as one of the principal reasons in determining a TMR of 6.5 per cent.

**Forward looking evidence:**

Ofwat presents a DGM TMR of 5.1 per cent to 5.9 per cent, based on DGM models applied by its advisors EE and PWC to the FTSE All Share index. As we explain below, the estimates presented by Ofwat's advisors are substantially below independent DGM-based estimates of the TMR from the Bank of England, which the CMA relied on in its 2014 NIE determination, and which support a real TMR of 7 to 8 per cent (RPI-deflated), as we show in Section 2.3.2. Ofwat advisors' DGM estimates are principally understated due to low assumptions on dividend growth based on UK GDP, which fail to reflect that over 70 per cent of FTSE companies derive earnings from outside the UK, where expected GDP growth is higher.

Ofwat notes that Bank of England DGM is overstated because it relies on analyst forecasts which suffer from optimism bias. However, Ofwat did not provide any evidence that supports its assertion of bias. By contrast, the CMA did rely on the Bank of England DGM evidence in its 2014 NIE decision.

[206] Ofwat (December 2017) Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return, p.43.

Ofwat also presents evidence from MAR analysis by PWC and EE which supports a TMR 7.4-8.6 nominal). As we explain below, the MAR evidence by PWC and EE is based on errors and correcting for these errors supports a far higher range.

## D.2. PwC

### D.2.1. June 2017 report

In its June 2017 report, PwC argued that the current low risk-free rate environment, which PwC expects to prevail over the PR19 period, implies a reduction in the TMR, as supported by evidence on reductions in recent *realised* returns for the UK equity market. Based on this assertion, PwC concluded that long-term historical data is inappropriate for estimating the TMR in the current market environment, because it is too slow to react to short-term dynamics. Instead, PwC recommended to estimate the TMR drawing on "current" or "forward-looking" approaches, such as the dividend growth model (DGM) applied to the UK FTSE market index or market-to-asset ratio analysis for listed UK water stocks (MAR). Based on its application of these "current" approaches, PwC estimated a real (RPI- deflated) TMR of 5.1 to 5.6 per cent, substantially below estimates based on historical data of around 7 per cent.[207]

In our November 2017 and December 2017 reports prepared for National Grid,[208] we demonstrated that PwC's approach to estimating the "forward-looking" TMR in its June 2017 report is flawed and leads to a substantial understatement of the TMR for PR19. As explained in section 2.3.2, we consider the most reliable forward-looking estimates of the TMR are based on the Bank of England's DGM which support a real (RPI deflated) TMR of around 7 to 8 per cent.

**There is no evidence of a reduction in TMR due to low RfR environment**

First, we explained that there is no evidence that the TMR has declined in the current market environment as argued by PwC in its June 2017 report, given reductions in the RfR are broadly offset by increase in the ERP (as discussed in section 2.3). In its June 2017 report, PwC presented evidence seemingly showing a decline in *realised* equity or total market return over recent periods for the UK, which it considered demonstrates that investors' *expected* returns are lower in the current period of low interest rates.[209] In our November 2017 report for National Grid, we showed that PwC's evidence is weak and selective. We showed that in most major equity markets (e.g. US and Germany), the realised TMR has increased over recent period despite the low RfR environment, a direct contradiction to PwC's conclusions. We also noted that it is unsafe to draw conclusions from short-term (e.g. decadal) averages of realised returns, given the volatility of stock market returns which results in high standard errors of these short-run averages, an accepted point in the academic literature.[210]

[207] PwC (June 2017), Refining the balance of incentives for PR19. Real TMR range derived from PwC's nominal estimate of 8.0 to 8.5 per cent, using PwC's RPI inflation assumption of 2.8 per cent (p. 50 fn. 86) and the Fisher formula.

[208] NERA (November 2017), Total Market Return for Determining the Cost of Equity at RIIO-2 and NERA (December 2017), Implications of Observed Market-to-Asset Ratios for Cost of Equity at RIIO-2.

[209] PwC (June 2017), Refining the balance of incentives for PR19, pp. 79-80.

[210] NERA (November 2017), Total Market Return for Determining the Cost of Equity at RIIO-2, pp. 6-8.

**PwC's estimates of TMR based on "current" approaches are unreliable**

Second, we showed that PwC's estimates of the TMR based on DGM and MAR analysis are based on incorrect assumptions and methodology, resulting in a substantial understatement of the "forward-looking" TMR.

In relation to PwC's DGM analysis, we explained that PwC's DGM-based TMR is understated, due to implausibly low assumptions around dividend growth rates, a key determinant of the implied TMR, when compared to independent estimates from the Bank of England. PwC assumed that FTSE dividends grow in line with short-term and long-term nominal growth in UK GDP, but provided no basis for the assumption that UK GDP forecast growth rates are a good proxy for investors' expectations of FTSE dividend growth rates. We explained that PwC's assumption is flawed, not least because FTSE companies derive over 70 per cent of their earnings from outside of the UK, which have higher forecast GDP growth than the UK. In addition, short-term UK GDP forecast growth rates are somewhat depressed (e.g. due to Brexit) and are substantially lower than independent analyst forecasts of dividend growth rates for FTSE stocks, which are used by the Bank of England as a basis of forecasting short-term dividend growth in its DGM.[211] PwC's understatement of the TMR based on its own DGM is evident when compared to independent estimates of the TMR based on the Bank of England's DGM which support a real (RPI deflated) TMR of around 7 to 8 per cent (as discussed in section 2.3.2).

In relation to PwC's MAR analysis, we explained that PwC failed to adequately adjust for important drivers of water companies' valuations, including value of non-regulated activities, value of regulated activities unrelated to wholesale, value of pension deficit/surplus, as well as expected outperformance. We explained that the value of these adjustments is subject to substantial uncertainty, but evidence from independent analyst reports suggests that the regulatory capital value (RCV) premium calculated by PwC is fully explained by these factors, and there is therefore no evidence that the "adjusted" MAR for listed water companies is different from 1. [212]

We also showed that even if we were to accept PwC's calculation of the "adjusted" MAR for listed UK water companies of around 1.1 (which we do not), PwC's calculations of the implied TMR of 4.7 to 5.2 per cent based on this MAR include two methodological errors, confusing real and nominal terms and ignoring real growth in RCV, which lead to PwC understating the implied TMR by 140-170bps.[213]

### D.2.2. December 2017 report

In its December 2017 report, PwC presented an updated estimate of the real (RPI deflated) TMR of 5.1 to 5.6 per cent and commented on some of the issues discussed in section

[211] NERA (November 2017), Total Market Return for Determining the Cost of Equity at RIIO-2, pp. 5-6.

[212] NERA (December 2017), Implications of Observed Market-to-Asset Ratios for Cost of Equity at RIIO-2, pp. 7-9.

[213] NERA (December 2017), Implications of Observed Market-to-Asset Ratios for Cost of Equity at RIIO-2, pp. 9-10. Specifically, PwC incorrectly interprets the MAR to represent a ratio of the allowed rate of return and investors' expected cost of capital nominal as opposed to real terms, which is incorrect for UK water companies and leads to an understatement of the TMR by PwC. In backing out the implied expected cost of equity and TMR, PwC also implicitly assumes zero real growth in RCV, which results in an understatement of the implied TMR given expected positive real growth in the RCV for water companies.

D.2.1.[214] Below, we explain that PwC's responses fail to address the issues discussed in section D.2.1 and that PwC's December 2017 updated TMR estimate remains understated as a result.

**PwC failed to correct errors in its DGM and MAR analysis**

In relation to its DGM estimates, in its December 2017 report, PwC acknowledged that FTSE companies derive a substantial portion of its earnings from outside of the UK but argued that its reliance on UK GDP growth as a proxy of future dividend growth is appropriate, as its objective is to derive a TMR for the UK market, as opposed to a world TMR.[215]

PwC's approach is illogical: In drawing on a FTSE stock market index value and FTSE dividend payments for its DGM, both of which reflect UK and foreign earnings, PwC must use a consistent dividend forecast, i.e. also based on UK and foreign GDP.

In relation to its MAR analysis, in its December 2017 report, PwC argued that it did not ignore growth in RCV in its MAR analysis. Specifically, PwC stated that in estimating the present value of expected cost and incentive outperformance, its calculations included an assumption on future growth in the RCV and there is therefore no need for an adjustment to reflect RCV growth.[216]

Accounting for growth in RCV in calculating the value of cost and incentive outperformance only partially addresses the impact of a growing RCV on the observed MAR. RCV growth must also be taken into account when backing out the "implied" TMR from the "adjusted" MAR, even after having adjusted for the impact of RCV growth on the value of cost and incentive outperformance. Since the effect of this outperformance is compounded with the expected growth in the RCV, any "outperformance" of the cost of equity will result in a higher observed MAR *the higher the expected real growth in RCV.* As we showed in our December 2017 report for National Grid, PwC failed to take this RCV growth into account in backing out the TMR, resulting in its implied TMR being understated.[217]

## D.3. Europe Economics

In its December 2017 report, EE estimated a real (RPI deflated) TMR of 5.22 to 5.96 per cent, based on a range of evidence including forward-looking approaches (DGM and MAR analysis), historical realised returns (based on DMS) and regulatory precedent.[218] Below, we explain the issues with the evidence presented by EE which result in an understatement of the TMR for PR19.

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214 PwC (December 2017), Updated analysis on the cost of equity for PR19. Real TMR range derived from PwC's nominal estimate of 8.0 to 8.6 per cent, using PwC's RPI inflation assumption of 2.8 per cent (PwC (June 2017), Refining the balance of incentives for PR19, p. 50 fn. 86) and the Fisher formula.

215 PwC (December 2017), Updated analysis on the cost of equity for PR19, para 4.30-4.31.

216 PwC (December 2017), Updated analysis on the cost of equity for PR19, para 5.8.

217 NERA (December 2017), Implications of Observed Market-to-Asset Ratios for Cost of Equity at RIIO-2, pp. 9-10.

218 EE (December 2017), PR19 – Initial Assessment of the Cost of Capital, section 5.

**EE's forward-looking evidence suffers from similar issues as PwC's analysis**

In relation to EE's forward-looking evidence, we consider the TMR estimates presented by EE based on its own DGM model as well as MAR analysis lead to an understatement of the forward looking TMR for the following reasons:

- ***DGM evidence***: Similarly to PwC's analysis (discussed in section D.2), EE's DGM-based real (RPI deflated) TMR estimates of around 4 to 6 per cent[219] are low compared to independent estimates from the Bank of England which support a real (RPI-deflated) TMR of 7 to 8 per cent (as explained in section 2.3.2). The EE DGM based TMR estimate is understated due to low estimates of future dividend growth based on UK GDP growth, which is incorrect for the same reasons as explained in section D.2.
- ***MAR evidence***: We understand EE's MAR calculations are based on the MAR analysis undertaken by PwC,[220] which fails to adjust for important drivers of water company valuations which can fully explain the observed MAR and includes calculation errors which leads to an understatement of the implied TMR (as discussed in section D.2). As a result, the errors in PwC's analysis discussed in section D.2 are also present in EE's results.

  We note that EE also calculated an alternative MAR for UU and SVT based on a "regulatory market value of debt" calculated as 70 per cent book value of debt plus 30 per cent fair market value of debt reported in companies' accounts,[221] resulting in a higher MAR and lower implied TMR compared to PwC. EE is incorrect to assume that the value of debt for UU and SVT should be 30 per cent of the market value and 70 per cent of the book value of debt. This assumes that companies retain 30 per cent of the benefit/cost of the change in the value of debt since it was issued, which does not reflect the way Ofwat sets allowed cost of debt. Ofwat's approach to setting the allowed cost of debt is to allow companies to recover the cost of debt at the point when it was issued (both embedded and new debt) and there is no benefit/cost from re-valuations of this debt after it was issued by companies.[222]

As explained in section 2.3.2, we consider the most reliable forward-looking estimates of the TMR are based on the Bank of England's DGM which support a real (RPI deflated) TMR of around 7 to 8 per cent.

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219 EE (December 2017), PR19 – Initial Assessment of the Cost of Capital, p. 36, Table 5.3.

220 EE (December 2017), PR19 – Initial Assessment of the Cost of Capital, p. 37.

221 Reflecting Ofwat's weighting on embedded (70 per cent) and new (30 per cent) debt for setting the allowed rate of return.

