NERA
ECONOMIC CONSULTING

Review of UKRN Report Recommendations on TMR

Energy Network Association

20 November 2018

CONFIDENTIALITY

Our clients' industries are extremely competitive, and the maintenance of confidentiality with respect to our clients' plans and data is critical. NERA Economic Consulting rigorously applies internal confidentiality practices to protect the confidentiality of all client information.

Similarly, our industry is very competitive. We view our approaches and insights as proprietary and therefore look to our clients to protect our interests in our proposals, presentations, methodologies and analytical techniques. Under no circumstances should this material be shared with any third party without the prior written consent of NERA Economic Consulting.

Contents

Executive Summary

NERA Economic Consulting (NERA) has been commissioned by the Energy Networks Association (ENA) to review the recommendations on the total market return (TMR) set out in the report by Wright, Burns, Mason and Pickford in a report prepared for the UK Regulators Network ("UKRN report").[1] This short paper addresses a number of issues that arose from the UKRN report at a RIIO-2 regulatory finance workshop attended by Ofgem, ENA and their respective advisers in early October 2018.

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. Drawing on historical CPI inflation from the Millenium dataset, the UKRN report estimates a real (CPI-deflated) TMR of 6 to 7 per cent based on long-run realised returns. The lower bound reflects a 1 per cent downward adjustment to the simple arithmetic mean of realised returns due to return predictability at long horizons.

NERA's analysis shows that the Millennium CPI dataset does not provide a reliable measure of historical CPI inflation. This has been clearly acknowledged by the ONS and academic research. We conclude that the historical TMR back to 1900 must instead be calculated relative to the "official" RPI inflation.

In this report, we show that the historical inflation data labelled as "CPI" in the Millennium dataset does not represent a reliable measure of CPI inflation prior to 1987, and therefore should not be used as a basis of estimating 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.

Our conclusion on this issue should not be contentious as the ONS (2013) have investigated the reliability of historical data on CPI and clearly concluded: *"sufficient data to calculate the CPI do not exist prior to 1987"*, as discussed further in this paper.

A further error in the UKRN's analysis is that we show for some parts of the historical data series (1915-1949) on TMR, the Millenium dataset has used a "CPI" index that is identical to the official "RPI" index, based on a single series of inflation data published by O'Donoghue et. al. (2004). There is no CPI data available for this period and instead the BoE CPI series uses RPI inflation data as a proxy.

Based on this analysis, we show that the UKRN's conclusions that TMR should be calculated with reference to a labelled "CPI" index is clearly flawed and results in their conclusions on the historical TMR being substantially downwardly biased.

UKRN's error substantially explains why its conclusions on TMR are below previous UK regulatory precedent, including CMA precedent.

The UKRN's assertions on the issue of the "predictability" of returns do not appear to be well founded. NERA conclude that the CMA's (NIE, 2014) position on this issue is much more robust.

The issue of the predictability of returns has received widespread academic attention over many years with seminal papers on this topic published since the 1970s. This issue is relevant to the extent that it

[1] 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).

affects the weight that should be placed on arithmetic versus geometric averages in the assessment of the appropriate TMR to be used as the basis for estimating future required returns.

The CMA (and previously the Competition Commission) has previously studied this issue in great detail and concluded that the arithmetic average return provides the most relevant measure for the purposes of setting the allowed cost of equity on the basis that the evidence for predictability of returns is extremely limited. The CMA's position on this issue is generally in line with seminal papers by Blume (1974), Cooper (1998) and Wright and Smithers (2003, 2013) as referenced in this report.

In its 2018 report, the UKRN report authors state that the evidence base for predictability of returns has strengthened and therefore it applies a downward adjustment of around 1 per cent to the simple arithmetic mean of historical realised returns to take into account the predictability of returns at long horizons.

In fact the additional evidence that the authors of the UKRN report cite to justify their new conclusions on the predictability of returns comes from a single source of evidence from the 1990s where Shiller used the cyclically adjusted P/E to correctly predict the end of the 1990s bull market.[2] However, this evidence would have been available (and prominent) at the time of many previous regulatory and academic studies on this issue and is not new evidence. Indeed, one of the authors of the UKRN report, Stephen Wright, also previously concluded in a 2003 paper that the evidence on the predictability of historical returns is "*extremely limited*".[3]

Overall, we conclude that there is no recent evidence that supports an overturning of recent regulatory precedent on this issue, including that used by the CMA in its 2014 NIE review, where established TMR estimators by Blume and JKM, which also consider serial dependence, support an adjustment to the arithmetic average of the order of a maximum of 30 bps, significantly smaller than UKRN's downward adjustment of up to 1 per cent.

A Real TMR deflated by RPI cannot be used in a CPI framework without adjustment

In the Ofgem-ENA workshop, Ofgem raised the following hypothesis: if investor's required compensation for inflation is based on the official inflation index at the time, which used to be RPI but is now CPI, it would be reasonable to use an historical RPI-deflated return (of around 7 per cent) and use this as the real return in a CPI regulatory framework, without any adjustment.

We show that this is a new hypothesis without any regulatory or academic support. Indeed, the recent UKRN report did not consider this hypothesis, and explicitly recommends using a real TMR deflated by CPI in a CPI framework. We also show that investors have expressed concerns about RPI as a measure of inflation at certain times in the past, and therefore it is improbable that investors consider, without question, that the official index is the relevant or only measure of inflation in forming expectations of returns.

We conclude that a real TMR deflated by RPI must be adjusted to reflect well-known differences between RPI and CPI. For the purposes of determining a forward-looking CPI-deflated TMR for setting the cost of equity allowance at RIIO-2, the historical RPI-deflated TMR should be adjusted upwards by the expected RPI-CPI wedge, of around 100 bps to 130 bps. In doing so, the derived CPI-deflated TMR will provide the same nominal returns in expectations as using an historical RPI-deflated TMR, and therefore fulfill the legitimate expectation that any switch to CPI indexation will be revenue neutral.

[2] Wright, Burns, Mason, Pickford (2018), op. cit., p.40

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

1. Introduction

NERA Economic Consulting (NERA) has been commissioned by the Energy Networks Association (ENA) to review the recommendations on the total market return (TMR) set out in the report by Wright, Burns, Mason and Pickford prepared for the UK Regulators Network ("UKRN report").[4] This short paper addresses a number of issues that arose from the UKRN report at a RIIO-2 regulatory finance workshop attended by Ofgem, ENA and their respective advisers in early October 2018. In this paper, we:

- Provide a summary of our concerns with UKRN's reliance on a Millennium dataset "CPI" series to calculate historical returns, drawing on a more detailed report submitted to Ofgem by energy network companies,[5] and review UKRN's proposed 1 per cent downward adjustment to the historical TMR to account for alleged predictability of returns. We address these issues in Chapter 2.
- Explain why a real TMR which has been calculated relative to RPI cannot be applied in a CPI context, in the absence of an upward adjustment to reflect the RPI-CPI wedge. We address this issue in Chapter 3.

[4] 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).

[5] NERA (May 2018), Review of UKRN recommendations on the appropriate inflation index for estimating historical TMR.

2. Summary of UKRN Report Recommendations on Real TMR

In this chapter, we review the recommendations on estimating Total Market Return (TMR) presented in the report by Wright, Burns, Mason and Pickford prepared for the UK Regulators Network ("UKRN report").[6]

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

- ***CPI as the 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 total market returns should be analysed with reference to historical CPI inflation published by the Bank of England (BoE) in the Millennium dataset ("Millennium dataset"), as it is more consistent over time and therefore superior to RPI over the historical period since 1900.[7]
- ***Downward adjustment to arithmetic mean to account for returns predictability***: The UKRN report argues that historical realised 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 realised returns to take into account the predictability of returns at long horizons. Based on this, the UKRN report recommends a real (CPI-deflated) TMR of 6 to 7 per cent.[8]

We disagree with both recommendations, as we explain below.