222 The fact that when Ofwat sets the allowed cost of debt at review, it has to estimate the cost at which new debt will be issued (the 30 per cent assumed by EE) is completely unrelated to the fact that at after debt is issued, it may have a market value which is different from book value, due to changes in interest rates since the debt was issued (which is what EE reflects in its MAR estimate by including the 30 per cent fair market value of debt). As explained above, companies do not benefit/or bear the cost of changes in interest rates on its existing debt, as they recover the cost of debt at the time when it was issued.

**EE misinterprets historical DMS returns data and applies downward adjustments as per DMS world index which do not apply to the UK**

In relation to historical realized returns, EE states that historical realized returns from DMS support a real (CPI-deflated) TMR of 7.3 per cent. EE also notes that historical returns were affected by "non-repeatable" factors such as changes in P/D ratios and real dividend growth which justify a 1 per cent reduction to historical returns of 100bps to calculate the expected return going forward (based on DMS adjustment for world index).[223]

As we explain in footnote 43, the returns for the UK market reported in the DMS publication of 7.3 per cent are based on a part RPI (until 1988) and part CPI (post 1988) historical inflation measure. EE is therefore incorrect to interpret the reported figure of 7.3 per cent as a real CPI-deflated measure, as all DMS historical returns data prior to 1988 reflect RPI inflation. As we explain, in footnote 43, we have re-calculated the DMS historical returns on a consistent real RPI-deflated basis which support a TMR of 7.1 per cent.

We do not consider that EE's adjustment of 100bps based on DMS adjustment to the world index for "non-repeatable" factors is appropriate for the UK market. DMS makes two adjustments to the TMR for the world index. First DMS adjusts for the historical expansion of the P/D ratio of around 50bps. Second, it applies a 30 bps adjustment for the difference between historical and forward-looking dividend growth.[224]

In relation to the first adjustment, DMS (2018) show that the historical growth in the P/D ratio for the UK market has been 1bps (as opposed to 51 bps for the world index).[225] As a result, no adjustment for the expansion of P/D ratio for the UK market is necessary. In relation to the second adjustment for future dividend growth, DMS (2018) note "***if we assume*** *that the historical real growth rate of dividends on the world index was at least half attributable to past good fortune, then the prospective premium on the world index declines*".[226] As demonstrated by the DMS quote, the adjustment for good fortune can only be considered as illustrative, rather than an objective adjustment based on evidence of historical good fortune. In the absence of any firm evidence that historical growth in dividends may be due to good fortune (equally, they may be understated by "bad fortune"), we do not consider an adjustment to historical realised returns is appropriate.

For these reasons, we do not consider that EE's adjustment to long-run average historical returns is reasonable, and conclude that the historical evidence supports a TMR range of 6.5 to 7.1 per cent (real RPI), as we set out in section 2.4.

**Regulatory precedent supports TMR higher than EE's TMR range**

In relation to precedent, we note that EE presents evidence on recent TMR determinations by UK regulators including the CMA in range of 6 to 6.75 per cent real (RPI-deflated), all of which are higher than EE's own TMR estimate of 5.22 to 5.96 per cent real (RPI-deflated).

223 EE (December 2017), PR19 – Initial Assessment of the Cost of Capital, section 5.2.5.

224 DMS (February 2018), Credit Suisse Global Investment Returns Yearbook 2018, p. 36.

225 DMS (February 2018), Credit Suisse Global Investment Returns Yearbook 2018, Table 10.

226 Credit Suisse Global Investment Returns Yearbook 2017, p37.

As we discuss in Appendix B, our update of the different approaches the CMA considered in determining the TMR at the 2014 NIE and 2015 Bristol water determinations show a slight increase in the estimates using latest available data compared to the evidence presented by the CMA in 2014 NIE and 2015 Bristol water determinations. This supports our conclusion that the TMR for PR19 should be no lower than 6.5 per cent real (RPI-deflated).

# Appendix E. Review of CAA and Its Advisors Evidence on TMR Presented at H7

In this appendix, we discuss the evidence on the TMR in CAA's recent policy update and consultation documents and in CAA's advisor PwC's November 2017 report[227].

## E.1. Summary of CAA's TMR approach

In its December 2017 policy update and consultation document, CAA presented its initial views on the cost of capital for Heathrow Airport over the next regulatory period (H7), including a view of the TMR. [228] CAA's view relies primarily on its advisor PwC's analysis, which recommends a TMR range of 5.1 to 5.6 per cent, based on *current* approaches including evidence from dividend growth models, market-to-asset ratios and investor surveys.

In its April 2018 consultation document[229] and a May 2018 working paper on cost of capital and incentives[230], CAA reiterated its advisor's PwC's approach to TMR, and discussed stakeholder views, including the responses from Heathrow and airline representatives. The CAA stated that it would consider the TMR issue further, and to reflect on the relative weight on historical and forward-looking approaches to estimating TMR, recent UK regulatory precedent, and the appropriateness of international case studies.

## E.2. PwC

In its November 2017 report prepared for the CAA, PwC presented a preliminary view of the cost of capital for H7. In its report, PwC argues that the low risk-free rate environment resulted in reductions in the TMR and recommended a real TMR estimate of 5.1 to 5.6 per cent (RPI-deflated) for H7 based on current approaches (DGM and market-to-asset ratio analysis). PwC also presents its estimate based on long-run historical average, but makes two adjustments to historical average returns. PwC's recommendations to the CAA on the TMR for H7 largely draw on PwC's report prepared for Ofwat on cost of capital for water companies for PR19 (2020-2024) published in June 2017 and updated in December 2017.

**PwC "current" estimates of the TMR are flawed**

As we explain in Section D.2.1 and, PwC's analysis is flawed and understates the TMR estimate. Our critique applies equally to PwC's estimated TMR range for H7, which draws on the same methodology as applied by PwC in its June 2017 report for Ofwat.

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227 PwC (November 2017), Estimating the cost of capital for H7: A report prepared for the Civil Aviation Authority (CAA), link: http://publicapps.caa.co.uk/docs/33/PwC_H7InitialWACCrange.pdf.

228 CAA (14 December 2017), CAP 1610: Economic regulation of capacity expansion at Heathrow: policy update and consultation, p.79. Link: http://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=8473

229 CAA (30 April 2018), CAP1658: Economic regulation of capacity expansion at Heathrow: policy update and consultation, link: ttp://publicapps.caa.co.uk/docs/33/CAP1658EconomicregulationofcapacityexpansionatHeathrow.pdf

230 CAA (30 May 2018), CAP1674: Economic regulation of capacity expansion at Heathrow: working paper on the cost of capital and incentives, p.14. Link: http://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=8473

In our February 2018 report for Heathrow Airport,[231] we showed that PwC's forward-looking estimates based on PwC's DGM and MAR analysis are unreliable. As we explain in Section D.2.2, PwC's DGM estimate is understated, due to implausibly low assumptions around dividend growth rates, a key determinant of the implied TMR, and are substantially below independent DGM estimates of the TMR from the Bank of England. We also explained that PwC's MAR calculations fail to adequately adjust for important drivers of water companies' valuations which can fully explain the RCV premium calculated by PwC. We also showed that even if we were to accept PwC's calculation of the "adjusted" MAR (which we do not), PwC's calculations include two methodological errors, confusing real and nominal terms and ignoring real growth in RCV, which lead to PwC understating the implied TMR by 140-170bps.[232]

**PwC's adjustments to long-run historical returns are not justified**

In its November 2017 report for the CAA,[233] PwC also presented TMR estimates based on long-run historical averages, but included two adjustments to the long-run historical averages:

- *RPI Formula effect*: PwC adjusted historical returns downward by 30 bps to reflect changes in how RPI is measured since 2010;
- *Forward looking returns adjustment*: PwC stated that Dimson, Marsh and Staunton (the source for the long-run historical returns data) believe that half of long-run historical dividend growth for global equities arose from past "good fortune" embedded in long-run historical equity returns data. PwC argues this allowance for "good fortune" should not be reflected in forward-looking estimates of the TMR and estimates a 0.4 per cent downward adjustment to the long-run historical TMR for the UK.

As we explain in section 2.3.1.1, we agree with PwC's observation that the change in the RPI formula may have resulted in a change in the RPI-CPI wedge going forward, although we only apply the ca. 30bps adjustment to our lower bound to reflect the uncertainty over the other off-setting adjustments for the "formula effect".

On the forward-looking adjustment, we consider that an adjustment for historical "good fortune" is not appropriate for estimating future expected equity returns. PwC's adjustment is based on Dimson, Marsh and Staunton (DMS), who argue that "*if we assume that the historical real growth rate of dividends on the world index was at least half attributable to past good fortune, then the prospective premium on the world index declines*".[234] As demonstrated by the DMS quote, the adjustment for good fortune can only be considered as

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231 NERA (February 2018), Cost of Equity for Heathrow in H7, p.12. Link: https://www.caa.co.uk/uploadedFiles/CAA/Content/Accordion/Standard_Content/Commercial/Airports/HAL%20-%20NERA%20Cost%20of%20Equity%20in%20H7.pdf

232 NERA (October 2017), A review of PwC's approach to setting cost of equity in a "lower for longer" era, Section 3.4. Specifically, PwC incorrectly interprets the MAR to represent a ratio of the allowed rate of return and investors' expected cost of capital nominal as opposed to real terms, which is incorrect for UK water companies and leads to an understatement of the TMR by PwC. In backing out the implied expected cost of equity and TMR, PwC also implicitly assumes zero real growth in RCV, which results in an understatement of the implied TMR given expected positive real growth in the RCV for water companies.

233 PwC (November 2017), Estimating the cost of capital for H7: A report prepared for the Civil Aviation Authority (CAA), para 5.38-5.43

234 Credit Suisse Global Investment Returns Yearbook 2017, p37

illustrative, rather than an objective adjustment based on evidence of historical good fortune. In the absence of any firm evidence that historical growth in dividends may be due to good fortune (equally, they may be understated by "bad fortune"), we do not consider an adjustment to historical realised returns is appropriate.

Overall, we conclude that PwC's errors in its DGM and MAR analysis result in a substantial understatement of the TMR under PwC's current (forward-looking) approaches, and conclude the only reliable approach is to draw on independent estimates by the Bank of England which support TMR of 7.2 to 8.1 per cent (real, RPI-deflated). We also conclude that PwC's downward adjustments to long-run average historical returns are not reasonable, and that the historical evidence supports a TMR range of 6.5 to 7.1 per cent (real RPI), as we discuss in Section 2.3.1.

# Appendix F. Updating CMA NIE 2014 evidence

In its NIE 2014 price control determination, the CMA considered three types of evidence for estimating the TMR:[235]

- studies that assume that historical realised returns are equal to investors' expectations (so-called "historical ex post" approaches);
- studies that fit models of stock returns to historical data to separate out ex-ante expectations from ex-post good or bad fortune (so-called "historical ex ante approaches");
- studies that use current market prices and surveys of market participants to derive current forward-looking expectations (so-called "forward-looking approaches").

The CMA noted that it used historical approaches (both ex-ante and ex-post) as its primary sources for estimating the equity market return, with forward-looking approaches being used as a cross-check.[236]

**Historical ex-post approaches**

The CMA used the DMS and Barclays capital databases as the basis for its long-run historical estimate. Drawing on a number of different measures differentiated by holding period and averaging technique (as discussed in section 2.3), the CMA concluded a TMR of around 6 to 7 per cent (real RPI) for UK and world markets in 2014.[237]

Our replication of the CMA's NIE calculations using DMS data up to 2017, as shown in Table 2.2, shows that the long-run historical averages have increased slightly relative to the 2014 NIE decision, with updated estimates in a range between 6.2 and 7.1 per cent (real RPI).

**Historical ex-ante approaches**

The CMA noted that an alternative approach to estimating expected returns from historical data can be made under the assumption that the dividend-price ratio is stationary, referred to as the Fama and French underlying return.[238] Under this assumption, the expected return can be estimated as the sum of the average dividend yield and the average annual dividend growth rate. Drawing on Barclay's data set up to 2009, the CMA estimated an expected market return of 4.5 to 5.5 per cent. The top end of the range was based on the CMA's application of the Fama French estimate to the historical data from Barclay's, while the bottom end of the range reflected a downward adjustment to the historical data to account for the fact that current dividend yields were about 1 per cent below historical averages.[239]

The CMA also acknowledged that the application of the Fama French approach may lead to an understatement of the expected market return due to dividend growth being less volatile

[235] CMA (March 2014), NIE Limited price determination, para, p.13-26, para 13.137.

[236] CMA (March 2014), NIE Limited price determination, para, p.13-26, para 13.137.

[237] CMA (March 2014), NIE Limited price determination, p.13-27, para 13.141.

[238] Estimated based on the approach developed in Fama and French (April 2002), The Equity Premium, the Journal of Finance, Vol. 57, No. 2, pp. 637-659.

[239] CMA (March 2014), NIE Limited price determination, p.13-27, para 13.143-13.144

than equity price index growth, with the understatement being equal to half the variance of the two growth rates (as suggested by Fama and French).[240] Applying the CMA's estimate of this understatement of around 75 bps results in a market return estimate between 5.25 and 6.25 per cent.

We have updated the CMA's calculations of the Fama French underlying return for the UK market based on the updated Barclay's data set up to 2015 and found that the estimate remains broadly unchanged relative to NIE 2014.[241]

The CMA also cited the DMS estimate of the expected market return for the world index. The DMS decomposes the historical returns into four elements: i) dividend yield (the dominant effect), ii) dividend growth rate, iii) the annual expansion in the price/dividend ratio, and iv) real exchange rate changes. The DMS then determines an expected market return based on consideration of which elements correspond to investor expectations, and elements of non-repeatable good or bad luck. Drawing on DMS forecasts, the CMA cited a value of 5.5 to 6 per cent for the world index.[242]

Our review of the most recent DMS forecast indicates that the forecast has not changed relative to NIE 2014.[243]

**Forward-looking approaches**

Finally, the CMA considered evidence from the Bank of England's DGM which it concluded supported a market return of between 5 and 6 per cent.[244]

As we set out in section 2.3.2, current estimates of the market return from the Bank of England's DGM are between 7.1 and 8.2 per cent (with the range based on a spot and 5-year average of monthly DGM estimates ending December 2016).[245]

Table F.1 below summarises the CMA's estimates of the total market return for the different approaches considered in the NIE decision, and our updated estimates drawing on latest evidence, as discussed above.

[240] CMA (March 2014), NIE Limited price determination, pp. A13(2)3-A13(2)4, para 8.

[241] Based on Barclay's (March 2016), Equity Gilt Study 2016, we calculate an updated estimate of the Fama French underlying return of 6.27 per cent, using data up to 2015 (based on 4.5 per cent historical dividend yield, 1.1 per cent historical dividend growth and 70bps historical volatility adjustment).

[242] CMA (March 2014), NIE Limited price determination, para 13.145

[243] DMS (20178), Credit Suisse Global Investment Returns Yearbook 2018., p. 36. DMS (2018) cites an arithmetic risk premium of 5 per cent relative to bills, and reports a historical bill return of around 0.81 per cent, supporting a forward-looking TMR of around 6 per cent.

[244] CMA (March 2014), NIE Limited price determination, p.13-31, para 13.155.

[245] We note that the Bank of England changed its methodology in applying the DGM in 2017, compared to the approach used in the 2013 study cited by the CMA in the NIE (2014) decision.

**Table F.1: Updating studies used by CMA at NIE 2014 does not support a reduction in the TMR**

| | CMA NIE 2014 evidence | Latest evidence |
|---|---|---|
| DMS long run *(historical ex post)* | 6 – 7 % | 6.2 – 7.1% |
| DMS decomposition *(historical ex ante)* | 5.5 – 6 % | 6 % |
| Fama-French *(historical ex ante)* | 5.25 – 6.25 % | 5.27 – 6.27 % |
| Bank of England DDM *(forward looking)* | 5 – 6% | 7.1 – 8.2 % |

*Sources: NERA analysis of CMA (March 2014) Northern Ireland Electricity price determination. section 13; DMS (February 2018), Credit Suisse Global Investment Returns Yearbook 2018; Barclay's (March 2016), Equity Gilt Study 2016; Bank of England (2017), An improved model for understanding equity prices, Quarterly Bulletin 2017Q2(4) and Bank of England yield curves.*

As can be seen from Table F.1 above, the latest evidence on the TMR based on the different methods considered by the CMA in the 2014 NIE determination does not support a reduction in the TMR.

# Appendix G. Review of CEPA evidence on Asset Beta

In this appendix, we assess CEPA's approach to estimating the asset beta for RIIO-T2. CEPA estimates an asset beta range of 0.25 to 0.40 for energy networks at RIIO-2, where it believes the top end of the range is more appropriate for certain sectors or companies with large investment programmes relative to the size of the asset base.[246] CEPA's estimates are based on the empirical asset beta estimates for four UK listed utilities, including three listed water and sewerage companies.

We have evaluated CEPA's method for estimating the asset beta below, in particular considering whether it is appropriate to use all four UK listed utilities to estimate the asset beta for RIIO-T2. Overall, we show that CEPA's recommended range of 0.25 to 0.4 is far lower than empirical estimates for NG's UK assets, which is around 0.44 to 0.53.

## G.1. CEPA uses outdated empirical evidence to estimate the asset beta for RIIO-T2

CEPA presents analysis of the asset beta over time for National Grid, Pennon Group, Severn Trent and United Utilities, which it identifies as the four principal UK listed utilities. CEPA considers a range of different beta estimation approaches, but its final asset beta range of 0.25 to 0.40 appears to be derived from 2-year daily estimates, presented below.

**Figure G.1: CEPA Estimates of Asset Betas for UK Listed Utilities**


*Source: CEPA (February 2018), Review of cost of capital ranges for Ofgem's RIIO-2 for onshore networks*

[246] CEPA (February 2018), Review of cost of capital ranges for Ofgem's RIIO-2 for onshore networks, p.54.

Figure G.1 shows that CEPA's asset beta range of 0.25 to 0.40 is clearly not based on the latest market evidence. As shown in the chart, the asset beta was in the range 0.30 to 0.36 at the end of 2017, well above CEPA's proposed lower bound of 0.25. It appears that CEPA's lower bound places weight on asset beta estimates from the period 2011 to 2014, when asset betas for the four listed utilities were depressed relative to the more recent trend.

We see no merit in using asset beta estimates from 2011 to 2014 to estimate the asset beta for RIIO-T2. These asset betas reflect the market's perception of risk facing the companies at that point in time. In the aftermath of the global financial crisis, the betas for regulated utilities declined as investors became more risk-averse and reallocated their portfolios towards less risky assets. As a result of the 'flight to quality', the asset betas declined.

However, the decline in asset betas at RIIO-T1 has now reversed. For example, our decomposition of NG's asset beta into its constituent elements, and the correlation with the market portfolio and relative volatility, show an increase in both elements since RIIO-T1 supporting higher values at RIIO-T2 (see Figure 3.2).

All macroeconomic forecasting agencies foresee sustained economic growth over the next five years,[247] and therefore we see no reason to estimate the beta for RIIO-T2 based on market conditions that are highly unlikely to prevail during the period.

In conclusion, we do not consider that any weight should be placed on the asset betas from the period 2011 to 2014 as CEPA does, because the estimates from this period are depressed by the temporary flight to quality phenomenon which has since reversed.

Finally, we note that CEPA focuses on a relatively narrow UK set, and ignores potential European comparator energy networks.[248]

## G.2. Our estimates support a beta of 0.3 to 0,4, with NG in upper-end

Table 3.2 shows the latest empirical asset betas for UK networks including SSE, using the CMA approach, although our preferred approach is using the 2 year daily betas. This evidence shows that in the most part the asset beta estimates lie in the range of 0.3 to 0.4, with the exception of SSE's beta which is higher (except in the daily 2 year window as of our cut-off date), reflecting its significant share of generation and supply activities, which are more risky. National Grid's asset beta is at the top-end of the range, excluding SSE. [249]

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[247] None of the forecasting agencies in HM Treasury consensus forecasts are currently forecasting a recession in the next five years.

[248] For example, potentially comparable networks include: EDP-Energias de Portugal (Portugal), Red Electrica (Spain), TERNA (Italy), ACEA (Italy), Gas Natural SDG (Spain), SNAM (Italy), and Enagas (Spain). Oxera presents evidence for European energy networks in its report for ENA concluding a range of 0.38 to 0.42 (0.05 debt beta) or 0.36 to 0.40 (zero debt beta). See: Oxera (2018) Cost of capital at RIIO-2, p.44. Link: http://www.energynetworks.org/assets/files/info/Oxera%20research%20on%20the%20cost%20of%20equity_2018-02-28.pdf

[249] Our estimates are also in line with Oxera's recent range proposed in its Report for ENA. Oxera estimate asset betas for both UK and European utility comparators, and concluded that 0.38 to 0.42 is an "appropriate assumption" for RIIO-2 based on the empirical betas of the same sample of UK and European network comparators. Oxera's range reflects a debt beta assumption of 0.05. Assuming a debt beta of zero, in line with our approach, Oxera's range would be 0.36 to 0.40. See Oxera (28 February 2018), The cost of equity for RIIO-2 - Prepared for Energy Networks Association, p.42-48. We use the Miller formula to solve for the implied asset beta: $\beta_{assets}=\beta_{equity}*(1-gearing)+\beta_{debt}*gearing$.

We now evaluate whether it is appropriate to place equal weight on all the UK listed utilities, including the UK water companies, given differences between the risks faced by UK water and energy networks.

## G.3. CEPA does not capture differences in relative risk between UK water and energy networks

CEPA argues the "*the energy sector is broadly comparable in (systematic) risk profile to the water sector*".[250] CEPA recognises there may be some differences in the regulatory regime, but believes that these differences will only affect the beta point estimate rather than the range itself.

CEPA asserts that energy networks face less risk relative to water companies from the treatment of pensions under their respective regulatory frameworks. UK water companies were able to recover 50 per cent of deficits as at PR09[251], whereas energy networks can recover the established deficit as at 2013 with triennial revaluation to allow for changes in the value of the deficit, but face risk on post-establishment deficits.[252] This difference in the treatment of pension deficit recovery suggests energy networks face less risk relative to UK water networks on this particular factor.

However, CEPA does not undertake a systematic relative risk analysis. Focusing on the difference in treatment of pension deficit recovery does not alone justify CEPA's suggestion that UK energy networks may be less risky than water companies.

We have undertaken comparison of risks across a range of factors as set out in Table G.1 below.

[250] CEPA (February 2018), Review of cost of capital ranges for Ofgem's RIIO-2 for onshore networks, p.54.

[251] At PR09, Ofwat determined the price control allowance for pension deficit repair costs associated with companies defined benefit pension schemes assuming a 10- to 15-year deficit repair period starting in 2009 or 2010. Ofwat allowed companies to recover about 50 per cent of pension deficit repair costs from customers from PR09, with the rest dealt with by management action or shareholder contributions. Source: Ofwat (October 2013), IN 13/17: Treatment of companies' pension deficit repair costs at the 2014 price review. Link: https://0980a19b0bb02fe4a86d-0df48efcb31bcf2ed0366d316cab9ab8.ssl.cf3.rackcdn.com/wp-content/uploads/2015/11/prs_in1317pr14pension.pdf

[252] Ofgem (17 December 2012), RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas - Finance Supporting Document, Appendix 5.