2.1. RPI data should be used to analyse *historical* real TMR as the Millennium dataset "CPI" is 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.

We understand that Ofgem has determined that it will switch from RPI to CPI indexation of allowed revenues, which will include a real CPI determined WACC at RIIO-2, i.e. UKRN's first recommendation.[9] However, the adoption of CPI indexation does not imply that the historical TMR should be measured relative to CPI. Rather, the appropriateness of using the Millennium CPI inflation data to calculate historical real TMR, as UKRN propose, depends on the reliability of this data as a measure of historical CPI inflation for the UK since 1900, given that the official CPI index is only available from 1989 onwards. As we have described in more detail in an earlier report submitted by National Grid in response to RIIO-2 consultation,[10] our review of the Millennium dataset data shows that the so-called CPI data series is not a reliable measure of CPI inflation going back to 1900 and indeed that RPI data is the only reliable measure of historical inflation since 1900.

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

[6] 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).

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

[8] Wright, Burns, Mason, Pickford (2018), op.cit., Appendix E.

[9] As we have set out in previous reports for network companies in response to Ofgem's RIIO-2 consultation. 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.

[10] NERA (2017), Total Market Return for Determining the Cost of Equity at RIIO-2, 3 November 2017.

Table 1: Sources of CPI Millennium dataset and RPI 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 Millennium 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[11] itself raises significant concerns regarding the reliability of this data:[12]

  "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.****"*

- For **1915-1949**, the Millennium dataset for "CPI" and "RPI" is identical, based on a single series of inflation data published by O'Donoghue et. al. (2004).[13] 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).[14] There is therefore no CPI data available for this period and instead the BoE CPI series uses RPI inflation data.

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

[12] Source: ONS (2013), Modelling a Back Series for the Consumer Price index, Robert O'Neill and Jeff Ralph, p.4.

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

[14] 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.)

- For **1900-1914**, the "CPI" data is based on Feinstein (1991),[15] which estimates a cost of living index for working class households only and not CPI inflation.[16] 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*.[17] We conclude the Feinstein (1991) data is not a reliable measure of CPI inflation over this period.

In contrast to the UKRN report, we conclude that the Millennium "CPI" historical data is unreliable and inconsistent over time. Indeed, the "CPI" series includes RPI data for a substantial part (1915 to 1949) of the historical period and the data for other historical periods is not a reliable estimate of CPI inflation historically. We conclude that RPI represents the most reliable measure of UK inflation historically and therefore should be used to determine the historical real TMR for the period since 1900, instead of the unreliable Millennium "CPI" series.

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"*[18] from Feinstein (1972) for the period before 1947 and the official RPI data post-1947 represent the appropriate data to be used for making *"long-run comparisons […] of consumer price inflation".*[19] 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).[20]

2.2. UKRN's Adjustment for Returns Predictability is Unfounded

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.

The UKRN report notes that it is well established that, since the CAPM relates to expected returns, the arithmetic average return provides the relevant measure for the purposes of setting the allowed cost of equity.[21] The UKRN report authors argue that rather than calculate arithmetic averages directly, it is more reasonable to start with the compound or geometric average returns and add an adjustment of 1 to 2 percentage points "*depending on the extent to which regulators wish to take account of serial correlation of returns.*"[22] The UKRN report does not explain the basis for the 1 to 2 per cent adjustment, however, these figures are explained in the Mason, Miles and Wright (MMW) 2003 report which we assume is the basis for the adjustment in the UKRN report.[23]

The MMW 2003 report explains that, assuming returns are log normally distributed, the arithmetic mean rate of return exceeds the geometric mean rate of return by $(1/2)*\sigma^2$, where σ is the variance of

[15] 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.

[16] 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.)

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

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

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

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

[21] Wright, Burns, Mason, Pickford (2018), op. cit., p. E-125; and Mason, Miles, and Wright (2003) op. cit. p.24

[22] Wright, Burns, Mason, Pickford (2018), op. cit., p. E-125

[23] Mason, Miles, and Wright (2003), A study into certain aspects of the cost of capital for regulated utilities in the UK.

the log of returns. The MMW 2003 report further explains that assuming annual volatility of log returns of 0.2, "*a rough ball-park figure for a range of equity markets*", implies a difference between the arithmetic and geometric mean returns of 0.02 or 2 percentage points (=0.2^{2*}/2). MMW adopt this figure as its upper-bound estimate of the TMR, which is equivalent to the historical simple arithmetic mean. [24]

The MMW 2003 report explains that the 2 per cent adjustment implicitly assumes that returns are unpredictable at longer horizons (i.e. follow a random walk), which implies that the annual volatility of log returns of 0.2 is the relevant estimate of volatility for (annualised) long horizon returns as well. However, they also consider the case where there is predictability in returns, which reduces the (annualised) long-horizon return variance relative to the random walk process, and therefore reduces the volatility adjustment required over long horizons. Using a model to predict returns, MMW 2003 calculate that five and ten-year return variances are significantly lower than if returns were random. MMW 2003 conclude that:

> "*the implication of these figures is that if they truly capture return predictability, the gap between the arithmetic mean return and geometric return would fall to only around one percentage point over a five-year horizon."*[25]

The MMW 2003 report concludes that: "*Our central estimate of the cost of equity capital, derived from a wide range of markets, is around 5.5 per cent (geometric average), and thus 6.5 per cent to 7.5 per cent (arithmetic average).*"[26] These figures are real RPI based.

Similarly, in the UKRN report, the authors recommend a geometric return of 5 per cent (CPI based but based on inaccurate proxies for CPI as we explain above), and an adjustment of 1 to 2 per cent to get to the correct arithmetic mean assumption to apply in the CAPM. However, the authors also note that:[27]

> "*We would argue that the case for an adjustment to arithmetic averages as large as 2 percentage points (which was implied by the upper end of MMW's range) is distinctly weakened if regulators wish to set returns on a consistent basis at a relatively long (e.g. 10 year) horizon, given that (as noted in MMW) long-horizon returns have distinctly lower volatility that would be the case in a random walk stock market."*

2.2.1. UKRN report provides no compelling evidence of return predictability

In its 2003 report, MMW note that the predictability of returns over long-horizons is a contentious issue among financial economists. MMW 2003 note that: [28]

> "*There is no clear cut empirical evidence, that we are aware of [...] Eminent academic economists have come down on both sides of the fence.*"

In its 2018 report, the UKRN report authors state that the evidence base for predictability of returns has strengthened. In support of this assertion, the authors state there is increased recognition that valuation indicators such as the cyclically adjusted P/E multiple or CAPE (popularised by Robert Shiller) appear to have predictive power for (at least) the US stock market. They go on to note that the acceptance of predictive power of CAPE was helped by evidence by Shiller to congressional

[24] Mason, Miles, and Wright (2003) op. cit. pp. 23-24

[25] Mason, Miles, and Wright (2003) op. cit. p. 26

[26] Mason, Miles, and Wright (2003) op. cit. p. 4

[27] Wright, Burns, Mason, Pickford (2018), op. cit., p. E-125

[28] Mason, Miles, and Wright (2003), op. cit., p.36-37, 41-42

hearings in the 1990s which used the cyclically adjusted P/E to correctly predict the end of the 1990s bull market.[29]

Thus, the authors appear to argue more forcibly for the predictability of returns based on a single source of evidence from the 1990s, although this evidence would have been available (and prominent) at the time of the 2003 report, where the authors concluded that there is no clear-cut empirical evidence.

2.2.2. Recent literature does not support predictability of returns

We have undertaken a review of recent papers on the topic of predictability of stock market returns published mainly since the MMW 2003 concluded that there was no clear-cut empirical evidence either way. We identify a large body of literature that finds that there is no predictability of returns on long horizons.