## Table G.1: Relative risk assessment shows energy networks face different risks relative to other sectors

| | SPTL (T1) | Gas Distribution | Electricity Distribution | Water | Heathrow | NATS (air traffic control) |
|---|---|---|---|---|---|---|
| **Form / length of control** | • Revenue-cap<br>• 8-years | • Revenue-cap<br>• 8-years | • Revenue-cap<br>• 8-years | • Revenue-cap<br>• 5-years | • Price-cap<br>• 5-years | • Part revenue part price-cap<br>• 5-years |
| **Setting cost allowances** | • Expert review of totex<br>• DB pension deficit recovery over 15yrs with 3Y re-valuation (but risk on post-2012 liabilities)<br>• Re-openers for some costs | • Comparative benchmarking of totex (UQ efficiency)<br>• DB pension deficit recovery over 15yrs with 3Y re-valuation (but risk on post-2012 liabilities)<br>• Re-openers for some costs | • Comparative benchmarking of totex (UQ efficiency)<br>• DB pension deficit recovery over 15yrs with 3Y re-valuation (but risk on post-2012 liabilities)<br>• Re-openers for some costs | • Comparative benchmarking of totex (UQ efficiency)<br>• 50% sharing of pension deficit repair costs with customers | • Opex based on benchmarking & capex agreed with airlines<br>• Pass-through of pension deficit costs | • Opex based on benchmarking & capex agreed with airlines<br>• DB pension deficit allowance and 80% pass through of savings / overspend within period |
| **Outturn cost risk & incentives** | • TIM<br>• Uncertainty/pass-through of non-controllables<br>• Disapplication of price control | • TIM<br>• Uncertainty/pass-through of non-controllables<br>• Disapplication of price control | • TIM<br>• Uncertainty/pass-through of non-controllables<br>• Disapplication of price control | • Totex sharing<br>• Pass-through of non-controllables<br>• IDoK/SAE clause | • Full risk on opex and pass-through of efficient actual capex (s.t. delay penalties) | • 5-year opex roller and pass-through of efficient capex |
| **- Capex/opening RAB** | • 15% (T1)/ 7% (T2) | • 6% | • 11% | • 6-8% (WaSC-WOC) | • 4% | • 10% |
| **- Totex/opening RAB** | • 17% (T1) | • 13% | • 15% | • 13-22% (WaSC-WOC) | • 11% | • N/a |
| **- Totex sharing factor** | • 50% (T1) | • 62-64% | • 53-58(70)% | • 50-57% | • 100% opex, 0% capex | • 5-year opex roller, 0% capex |
| **Financing cost risk** | • COD update = 10Y trailing average iBoxx | • COD update = 10Y trailing average iBoxx | • COD update = 10-20Y trailing average iBoxx | • Fixed at weighted average of industry embedded and new forecast COD | • Fixed at weighted average of HAL embedded and new forecast COD | Fixed at weighted average of NERL embedded and new forecast COD |
| **Quality of Service/Output incentives** | • Performance incentives : +0.9/-1.4% of RORE | • Performance incentives : +1.3/-0.7% of RORE | • Performance incentives : +2.2/-2..8% of RORE | • Performance incentives (SIM,ODI): +0.8/-2.1% of RORE | • Service quality: asymmetric -7% penalty.+2% reward of airport charges | • Delays: +/-1% revenue |
| **Stranding/ competition / regulatory risk** | • Uncertainty over future role and operation of system from distributed generation | • Uncertainty over future gas flows (domestic heat decarbonisation) | | • Competition in NHH retail; future competition for water/ bioresources | • Competition from other London/UK and European hub airports | • No competition in immediate future |

*Source: Bloomberg, NERA analysis.*

At a high level, the regulatory regimes in energy and water are closely aligned, but there are some differences in the respective regimes that would lead to different exposures to systematic risk. UK energy networks may face greater risk from the longer regulatory review period of eight years compared to five years in the water sector, as it can increase in-period volatility in returns. However, such forecasting risk is mitigated (at least in part, if not wholly) by uncertainty mechanisms, reopeners and the mid-point review.[253] UK energy networks may also face greater risk relative to the water sector from the cost of debt indexation mechanism which increases the pro-cyclicality of returns relative to a fixed ex ante allowance.[254,255]

By contrast, UK energy networks bear somewhat lower risk than companies in the aviation sector (HAL and NATS). Whereas energy companies have higher incentives with regard to cost and output, aviation companies are exposed to material within-period volume and competition risks, given their price cap regimes.

In addition to differences in the regulatory framework, our comparative analysis suggests that investors in UK energy networks face higher risk than investors in water networks given the greater capex size (as measured by capex/RAB), and greater exposure to asset stranding risks due to government's decarbonisation plans and uncertainty over the future role of energy networks.

In summary, we consider that CEPA's beta estimates based on historical data, and during the period of the financial crisis, understate the risks faced by investors today. Our empirical analysis provides for a range of around 0.3 to 0.4; NG's asset beta is towards the top-end of the range potentially reflecting investors' perceptions of higher risk for energy networks relative to water networks

## G.4. CEPA does not consider how National Grid's US operations affects its beta estimate

CEPA includes National Grid in its group of comparators to estimate the asset beta for RIIO-T2, but notes that it is not a pure play comparator because only 36 per cent of its operating profit in 2017 was derived from UK regulated network businesses. CEPA makes no attempt to adjust National Grid's asset beta for the differences in risk in its underlying business segments. We have considered how National Grid's non-UK regulated businesses affect its asset beta.

[253] We note that there may some other benefits of a longer regulatory period including lower regulatory burden and better alignment between investment and the price control period.

[254] However, we note that Ofgem and its advisers did not accept that the cost of debt indexation method increased the procyclicality of returns. See for example, FTI (2012) A report for Ofgem (2012) Cost of capital study for the RIIO-T1 and GD1 price controls, p.96. Link: https://www.ofgem.gov.uk/ofgem-publications/53728/riio-t1-cost-capital-study-riio-t1-and-gd1.pdf.

[255] Any changes that would create greater convergence in the regulatory regimes in the future, such as Ofwat's intention to introduce a cost of debt indexation mechanism, would increase the appropriateness of UK water companies as comparators for RIIO-2.

In 2017/18, National Grid's UK non-regulated activities accounted for 5 per cent of the group's revenues and about 6 per cent of the group's fixed assets.[256] US regulated operations accounted for 41 per cent of the group's combined regulated asset base.[257] In order to estimate the asset beta of National Grid's UK regulated business, we have decomposed its overall asset beta into a UK asset beta and a US asset beta.

In the US, National Grid's operations are subject to various regulatory regimes, depending on the state in which they operate and the business activity in question. The majority of these businesses are subject to incentive regulation (about 90 per cent of regulated assets), albeit a lower-powered incentive regime than the UK. However, around 8 per cent of assets are subject to rate of return regulation, which exposes the company to less risk in terms of potential over or underperformance. In addition, National Grid Generation, which comprises around 2 per cent of the business' regulated assets, operates under a long-term power supply agreement with the Long Island Power Authority, with very low systematic risk.[258]

### G.4.1. US regulatory regimes are lower risk than UK

Although National Grid's US businesses that are regulated under incentive based regimes are subject to revenue caps similar to the UK regulated business, i.e. do not bear material demand or revenue risk, there are some key differences that mean the US incentive based regimes are less risky than RIIO-T2:

- National Grid's US businesses are regulated under shorter regulatory periods (mostly 3-4 years, except gas businesses in Massachusetts which account for only 11 per cent of regulated assets) which reduces the within-period volatility of returns with more frequent updating of revenues in line with costs;[259]
- Greater objectivity in setting allowed costs: in most cases, cost allowances are set based on outturn costs for a base year and projected forwarded, without explicit efficiency factors that reduce allowances over time. Some are also based on historical costs (especially in Massachusetts). The prudency standard for permissible costs sets a high evidentiary bar for the disallowance of incurred costs. By contrast, RIIO draws on more subjective comparative efficiency analysis and technical review of costs;
- US regimes provide a true-up for pension and other post-employment liabilities, whereas National Grid bears the risk on its post-2012 liabilities in the UK;
- US companies generally have less stringent output and quality of service incentives (they focus mainly on reducing and preventing gas leakage and some efficiency incentives);

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256 These activities included National Grid Ventures, UK property development and insurance and corporate activities in the UK and US. See National Grid Annual Report 2017/18, p.108-110.

257 National Grid (17 May 2018), 2017/18 Full Year Results, p.13-15. This calculation only takes into account NG's remaining 39% stake in its former gas distribution business, whose regulated asset base can be found on Cadent Annual Report 2017/2018, p.1

258 See National Grid US Databook for 2017/18, p.7.

259 We note that the risks associated with a longer regulatory period can be in part mitigated by uncertainty mechanisms, reopeners and the mid-point review. Moreover there are other benefits associated with a longer price review, including lower regulatory burden and better alignment between investment and the price control period.

- The US regimes incorporate greater use of cost pass-through or true-ups, e.g. for commodity prices, commodity related bad debt, some mandated capex, and environmental remediation costs. By contrast, the true-ups or pass-through provisions for National Grid are more limited, e.g. relating to security, network development, infrastructure enhancement, strategic wider works, and some environmental costs.[260]

Overall, US regulatory regimes are determined with reference to case law which has been tested in the courts. The nature of the proceedings offers greater investor security relative to the more subjective approach, and weaker appeals mechanisms, associated with GB price controls. For example, the rate cases have enshrined principles in relation to the protection of property rights, and notions of prudency standards in relation to permissible costs.[261]

### G.4.2. Empirical asset beta evidence for US networks are lower than for NG Group

In order to obtain a measure of the systematic riskiness of National Grid's UK regulated business, we decompose its group asset beta into a UK and US asset beta, based on the equation below.

$$\beta_{National\ Grid} = \frac{Regulated\ assets\ in\ UK}{Total\ regulated\ assets} * \beta_{UK} + \frac{Regulated\ assets\ in\ US}{Total\ regulated\ assets} * \beta_{US}$$

$$\beta_{National\ Grid} = 59\% * \beta_{UK} + 41\% * \beta_{US}$$

In order to estimate the beta associated with National Grid's US regulated businesses ($\beta_{US}$), we have identified a preliminary sample of 20 network comparators in the US.[262] We selected these comparators based on networks operating exclusively in the US, and principally engaged in regulated energy network, retail, or generation activities, as well as ensuring that the stocks met standard liquidity thresholds.[263]

Of this initial set of comparators, 3 comparators operate in the same states, and hence similar regulatory regimes, as National Grid. In particular, Consolidated Edison operates in New York (where National Grid USA has about 56 per cent of its regulated assets), and Unitil Corp and Eversource Energy have significant operations in Massachusetts, New Hampshire (and Maine), where about 30 per cent of National Grid USA's regulated assets are located.

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260 Ofgem (2012), RIIO-T1: Final proposals for National Grid Electricity Transmission and National Grid Gas – Finance support document, p.89, 90.

261 The regulation of utilities in North America faces a special kind of constraint that most other nations do not exhibit. Particularly in the United States, major regulatory statutes do not become settled methods of government control over private businesses until they are tested in the courts. There are established principles in relation to property rights, and prudency standards. See for example: NERA (2015) Half a century of estimating the cost of capital, Link: http://www.nera.com/content/dam/nera/publications/2015/PUB_Cost_of_Capital_1115.pdf

262 Bloomberg, CEG (2013), Information on equity beta from US companies.

263 We look at bid-ask spreads as a proxy for the liquidity of the listing. We consider stocks with bid-ask spreads above 1 per cent to meet liquidity threshold, based on UK and European regulatory approaches. See for example, NERA (2016) Update of the Equity Beta and Asset Beta for BT, A report for Ofcom. Section A4, pp 58-59. Link: https://www.ofcom.org.uk/__data/assets/pdf_file/0028/97039/annex_31.pdf

We show the estimates from both sets of comparators in Table 3.3 and Table 3.4 in the main report.

### G.4.3. We derive a higher NG UK asset beta of between 0.46 and 0.57

Using the average asset beta of these three comparators as a proxy of the systematic riskiness of National Grid's operations in the US, and drawing on the equation above, we calculate an implied UK asset beta of 0.57 based on a two-year estimation window, and 0.49 based on a five-year estimation window (see Table 3.3). Our estimate is considerably higher than both the composite National Grid asset beta of 0.39 (two –year beta) and the empirical betas of UK water companies and SSE (see Table 3.2). Our estimates are also significantly higher than CEPA's estimated asset beta range of 0.25 to 0.40 for RIIO-T2.

To check the sensitivity of our results to the three main comparators, we also present asset betas for the full sample of 20 comparators (see Table 3.4). We obtain very similar results for the two-year betas, which are in the range of 0.06 to 0.31, with an average of 0.16. This average is considerably lower than National Grid's two-year asset beta of 0.39.

Using the full sample, we obtain an implied asset betas for National Grid's UK operations of 0.55 (2Y) and 0.46 (5Y), only marginally lower than the betas we obtained using the most relevant comparators only.

This evidence supports the conclusion from our relative risk assessment: the asset beta for UK energy networks at RIIO-T2 should lie above the overall National Grid asset beta, with an implied value of between 0.46 to 0.57 based on decomposing the National Grid composite beta into UK and US operations.

CEPA does not present any such analysis in evaluating the asset beta for National Grid, and as a result, we consider its approach of simply taking the National Grid group beta understates the true systematic risk faced by UK energy networks.

## G.5. Conclusions on CEPA's asset beta

CEPA's asset beta range of 0.25 to 0.40 is clearly not based on the latest market evidence, and instead draws on evidence when betas were depressed during the financial crisis. In interpreting the evidence for RIIO-T2, CEPA also fails to rely on NG, which is the most obvious comparator for energy networks, and fails to decompose NG's group asset beta into the beta associated with higher risk UK versus lower risk US operations. Undertaking this decomposition we identify a beta range for NG, and therefore RIIO-T2, of between 0.46 and 0.57, far higher than CEPA's range.

# Appendix H. Review of Indepen Evidence on Beta

In this appendix we review and comment on Indepen's proposals to Ofgem for the estimation of betas for RIIO-2. The Indepen report reviews a number of issues in the estimation of betas for setting an allowed cost of equity, and provides recommendations on its preferred approach.