For example, Ang and Beckaert (2001)[30] 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: [31]

> "[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"*

Similarly, Goyal and Welch (2002)[32] classify the predictability of returns in "*the long list of great ideas in economics that ultimately failed to live up to expectations".*[33] The authors draw the same findings in further research.[34] In addition, recent papers by Boudoukh, Richardson, Whitelaw (2008), Torous, Valkanov, and Yan (2004) and Lanne (2002)[35] do not find evidence for predictability of returns at long horizons.[36] Ian Cooper (1996), in widely cited work in regulatory contexts, reaches similar conclusions that the correct discount rates are closer to the arithmetic than the geometric mean.[37]

Indeed, 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*".[38] In this report, the authors saw no reason to change their stance relative to their 2003 report.[39]

[29] Wright, Burns, Mason, Pickford (2018), op. cit., p.40

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

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

[32] Goyal, and Welch (2002), Predicting the equity premium with dividend ratios

[33] Goyal, and Welch (2002), op.cit., p.16

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

[35] Lanne (2002), Testing the predictability of stock returns.

[36] Torous, Valkanov, and Yan (2004), On predicting stock returns with nearly integrated explanatory variables.

[37] Ian Cooper (1996) Arithmetic versus geometric mean estimators: Setting discount rates for capital budgeting, European Financial Management, Volume 2, Issue 2 European Financial Management banner

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

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

2.2.3. UKRN report ignores established approaches to derive unbiased estimators of TMR 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.[40]

The UKRN report ignores more established methods for estimating unbiased estimators of TMR for long investor horizons, and which also consider serial dependence of returns. These estimators support an unbiased estimator close to the arithmetic mean and provide for a more modest adjustment relative to magnitude of the adjustment proposed by the UKRN report (of up to one per cent), as we discuss below.

Blume (1974) was among the first to propose unbiased estimates of returns for investment horizons longer than a single period.[41] Blume shows that if the investment horizon (or holding period, N) is less than the period for which we have historical data (T), the historical arithmetic mean will provide an upward biased estimate of expected returns, whereas the geometric mean will provide a downward bias, and therefore an unbiased estimate will lie somewhere between the two. For a single period investment horizon, Blume notes that "*the arithmetic mean provides a superior estimate of the expected one-period relative compared to that provided by the geometric mean.*"[42]

Blume suggested a number of unbiased measures if the holding period N is longer than one year. These included:

- 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 is then used to form the expected return based on the arithmetic mean.
- 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:

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

[40] 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.

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

[42] Blume (1974) op. cit. p. 636.

Blume also considers the potential impact of predictability of returns on his proposed estimators. He concludes that:[43]

> *"if one cannot assume independence of successive one period relatives* [returns] *or if there is even a slight chance that these relatives are dependent, the simple average of N-period relatives would appear preferable* [relative to the other estimators]*."*

Jacquier, Kane and Marcus (JKM, 2005)[44] also derive an unbiased estimator of the expected return. As with Blume, the JKM estimator return 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.

Like Blume, JKM also consider the impact of predictability of returns on their unbiased estimator. Although they note that the predictability as "*far from uncontroversial*"[45], the authors find that allowing for predictability has *"little effect"*[46] on their estimators.

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

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).[48]

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 noted by UKRN, implies only a

[43] Blume (1974) op. cit. p. 638.

[44] 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.

[45] Jacquier, Kane, and Marcus (2005), op. cit., p.53.

[46] Jacquier, Kane, and Marcus (2005), op. cit., p.39.

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

[48] 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.

10 bps to 50 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.

Table 2.2 shows that the assumed holding period is an important factor in informing the adjustment to the simple arithmetic mean. 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 around 8 months as of December 2016.[49]
- 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.[50]
- Helm and Tindall (2009)[51] 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.

The evidence therefore supports holding periods of 1 to 5 years. Setting aside the simple average method where 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 where the estimates are not stable over time as a result,[52] 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. The implication is that the downward adjustment to the simple one period arithmetic average should be of the order of a maximum 30 bps, relative to UKRN's 1 per cent downward adjustment.

2.3. Conclusions on UKRN report recommendations

In this chapter, 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 an adjustment to the arithmetic average of the order of a maximum of 30 bps, smaller than UKRN's downward adjustment of up to 1 per cent.