The Indepen report makes the following recommendations which we broadly agree with:

- **Use of high frequency data**: Indepen argues that when choosing the data frequency, there is a trade-off between obtaining more data points (and making inference possible) and the noise introduced from the use of more data (breaching OLS's statistical assumptions).[264] Its recommendation is to use higher frequency data (daily or weekly returns) over longer windows and its recommended beta range is informed by estimates using daily data.[265]
- **Existence of structural breaks**: Indepen acknowledges the existence of structural breaks in the data (presenting its beta estimates for three windows: 2000 to 2018, 2008 to 2018 and 2013 to 2018) and recommends the use of the period since the most recent structural break as the estimation window (which implies the use of a five-year estimation window).[266]
- **Other measures of beta**: Indepen considers two additional measures of beta: accounting beta (regressing beta of listed stocks on various accounting measures) and use of returns on debt as an indicator of the market's view on the company's riskiness. However, Indepen concludes that the methods are either unreliable (in the case of the accounting beta) or not viable (in the case of the return on debt).[267]
- **Ordinary Least Squares (OLS) as the estimation model**: While Indepen presents its recommended beta range taking into account Generalised Autoregressive Conditional Heteroscedasticity (GARCH), OLS and Least Absolute Deviation (LAD) models, it recognises that the results are not widely divergent and OLS can continue to be used as the estimation model, provided that the time window and appropriate corrections to standard errors are considered.[268]

In the following sections of this appendix, we present our view on the other Indepen recommendations where we have concerns.

## H.1. Beta decomposition

As pointed out in Section 3.3.3, Indepen acknowledges that a case can be made for a beta decomposition of National Grid, but raises three conceptual questions that it argues need to be addressed before drawing on decomposition data:

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264 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 2, p.8.

265 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 2 and Section 5, pp.18, 19 and 45.

266 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 2 and Section 5, pp.6,7 and 45.

267 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 3, pp.20 to 24.

268 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Executive Summary and Section 5, pp. xi, 45 and 46.

a. Should it [the decomposition] be applied to equity or asset betas?

b. If applied to asset betas, should a group average, group actual or industry specific gearing be used?

c. Are net assets the right way of measuring the weights?[269]

We argue in Appendix G.4 that the relative risk of US networks is lower than that of UK networks. This view is further backed in the empirical beta estimates for US comparators, which are lower than those of National Grid, as presented in Table 3.3and Table 3.4.

Given this evidence, we now address the conceptual questions raised by Indepen, relying on finance theory and presenting regulatory precedent as a cross-check.

### H.1.1. Beta decomposition is established in finance theory and UK regulation

Beta decomposition is a practice that is widely applied in finance literature, commonly used in the "bottom-up beta" approach. This approach calculates the beta of a company by calculating individual betas for each business segment based on specific industry comparators. The comparator equity betas are de-leveraged using their actual gearing to obtain comparable asset betas, which are then used to estimate an asset beta for each segment of the company. Given that a portfolio beta is the weighted average beta of the securities in the portfolio,[270] we can calculate a company asset beta by taking a weighted average of the specific business segments asset betas. These weights should be reflective of the proportion of firm value derived from each business segment. Equation 1 shows the formula for this composite asset beta:

(1) $Composite\ Asset\ Beta = \sum_{i=1}^{N} W_i \times Asset\ \beta_i$

where N = total number of business segments and W = weight given to each business segment

Finally, the weighted average asset beta (composite asset beta) is re-leveraged at the current gearing of the company or a forward-looking measure.[271]

Note that the property relating to the weighted average beta of securities in a portfolio being the portfolio beta is usually considered in the context of the estimation of equity betas, i.e. the equity beta of a portfolio is the weighted average equity beta of the securities in the portfolio. Nonetheless, it is commonly accepted that the asset beta is linear in the equity and debt betas,[272] which means the property can also be applied to asset betas, as described in the approach above. While Indepen casts doubt on this linear relationship,[273] we do not consider that there is enough evidence to move away from what has been used in regulatory and academic evidence.

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269 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 4, pp.36 to 39.

270 See for example Berk, J. and DeMarzo, P. (2014), Corporate Finance, Third Edition, Chapter 11, p.385.

271 See for example Damodaran, A (2012), Investment Valuation: tools and techniques for determining the value of any asset, Chapter 8, p.197.

272 See for example Berk, J. and DeMarzo, P. (2014), Corporate Finance, Third Edition, Chapter 12, p.416.

273 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 4, pp.29 and 30.

The approach set out above, commonly used in finance literature, provides the answers to Indepen's questions set out in the previous section.

First, the decomposition should be applied to asset betas. This is because if we are drawing on comparator firms to inform elements of a business risk (for example, drawing on comparable US networks to decompose National Grid's beta), we must compare these elements on a common financial leverage. By using equity betas, we would be distorting the estimated betas by including the riskiness derived from financing decisions, i.e. a firm that has a higher leverage could be perceived as riskier and this would affect the estimated beta. This is what Indepen does when presenting an equity beta for a business segment by relying on comparators' equity betas without adjusting for financing effects.[274] The use of an asset beta removes these effects and is a sensible way to compare the pure business risk of different comparators.

On the question of which gearing level to use, there are implicitly two questions: the gearing level to use when de-leveraging equity betas and the gearing level to use when re-leveraging the asset betas. Indepen uses the same gearing level for both and presents three alternatives to calculate the gearing: actual gearing of the group, actual gearing of each business segment and industry gearing of each business segment. As it pertains to the gearing used to de-leverage equity betas, finance theory is clear: this should be the actual gearing of each comparator, as this removes the specific effects of financing included in the equity beta of each company.

Finance theory does not provide a clear indication on the gearing to use to re-leverage the asset betas. In theory, our view is that in a regulated context it seems correct to use a measure of the future gearing level of the company over the relevant regulatory period. In a regulatory context, this expected level could be proxied by a notional gearing level, which is the assumed level of gearing an efficiently financed company would choose. If we assume that in the long-term, a company trends towards this level (because otherwise it would not be efficient and would have sustainability concerns), then the use of a notional gearing level (proxied by D/RAB) would be consistent with finance theory.

Finally, regarding the weights used, these should reflect the value of each business segment, typically assumed to be the present value of future cash flows. In the case of regulated firms, such as National Grid, this present value is already calculated in the form of the RAB. Thus, our preferred approach of using the proportion of regulated assets, set out in our previous report, is supported by financial theory.

We note that option of decomposing a company's beta to account for the different business lines' exposure to systematic risk is not without precedent in the UK. For example, Ofcom and the then Competition Commission, now Competition and Markets Authority have applied asset beta decompositions in their determinations.[275] In both cases, the approach is consistent with our recommendation: Decomposition is applied to asset betas; actual gearing

[274] Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 4, pp.36.

[275] Ofcom (28 03 2018): Wholesale Local Access Market Review: Statement, Annexes 17-27, pp.76 and 115-136.; Competition Commission (28 September 2007), BAA Ltd, A report on the economic regulation of the London airport companies (Heathrow Airport Ltd and Gatwick Airport Ltd), Appendix F, pp.F-7, F-8 and F-28 to F-31.

is used to de-leverage equity betas and notional gearing is used to re-leverage asset betas and weights are based on measures of the firms' value.

### H.1.2. Indepen's beta decomposition example is flawed but supports a higher asset beta for National Grid's UK operations

As mentioned in the previous sections, Indepen agrees in principle that National Grid's beta could be decomposed to account for the differences in risk of its US and UK businesses. Furthermore, Indepen provides an illustrative example, calculating betas for the UK and US businesses to show the impact that different gearing assumptions can have.

We understand that in calculating the beta for National Grid's UK operations, Indepen assumes fixed equity betas for National Grid as whole and for National Grid's US operations. It then de-leverages these betas using specific gearing measures for each segment, but it is not clear to us how these gearing values are calculated. Indepen then calculates the UK asset betas through an asset beta decomposition using the formula below, where the weights are based on RAB values.

(2) $\beta_{National\ Grid} = W_{UK} * \beta_{UK} + W_{US} * \beta_{US}$

Finally, Indepen then re-leverages the UK asset beta using a measure of gearing, whose derivation is unclear to us.

In our view, Indepen's approach is flawed based on the finance theory presented above. Indepen assumes that the equity betas obtained from US comparators can be used directly to inform National Grid's US equity beta. This is not correct because, as explained above, directly estimated equity betas are influenced by each comparator's financing decisions (i.e. the chosen D/E structure) and does not simply reflect the business risk. When performing a beta decomposition, the comparator's betas are used to inform the risk of a specific segment, regardless of the financing decisions and thus it is sensible to use comparators' betas de-leveraged using the company's own financial structure. By using equity betas, Indepen is likely to introduce a bias into the asset beta estimation if the comparators' financial structures are not adjusted.

Despite the flawed methodology, Indepen arrives at an asset beta for National Grid's UK operations which is higher than the beta for National Grid as a whole. This is supported by our relative risk analysis summarised in Appendix G.4, where we conclude that the UK operations were likely to face a higher systematic risk than US operations. Moreover, the UK asset beta value Indepen estimates using data from the last two years, 0.44, is not far from the asset beta we estimated, which ranges from 0.40 to 0.45 (presented in Section 3.6). Indepen, despite having a flawed methodology for decomposing the beta, should have used this evidence in informing its recommended beta range, by considering a higher beta for National Grid to reflect the higher risk of its UK operations compared to the US operations.

### H.1.3. Conclusion on beta decomposition

In summary, in our view, there is enough support behind the assumptions required by Indepen to justify the use of the National Grid's beta decomposition in the estimation of betas for RIIO-2. As discussed above, there is support in finance theory to decompose the asset beta of a company as method of differentiating the risks faced by different business segments of the same company. The evidence from finance theory allows us to answer Indepen's three conceptual questions. First, the decomposition should be done using asset betas because

these are the correct measures of a segment's business risk, without introducing financing decisions into the beta. Second, the gearing used for de-leveraging the comparators' equity betas should reflect the actual gearing of the comparators', while the gearing used for re-leveraging the estimated asset beta should be a notional gearing level. Finally, the weights used should be based on the present value of future cash-flows, which, in our view, can be proxied by the proportion of regulated assets out of total regulated assets. We also show that there is a regulatory precedent in the UK for decomposing asset betas, which is consistent with the presented finance theory.

While Indepen acknowledges the case for decomposing the beta of National Grid, it presents a flawed methodology for doing so, as it relies on directly estimated equity betas of US comparators to inform the equity beta of National Grid's US operations, which then introduces a capital structure bias in the asset beta estimated for this segment. However, the finding that National Grid's UK operations command a higher beta than the US operations is consistent with our relative risk analysis. Moreover, the estimated value, 0.44, is consistent with our estimates for National Grid's UK beta, ranging from 0.40 to 0.45, as mentioned in Section 3.6. Thus, in our view, Indepen should have included this evidence in informing their recommended beta range.

## H.2. The inconsistency in leveraging/de-leveraging betas

In Section 3.2.2, we had mentioned that Indepen, while only estimating raw equity betas, believes there is an inconsistency in the leveraging process followed by regulators, and that notional gearing should be adjusted according to the formula D/(RAB*MAR). We also pointed out that Ofgem's approach is inconsistent with both this recommendation and finance theory. We address our concerns with both approaches below.

### H.2.1. Indepen provide no reason for not estimating re-leveraged equity betas

Indepen provides a recommended equity beta range, not de-leveraging and re-leveraging equity betas as they consider that core comparators have gearing levels sufficiently close to the notional gearing assumption. Indepen considers that due to this, the leveraging impact would be small and would not justify the numerous assumptions required. However, Indepen does recommends that regulators continue estimating re-leveraged equity betas but provided they investigate issues surrounding debt betas and gearing levels.[276]

This view is not consistent with the measures of gearing provided by Indepen. Indepen's estimates of enterprise value gearing are substantially different from Ofgem's notional gearing assumption of 60 per cent for all but one comparator.[277] Even using Indepen's "adjusted" notional gearing measure, which is calculated using a "normal" MAR of 1.1 to adjust the RAB-based notional gearing of 60 per cent, we still see considerable differences for 3 out of the 5 comparators.

[276] Indepen (December 2018), Ofgem Beta Study – RIIO-2 Main Report, Final, Section 4, p.34.

[277] Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 4, Table 4.4. pp.32,

The fact that the companies actual gearing levels are below both Ofgem's notional gearing level and the Indepen "adjusted" notional gearing level means that by not de-leveraging and re-leveraging, Indepen's recommended range is understating the equity betas.

Ofgem, on the other hand, while stating that further research into de-leveraged and re-leveraged asset betas is recommended, continues to calculate equity betas resulting from re-leveraging asset betas with a notional gearing level.[278] We note that if Ofgem used the raw equity betas estimated directly by Indepen without de-leveraging and re-leveraging, this would be problematic as it would mean the notional gearing structure would be tied to the gearing decisions of relatively few comparators. It would also mean that Ofgem would have to adopt a common notional gearing across all sectors, in contrast with its approach at RIIO-1.

One of the UKRN report authors, Burns, also agrees with the use of re-leveraged equity betas, as these allow the regulator to assess what the equity beta of a company with similar risk would be, at a notional gearing level, leaving financing decisions and responsibilities to the companies.[279]

### H.2.2. Even if we accepted Indepen's "adjusted" notional gearing measure, there is no evidence that MAR are different from 1

Indepen argues for the use of a "normal" MAR of 1.1 on the basis of evidence from water and energy network comparators, pointing to an average MAR of 1.1 and 1.2, respectively.

MARs measure the ratio of the market value (MV) of the regulated business to the value of the RAV,[280] as shown in Equation 3.

$$(3)\ MAR = \frac{MV\ of\ regulated\ business\ (debt+equity)}{RAV}$$

To estimate a "normal" MAR, we calculate so-called *adjusted MARs* for listed UK networks, to remove the effects of non-regulated/non-UK activities, which can form a substantial portion of the overall market value of the company. These activities are not included in the RAV values, the denominator in the above equation, and thus should not be included in the numerator, for the purposes of calculating a MAR for the regulated UK activities.

The value of the adjustments for these factors is inherently uncertain, which represents one of the key practical difficulties with estimating adjusted MARs. Nevertheless, to assess the likely value impact of the above adjustments on National Grid, Severn Trent and United Utilities' valuation and MAR, we collected estimates for each of the above factors from independent equity analyst reports. We use analyst valuations for each of the factors reported in £m terms and express these values as a percentage of the UK RAB as reported by each analyst.

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278 Ofgem (18 December 2018), RIIO-2 Sector Specific Methodology, Section 10, p.104, para 10.48; Ofgem (18 December 2018), RIIO-2 Sector Specific Methodology Annex: Finance, Section 3, pp.39 and 40.

279 Wright, S, Burns, P, Mason, R, and Pickford, D (2018), Estimating the cost of capital for implementation of price controls by UK Regulators, An update of Mason, Miles and Wright (2003), Introduction, p.10.

280 Throughout the report, we consistently refer to the value of regulated assets for UK networks as the Regulatory Asset Base (RAB). We note that different regulators use different terminology, e.g. Ofgem refers to the asset base as the RAV (Regulated Asset Value) while Ofwat uses the term RCV (Regulated Capital Value).

For National Grid, the factors for which we adjust the MAR are US regulated business and non-regulated activities.[281] We present separate estimates for the value of the adjustments for the period prior to, and post, NG's partial sale of its gas distribution business (NGGD) in March 2017. The partial sale of its gas distribution businesses resulted in a reduction of the UK transmission and distribution RAB and in turn increased the estimates of the value of the adjustments (all else equal).

For UK water companies (Severn Trent and United Utilities), the factors for which we adjust are non-regulated activities and non-wholesale regulated activities.[282]

The analyst estimates supporting our adjustments are presented in Table H.1 to Table H.4.

**Table H.1: Analyst Estimates of Value of US Business and Non-Regulated Activities as Percentage of UK RAB (Pre-NGGD Transaction)**

| Analyst | Report date | US Activities | Non-regulated activities |
|---|---|---|---|
| JPMorgan | 30-Jan-13 | 50% | 15% |
| RBC | 25-Mar-13 | 62% | 17% |
| RBC | 20-May-14 | 70% | 18% |
| Deutsche Bank | 12-Jun-14 | 50% | 12% |
| RBC | 11-Sep-14 | 66% | 17% |
| Societe Generale | 09-Oct-14 | 59% | 12% |
| Societe Generale | 12-Nov-14 | 59% | 13% |
| Deutsche Bank | 19-Nov-14 | 53% | 14% |
| Edison | 12-Jan-15 | 59% | 15% |
| Investec | 10-Mar-15 | 54% | 16% |
| RBC | 29-May-15 | 72% | 16% |
| JPMorgan | 04-May-16 | 75% | 16% |
| Investec | 27-May-16 | 74% | 19% |
| **Range of Estimates** | | 50% - 75% | 12% - 19% |

*Source: JPMorgan (January 2013), p.14; RBC (March 2013), p.11; RBC (May 2014), p.8; Deutsche Bank (June 2014), p.6; RBC (September 2014), p.7; Societe Generale (Oct 2014), p.94; Societe Generale (November 2014), p.5; Deutsche Bank (November 2014), p.8; Edison (January 2015), p.14; Investec (March 2015), p.25; RBC (May 2015), p.9; JPMorgan (May 2016), p.7; Investec (May 2016), p.2.*

[281] US regulated business include electricity transmission and distribution facilities, as well as gas distribution networks. Non-regulated activities include interconnectors, LNG operations, UK gas metering, UK property management, and US non-regulated businesses. Source: National Grid, Annual Report and Accounts 2017/18, p.3.

[282] In PR14, Ofwat introduced separate wholesale and retail controls, with the RAB going forward only relating to wholesale controls. As a result, the value of all other non-wholesale regulated activities (most notably household retail) needs to be removed to arrive at a market value for the wholesale regulated business only, which is relevant for making comparisons to the wholesale RAB.

**Table H.2: Analyst Estimates of Value of US Business and Non-Regulated Activities as Percentage of UK RAB (Post-NGGD Transaction)**

| Analyst | Report date | US activities | Non-regulated activities |
|---|---|---|---|
| JPMorgan | 31-Mar-17 | 112% | 19% |
| Edison | 28-Apr-17 | 93% | 26% |
| Edison | 04-May-17 | 93% | 26% |
| JPMorgan | 18-Aug-17 | 129% | 22% |
| JPMorgan | 14-Nov-17 | 129% | 22% |
| RBC | 11-Dec-17 | 128% | 27% |
| JPMorgan | 22-Jan-18 | 141% | 19% |
| JPMorgan | 23-Jan-18 | 141% | 19% |
| JPMorgan | 02-Mar-18 | 133% | 17% |
| Societe Generale | 18-May-18 | 98% | 24% |
| JPMorgan | 31-May-18 | 126% | 18% |
| RBC | 03-Aug-18 | 143% | 29% |
| JPMorgan | 08-Nov-18 | 126% | 18% |
| Societe Generale | 08-Nov-18 | 109% | 25% |
| JPMorgan | 11-Dec-18 | 159% | 20% |
| **Range of Estimates** | | **93% - 159%** | **17% - 29%** |

*Source: JPMorgan (March 2017), p.4; Edison (April 2017), p.11; Edison (May 2017), p.11; JPMorgan (August 2017), p.4; JPMorgan (November 2017), p.4; RBC (December 2017), p.9; JPMorgan (January 2018), p.2; JPMorgan (January 2018), p.2; JPMorgan (March 2018), p.15; Societe Generale (May 2018), p.6; JPMorgan (May 2018), p.12; RBC (August 2018), p.9; JPMorgan (November 2018), p.3; Societe Generale (November 2018), p.6; JPMorgan (December 2018), p.25.*

**Table H.3: Analyst Estimates of Value of Non-Regulated Activities as Percentage of UK RAB**

| Analyst | Report Date | Severn Trent | United Utilities |
|---|---|---|---|
| Societe Generale | 29-Mar-16 | 3% | 1% |
| RBC | 05-Oct-16 | 4% | 2% |
| Societe Generale | 13-Oct-16 | 7% | 3% |
| RBC | 30-Jan-17 | n/a | 2% |
| JPMorgan | 23 & 25 May 2017 | 2% | 1% |
| RBC | 31-Jul-17 | 5% | 2% |
| JPMorgan | 09-Mar-18 | 2% | 1% |
| Deutsche Bank | 01-Jun-18 | 3% | 1% |
| RBC | 26-Nov-18 | 5% | 1% |
| **Range of Estimates** | | **2% - 7%** | **1% - 3%** |

*Source: Societe Generale (March 2016), United Utilities, p.6; Societe Generale (March 2016), Severn Trent, p.2; RBC (October 2016), UK Water: RORE and valuations, p.12; Societe Generale (October 2016), United Utilities, p.11; RBC (January 2017), United Utilities Group, PLC, p.3; JPMorgan (May 2017), Severn Trent, p.2; JP Morgan (May 2017), United Utilities, p.2; RBC (July 2017), United Utilities Group PLC, p.4; RBC (July 2017), Severn Trent PLC, p.4; JPMorgan (March 2018), United Utilities, p.19; JPMorgan (March 2018), Severn Trent, p.23; Deutsche Bank (June 2018), p.15; RBC (November 2018), United Utilities, p.3; RBC (November 2018), Severn Trent, p.3.*

**Table H.4: Analyst Estimates of Non-Wholesale Regulated Activities as Percentage of UK RAB**

| Analyst | Report date | Severn Trent | United Utilities |
|---|---|---|---|
| RBC | 05-Oct-16 | 6% | 1% |
| RBC | 30-Jan-17 | n/a | 1% |
| RBC | 31-Jul-17 | 7% | 3% |
| RBC | 26-Nov-18 | 4% | 2% |
| **Range of estimates** | | **4% - 7%** | **1% - 3%** |

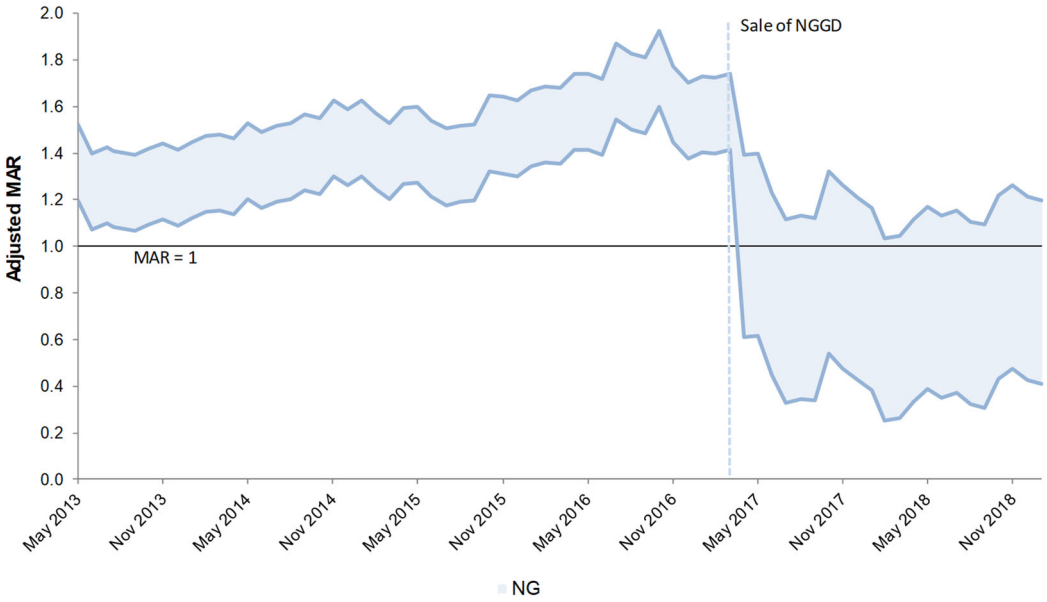
*Source: RBC (October 2016), UK Water: RORE and valuations, p.12; RBC (January 2017), United Utilities Group, PLC, p.3; RBC (July 2017), United Utilities Group PLC, p.4; RBC (July 2017), Severn Trent PLC, p.4; RBC (November 2018), United Utilities, p.3; RBC (November 2018), Severn Trent, p.3.*

One other possible adjustment would be for outperformance of regulatory assumptions, e.g. outperformance on costs under the totex incentive mechanism. For the purposes of estimating a notional gearing, as proposed by Indepen, we do not consider that we should adjust the MARs for outperformance, given that this outperformance is a reason why the enterprise value could be different from RAB in the UK-regulated business segment. We note that if we adjusted for outperformance, this would result in lower adjusted MARs than those presented below.

As shown for National Grid in Figure H.1, analysts' estimates of the value of the adjustments are subject to a large degree of uncertainty. In the period since the start of RIIO-T1/GD1 until the sale of NGGD, National Grid's adjusted MAR lied in a wide interval of approximately c.1 to 1.9. More recently, after the sale of NGGD, these estimates have lied in a range of c.0.3 to 1.2. Thus, we consider than recent evidence points to ratios much closer to 1 and possibly lower, suggesting that there is no RAB premium for National Grid.

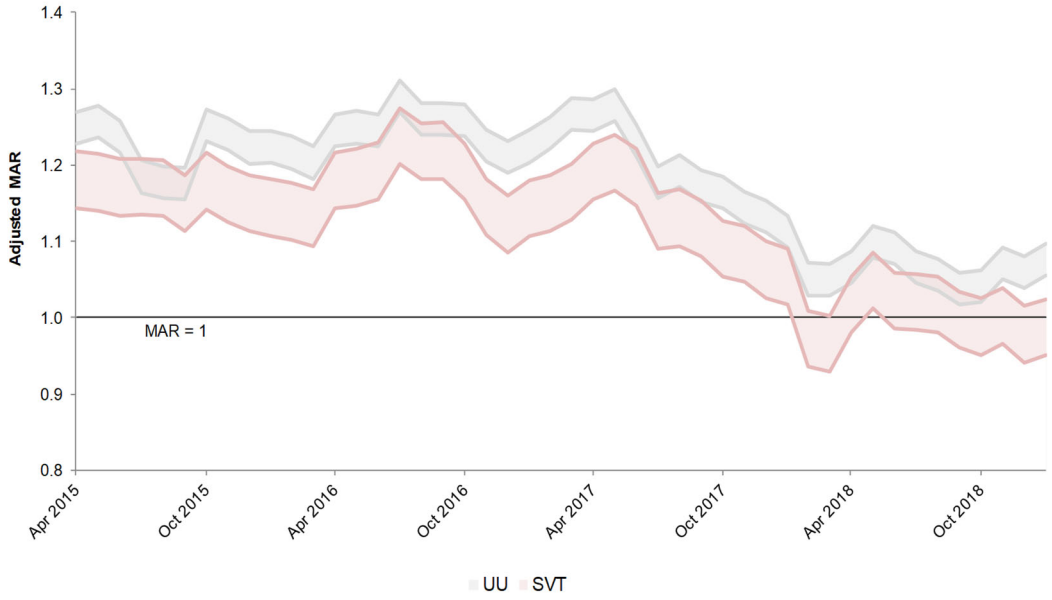
In Figure H.2, which shows the adjusted MARs ranges for UK water companies, we still obtain relatively wide estimates, although less wide than National Grid's ranges. We see that recent drops in the adjusted MARs, coinciding with the publication of Ofwat's PR19 consultation, resulted in ranges of approximately 0.9 to 1.2 for Severn Trent and 1 to 1.2 for United Utilities, since April 2018 (after which adjusted MARs became relatively more stable). As with National Grid, we consider that there is no conclusive evidence that the adjusted MARs for water wholesale businesses are different from 1.

**Figure H.1: National Grid's Adjusted RAB Estimates are Consistent with a MAR of 1**




*Note: Ranges for adjustments are calculated based on min and max of all analyst estimates. We apply two sets of adjustments: one pre-sale of NGGD and one post-sale. We assume that the ranges estimated for each period can be applied throughout the duration of the same period.*
*Source: Equity analyst reports.*

**Figure H.2: Severn Trent and United Utilities Adjusted MARs are Consistent with a MAR of 1**




*Note: Ranges for adjustments are calculated based on min and max of all analyst estimates. We assume that the ranges estimated for each company can be applied throughout the duration of the estimation window.*
*Source: Equity analyst reports.*

Our analysis shows that it is necessary to make sizeable and uncertain adjustments to convert the raw MARs to a MAR that reflects only the UK regulated part of the businesses. This is recognised by Indepen, who cites circularity and valuation issues as reasons for not setting the MAR equal to the actual MAR.[283] However, unlike Indepen, we find no conclusive evidence that a "normal" MAR should be different from 1, given the recent trends and the relatively wide intervals obtained.

### H.2.3. There is no regulatory precedent in the UK for adjusting notional gearing

Even if we were to accept that MARs were higher than 1, Indepen's proposed adjustment to notional gearing does not have any precedent in UK regulation. Other UK regulators have opted for the use of a notional gearing without any adjustment in their previous determinations:

- Ofwat, in their RP14 determination, proposed a notional gearing level based on actual gearing (enterprise value gearing) and other factors such as credit rating and used it to re-leverage the estimated asset beta; [284]
- Ofcom determined re-leveraged equity betas based on notional gearing informed by evidence including actual gearing (enterprise value gearing), in their 2018 Wholesale local access determination;[285]

The Civil Aviation Authority (CAA) re-leverages asset betas using a notional gearing measure and presents no further adjustments.[286]

This was also the proposal of Ofgem's consultants CEPA, in a report published alongside Ofgem's framework consultation. In this report, CEPA presents a notional gearing estimate informed by regulatory precedent and actual gearing, which is then used to re-leverage the asset betas estimates.[287]

In none of the cases above was the estimate of a notional gearing level adjusted to reflect the differences between the RAB and enterprise value.

### H.2.4. Conclusion on Indepen's adjustment

In summary, Indepen does not provide a reason for not estimating re-leveraged equity betas, which leads to an understatement of the equity beta values in its recommended range. Regarding Indepen's "adjusted" notional gearing measure, we note that this has no precedent in UK regulation. Moreover, even if we were to accept Indepen's recommendation of adjusting notional gearing by a "normal" MAR value, there is no evidence that this value is significantly different from 1, which means the adjustment would have no effect on the notional gearing level. Finally, Indepen's adjustment, by lowering the notional gearing level,

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283 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Main Report, Final, Section 4, p.33.

284 Ofwat (December 2014), Setting price controls for 2015-20 Final price control determination notice: policy chapter A7 – risk and reward, pp.41-42; Ofwat (January 2014), Setting price controls for 2015-20 – risk and reward guidance, Appendix 1, pp.8-9

285 Ofcom (28 03 2018): Wholesale Local Access Market Review: Statement, Annexes 17-27, pp.75, 111 and 112.

286 CAA (2013), Economic regulation at Heathrow from April 2014: final proposals – WACC appendix, pp.35-37 and 52.

287 CEPA (February 2018), Review of Cost of Capital Ranges for Ofgem's RIIO-2 for Onshore Networks, pp.62-64 and 71.

also implies that a greater weight must be applied on the cost of equity in the WACC to reflect the lower level of leverage.

### H.2.5. Ofgem's approach to beta estimation is inconsistent with finance theory and Indepen's approach

As presented in Section 3.2.2, Ofgem's approach is not in line with Indepen's approach nor finance theory. Ofgem applies the MAR "correction" proposed by Indepen to the actual gearing (enterprise value gearing), instead of applying it to the RAB-based gearing, as proposed by Indepen. By applying the adjustment to actual gearing, Ofgem is overstating the actual gearing level and, consequently, understating the asset betas.

Indepen, in its example for beta decomposition, as described in Appendix H.1, presents several alternatives for the gearing to use to de-leverage the equity beta of businesses. All the options focus on measures of actual gearing (be it the group gearing, specific segment gearing or industry average gearing), with no adjustment similar to that of Ofgem.

In standard financial theory, as explained in Appendix H.1, the de-leveraging of equity betas is done with the purpose of removing the financing decisions effects from the beta, to get a measure of the business risk. Given that these equity betas incorporate the effects of financing from those specific firms, they should be de-leveraged using a gearing reflecting the specific decisions of those firms and not a measure adjusted to reflect a notional level.

We also note that the use of an average gearing level to de-leverage the raw equity beta range is not conceptually correct. When de-leveraging equity betas, the objective is to remove the effects of financing for each company out of their equity betas. Given that the range is informed by betas of comparators, using an average gearing means that we are de-leveraging the beta of a company using a gearing measure that incorporates other companies financing decisions, which introduces an additional bias into the asset betas estimated.

### H.2.6. Ofgem's approach punishes outperformance

As shown in equation 3, the MAR is defined as the ratio of enterprise value to RAB. After adjusting for the non-regulated and non-UK activities, an adjusted MAR above 1 would be reflecting outperformance, as the market value of the firm (adjusted to include the same assets as the RAB) would be above the predicted value in the RAB.

The existence of outperformance, for some companies at least, is expected to be part of an incentive regulation framework and should not be clawed back in the asset beta estimation.

Ofgem's approach of adjusting the gearing level used to de-leverage equity betas, overstates the actual gearing level. This gearing overstatement leads to an understatement of asset betas and, by extension, the cost of equity, thereby punishing outperformance. In Table H.5, we show that Ofgem's approach of adjusting the gearing level used to de-leverage raw equity betas, leads to an understatement of asset betas by 0.02 to 0.03 and of the cost of equity by 0.39 to 0.56 percentage points. To calculate these values, we use the same assumptions as Ofgem, aside from the adjustment to the actual gearing levels.

**Table H.5: Ofgem's Approach Understates Asset Betas and Cost of Equity**

| | Ofgem Lower Bound | Ofgem Upper Bound | NERA Lower Bound | NERA Upper Bound |
|---|---|---|---|---|
| Raw equity beta | 0.6 | 0.7 | 0.6 | 0.7 |
| Actual gearing | 50.80% | 50.80% | 50.80% | 50.80% |
| EV/RAV | 1.1 | 1.1 | n.a. | n.a. |
| Adjusted gearing | 56% | 56% | 50.80% | 50.80% |
| Debt beta | 0.15 | 0.1 | 0.15 | 0.10 |
| **Asset beta** | **0.35** | **0.36** | **0.37** | **0.40** |
| Notional gearing | 60% | 60% | 60% | 60% |
| **Notional equity beta** | **0.65** | **0.76** | **0.70** | **0.84** |
| Risk-free rate | -1.68% | -1.68% | -1.68% | -1.68% |
| Equity risk premium | 6.9% | 7.4% | 6.9% | 7.4% |
| **Cost of equity (real post-tax, RPI)** | **2.76%** | **3.93%** | **3.15%** | **4.49%** |

*Source: NERA calculations based on Ofgem's data.*

### H.2.7. Financeability tests would need adjustments

Ofgem also considers whether the regulated companies are able to finance its activities and whether they are able to maintain an investment grade credit rating. To do so, it conducts several stress tests to assess the financeability of the notional company, including testing against the financial metrics used by credit rating agencies.[288]

Credit rating agencies do not usually consider adjustments to the standard measures of gearing, as those proposed by Indepen. Typically, the gearing ratio assumed would be a D/RAB measure. If Ofgem adjusts the notional gearing value when assessing financeability, this would create an inconsistency with the way gearing is measured by credit rating agencies.

In our view, if Ofgem adopts the adjustment of notional gearing as proposed by Indepen, it would then have to calculate two separate WACCs: One for the purpose of estimating the allowed returns (using Indepen's adjustment to notional gearing) and another for the purpose of assessing financeability (using the notional gearing measure of D/RAB).

### H.2.8. Conclusion on Ofgem's approach

In summary, Ofgem's adjustment to gearing levels is not only inconsistent with Indepen's approach, but it is also inconsistent with standard finance theory. By overstating the actual gearing levels when de-leveraging the raw equity betas, Ofgem is not correctly estimating a measure of business risk and understates the asset betas. We conclude that this issue leads to an understatement of the asset betas by 0.02 to 0.03 and of the cost of equity by 0.39 to 0.56 percentage points. Finally, we also conclude that performing Indepen's proposed adjustment

[288] Ofgem (18 December 2018), RIIO-2 Sector Specific Methodology Annex: Finance, Section 4, pp.55-57.

would imply calculating a different WACC for the purpose of assessing financeability, given the financing metrics used by credit agencies not taking into account this adjusted notional gearing.

## H.3. Use of international comparators

Indepen argues that the advantages of using international comparators may be limited, given that issues such as comparability of regulatory regimes. It further mentions that a good starting point for the estimation of RIIO-2 betas is researching listed UK examples.[289]

We agree with Indepen, that the use of listed UK examples is valuable, although a relative risk analysis should be undertaken first. We do this in Section 3.4, concluding that SPT faces higher risk than water companies and other energy networks, but less so than airports.

In the case of international comparators, while we agree that companies from different countries may not be the most comparable evidence, it is also the case that they can be useful as benchmarks, provided a relative risk analysis is conducted. We perform this analysis in Section 3.5, where we find that investors in SPT are likely to be exposed to similar risk to investors in Italian and Spanish networks. We thus find value in estimating betas for international comparators and using them as benchmarks for betas in RIIO-2.

We also note that other UK and European regulators have used betas from other countries in their determinations. For example, the CAA in its 2014 price review for Heathrow and Gatwick estimated an asset beta by reviewing evidence from airports from countries such as Germany (Fraport) and France (ADP).[290] Another example is a Portuguese waste regulator (ERSAR), which used UK water companies (Pennon, United Utilities and Severn Trent) as a benchmark to assess systematic risk for a Portuguese waste company.[291]

[289] Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 3, pp.23 and 24.

[290] CAA (2014), Estimating the cost of capital: technical appendix for the economic regulation of Heathrow and Gatwick from April 2014: Notices granting the licenses, pp.39-43

[291] ERSAR (31 July 2018), Proposal of an Asset Remuneration Rate for the determination of Allowed Revenues in the scope of Tariff Regulation for Urban Waste management services for the regulatory period 2019-2021, pp.49-51

# Appendix I. Review of GARCH Evidence Presented by UKRN, Indepen and Dr Robertson

In this appendix we comment on the approach of the UKRN, Indepen and Dr Robertson reports for estimating betas using GARCH models. We also discuss the use of these complex models in a regulatory context.

## I.1. Indepen and Dr Robertson address some of the UKRN issues

As pointed out in Section 3.2 and in a previous report prepared by us,[292] there are several areas where we do not agree with the approach followed by the UKRN report authors, namely the use of low frequency (e.g. quarterly) data, the long estimation window (since 2000) and the non-discussion of the modelling choice (given the existence of several GARCH models).

Indepen and Dr Robertson partially addresses these concerns in their recommended process for estimating betas. We present these views and our thoughts below.

### I.1.1. Use of low frequency data

MPW recommend the use of low frequency data for estimating beta.[293] This would require extending the estimation period to ensure sufficient observations, leading to the inclusion of periods that are not relevant in terms of risk profile. Even when all the data available is used (in MPW's case, data from 2000 to 2017), the number of observations is still considerably smaller compared to the common practice of using daily data, leading to less precise beta estimates as measured by standard errors. The use of high frequency data over low frequency data, provided there is sufficient variation between observations, is also present in the academic literature as evidenced by the following quote from Morse (1984):

> *"The most powerful estimate of mean abnormal returns is generated by the return series that minimizes bias and maximizes efficiency. The results generally support the use of daily return data to estimate information effects, with the possible exception of cases in which there is uncertainty about the date of the information release. Even with this uncertainty, however, daily returns may still be preferred to monthly returns in some situations."*[294]

Moreover, MPW propose to use GARCH models for estimating betas to reflect time-varying properties of asset returns (such as time-varying volatility) but at the same time they also propose to remove those very properties that GARCH models are designed to deal with from the data by aggregating returns. Therefore, we find the simultaneous recommendation for the use of GARCH-type models and the aggregation of returns inconsistent.

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[292] NERA (2018), Review of UKRN report recommendations on beta estimation

[293] Wright, S, Burns, P, Mason, R, and Pickford, D (2018), Estimating the cost of capital for implementation of price controls by UK Regulators, An update of Mason, Miles and Wright (2003), p. 53, and appendix G.

[294] Morse, D. (1984), An Econometric Analysis of the Choice of Daily Versus Monthly Returns in Tests of Information Content, Journal of Accounting Research, vol. 22(2), p. 606.

Indepen provides a different view on the frequency of data, arguing against the use of low frequency data in the form of monthly data given its lower number of observations and the existence of structural breaks and does not mention the possibility of using quarterly data.[295]

For its equity beta range, Indepen provides betas estimated with high frequency-data, specifically daily data, which addresses our points above.[296]

Similar to Indepen, Dr Robertson also argues that the use of higher frequency data provides more precision in the beta estimation process. Furthermore, Robertson sets out equity beta estimates relying on daily data.[297]

### I.1.2. Use of long estimation windows

MPW recommend estimating betas over long horizons going back to 2000. We had argued that doing so would ignore material changes in UK (and other comparator) companies' business and financial risk, changes in market conditions as well as changes in the regulatory regime and risk.[298]

This is still a concern in the Indepen report, which estimates an equity beta range based on three estimation windows, one of those going as far back as 2000. Indepen argues that it is important to take a longer view and longer windows to address issues surrounding noise in the estimation process.[299]

However, in the same report, Indepen argues for the use of data since the most recent structural break, which in this case, would be the last five years (since 2013).[300] This is then not reflected in Indepen's "narrower range", which is estimated by placing lower weight in the data from the 2013-2018 estimation window and more weight in the 2008-2018 estimation window. The argument presented for choosing a lower weight for the most recent estimation period is the spike occurring around the 2017 election, which has since reversed according to Indepen. This seems inconsistent with then placing weight on data from 2000 to 2018, which includes other clear structural breaks.[301]

We agree with Indepen's move towards using more recent data, but still have concerns that weight is being placed in data going as far back as 2000, which biases beta with risks that are not as relevant going forward, as explained above.

Dr Robertson also acknowledges the existence of structural breaks, thus providing an argument against the use of very long run data. Nonetheless, and as was the case with Indepen, Robertson estimates equity betas relying on data that goes as back as 2000.[302]

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295 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 2, p.19.

296 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 5, p.45.

297 Donald Robertson (April 2018), Estimating β, pp. 3, 39 and 40.

298 For a more detailed discussion, see NERA (2018), Review of UKRN report recommendations on beta estimation.

299 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 2, p.18.

300 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 2, p.7.

301 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Section 5, p.46.

302 Donald Robertson (April 2018), Estimating β, pp. 36, 39 and 40.

### I.1.3. Discussion of the modelling choice

GARCH models address the issue of conditional heteroscedasticity of returns, making it possible to estimate time variation in beta. There is a wide range of GARCH models including the one used by MPW (BEKK-MGARCH). Given the possibilities around introducing a GARCH model for estimating betas, it is important that several alternatives are tested against each other using an appropriate selection criterion to justify the eventual use of one particular model. Examples of these criteria include the Bayesian Information Criterion (BIC), the Akaike Information Criterion (AIC) and the Hannan-Quinn Information Criterion (HQIC). In the case of MPW, no discussion surrounding the choice of the modeling choice is provided.

Indepen presents a significant improvement in this aspect, providing a detailed explanation on the choice of the GARCH model. The choice is based on the BIC, which is calculated using daily data for each company over the period 2000-2018. The equity betas are then estimated using the preferred GARCH model for each company (Triangular BEKK and Full VECH (Half-vectorisation)), as determined by the BIC.[303] Indepen also performs a sensitivity analysis considering higher order GARCH models, but finds that for most cases this does not change the choice of the preferred model and order.[304]

On the other hand, Dr Robertson uses a Diagonal BEKK model on the basis of this being a *"relatively simple formulation that can already capture persistence in the variances and comovements between returns"*.[305]

We present further thoughts on the use of GARCH instead of OLS in regulatory determinations in the section below. However, if GARCH is to be used for the estimation of betas, we would recommend an approach similar to that of Indepen, where different models are measured against each other using the appropriate criteria.

## I.2. Use of GARCH in a regulatory context

We consider that in the future more advanced time series models may prove useful insight for beta estimation in the regulatory context. In particular, they may help understand and assess variation in betas over time.

Beta is defined as the covariance between returns on the asset and returns on the market portfolio, divided by the variance of returns of the market portfolio. In academic literature, there are several econometric methods available for estimating the CAPM beta.

The earliest and possibly the most widely used method to date is the standard linear regression model, estimated by ordinary least squares (OLS). One of the potential restrictions of the OLS model is that it assumes the beta is constant over time. However, there is a body of empirical evidence showcasing that betas may vary over time.[306]

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303 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Appendices A-C, Appendix C, pp.55-59.

304 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Appendices A-C, Annex C1, pp.82.

305 Donald Robertson (April 2018), Estimating β, pp.14-15

306 For example, Engle and Patton (2001) survey the most important stylized facts about the volatility of asset returns.[306] They present evidence of so called volatility clustering, which means that large moves in returns (of either direction) are

There are a number of models which allow analysing time variation in beta. Variants from the GARCH family provide a framework to explicitly model how the variance and covariance of stock returns changes over time. State-space models relying on the Kalman filter (KF) represent another class of models besides GARCH which also accommodate time-varying betas. The KF is widely employed in academic literature, but also in engineering technical applications where results can be tested experimentally. The OLS model using a rolling window (RW) estimation approach is a much simpler model that may incorporate time variation in beta as well.

Hollstein and Prokopczuk (2016) provide a comprehensive survey of market beta estimation techniques comparing a broad range of models, including GARCH, Kalman Filter and even more advanced, option-based models.[307] They find that:

> *"estimators using historical information perform well only if they do not make too strong structural assumptions, like the simple historical beta and the Kalman filter approach with a random walk parametrization. In contrast, models that make strong assumptions on the volatility and correlation processes (like the GARCH-based DCC) are shown to produce very large errors."*[308,309]

Indepen, while estimating betas using GARCH and LAD processes, acknowledges that the different approaches give relatively similar numbers.[310] The differences in equity betas estimated from all the different approaches considered by Indepen are on average 0.04, 0.07 and 0.07 for the estimation periods 2000-2018, 2008-2018 and 2013-2018, respectively. If we consider the differences using only GARCH and OLS specifications, the values drop to 0.04, 0.06 and 0.05, respectively.[311] Dr Robertson also states that long-run estimates from GARCH and OLS are quite similar.[312] These values are consistent with our previous conclusions on the report commenting on the UKRN estimates, which concluded that once consistent time periods and data frequencies are used, the results from standard OLS estimation and the MGARCH model proposed by MPW become very similar.[313]

The use of GARCH implies a certain degree of subjectivity in the model selection. Indepen, even testing for various specifications, only tests for 10 GARCH specifications. It also

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typically followed by large moves and small moves are typically followed by small moves, creating persistence in volatility. They also show that volatility is mean reverting, i.e. a period of high volatility will eventually give way to a more normal level of volatility and conversely a period of exceptionally low volatility will eventually reverse, too. These stylised observations about asset returns' volatility imply that beta may vary over time. (Source: Engle, R.F., Patton, A.J., 2001. "What good is a volatility model?" Quantitative Finance, vol(1), pp. 237-245)

307 Hollstein, F. and Prokopczuk, M. (2016), Estimating Beta, Journal of Financial and Quantitative Analysis, vol. 51(4), pp. 1437-1466.

308 Hollstein, F. and Prokopczuk, M. (2016), op. cit., p. 1464.

309 By simple historical beta the authors refer to an OLS regression with a rolling window of one year.

310 Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Main Report, Executive Summary, p. xi.

311 Based on Indepen's reported equity beta estimates. Source: Indepen (December 2018), Ofgem Beta Study – RIIO-2 Final, Section 5, p.45.

312 Donald Robertson (April 2018), Estimating β, p.39.

313 NERA (2018), Review of UKRN report recommendations on beta estimation, Section 5, p.23.

admits that higher GARCH orders are possible (although it only tests for a GARCH(2,2) in comparison with GARCH (1,1)).[314]

We believe the rolling-window OLS approach may potentially provide the most suitable method for analysing time-varying properties of betas in the regulatory context, as it offers the best trade-off between various regulatory objectives. It i) is easy to implement and well understood, ii) incorporates time-varying betas, and iii) minimizes the scope for regulatory discretion/arbitrariness. Moreover, as discussed above, given that GARCH and OLS models produce consistent results, we consider the benefits from implementing a more complex model (GARCH) relative to OLS appear questionable in a regulatory context.

## I.3. Conclusion on the estimation model to be used

The choice of an estimation model for the purposes of regulation is a task that requires the balancing of several regulatory objectives.

When estimating betas using the GARCH model, our view is that some of the issues we identified in MPW's method had to be addressed before consideration was given to the use of GARCH models in a regulatory context. Indepen address some of these issues, namely the use of high frequency data and the testing of different specifications, but still places evidence in data going back to 2000. Meanwhile, Robertson addresses the issues surrounding the use of high frequency data.

Our view is that a rolling-window OLS is the approach that provides the best trade-off between the regulatory objectives. We noted that there is always a degree of subjectivity in the selection of the GARCH model, which affects the transparency of the estimates. Moreover, the similarity in estimates provided in our report for National Grid, the Indepen report and Dr Robertson report between betas estimated using a GARCH or a OLS model is evidence that the use of an OLS model is not leading to under/overstated betas.

[314] Indepen (December 2018), Ofgem Beta Study – RIIO-2, Appendices A-C, Final, Appendix C, pp.55-58.

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