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

[50] 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.

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

[52] 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.

3. A Real TMR Deflated by RPI Cannot be Applied in a CPI Context Without Adjustment

In the Ofgem-ENA workshop, Ofgem raised the following hypothesis: if investor's required compensation for inflation is based on the official inflation index at the time, which used to be RPI but is now CPI, it would be reasonable to use an historical RPI-deflated return (of around 7 per cent) and use this as a basis for a real return in a CPI regulatory framework, without any adjustment.

In other words, TMR could be reasonable deflated by RPI for the period in which RPI was the official measure of inflation, and this real TMR (RPI deflated) could be applied even where Ofgem adopts CPI indexation, and therefore investors receive compensation for inflation based on CPI.

In this section, we show that this is a new hypothesis without any regulatory or academic support. We conclude that the real TMR deflated by RPI must be adjusted to reflect well-known differences between RPI and CPI.

3.1. This Hypothesis is New and Represents A Substantive Departure from Regulatory Practice

At the ENA-Ofgem workshop, Ofgem raised the hypothesis that the TMR could be reasonably deflated by RPI for the period in which RPI was the official measure of inflation,[53] and this real TMR (RPI deflated) could be used as the basis to determine the real return even where Ofgem adopts CPI indexation given CPI's status as the official measure of inflation.

Ofgem's hypothesis was not considered by the authors of the UKRN report, despite the comprehensive nature of its research into issues of setting the cost of capital for regulated sectors. Indeed, as we explain in section 2, UKRN propose that under CPI indexation the real TMR should be calculated relative to historical CPI, and the report's authors draw on the Millennium CPI dataset to do so.[54] Although we have concerns with the Millennium CPI dataset,[55] it is clear that Ofgem's hypothesis contradicts the approach of the UKRN's authors.

If Ofgem were to adopt the approach of using a TMR deflated in RPI terms within a CPI regulatory framework, it would also contradict recent regulators' decisions on the cost of capital who have continued to allow a real RPI-deflated return plus RPI as compensation for inflation (as per the indexation of the regulated asset base), despite CPI being adopted as the official measure of inflation. Ofgem's hypothesis implies that all recent regulatory decisions (including RIIO-1, and CMA NIE 2014) have erred in not simply allowing for a CPI adjustment for inflation (as the official measure). However, we are not aware of any analysts or market commentators that have stated that allowing a real RPI deflated return plus RPI indexation, as allowed by Ofgem and CMA at all recent reviews, constitutes an error.

If Ofgem were to adopt such an approach, it would also mean that the switch to CPI indexation would not be revenue neutral to networks as they would receive lower allowed nominal revenues (based on RPI deflated TMR and CPI indexation), and would contradict regulators' undertaking that such a switch would or should be revenue neutral.[56] Under a CPI approach, Ofgem should ensure that

[53] For example, the UK government adopted CPI as its official measure for monetary targeting in 2003. Office for National Statistics (2012), International Comparison of the Formula Effect between RPI and CPI, p.1.

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

[55] NERA (May 2018) Review of UKRN recommendations on the appropriate inflation index for estimating historical TMR, Section 4.4

[56] While Ofgem does not commit to revenue neutrality explicitly, its RIIO-2 consultation implied that the switch to CPI should not have a material impact on allowed revenues. Source: Ofgem (March 2018) RIIO-2 Framework Consultation, p. 99, para 7.97. Otherwise, Ofwat has made an explicit commitment that the switch to CPI will be revenue neutral on

investors receive the same expected nominal TMR return that they would have earnt under an RPI regime, irrespective of the change to CPI.

Overall, in proposing a new framework for calculating real returns (i.e. real TMR deflated by RPI plus CPI indexation), Ofgem has to provide a coherent and compelling argument for its approach. Thus far this has not been offered.

Moreover, this approach is based on the theory that investors have always assumed the prevailing measures of inflation to be accurate representations of the true rate of inflation required as compensation. However, academics and policymakers have raised issues about the relevance of RPI as a measure of general price inflation at certain times in the past.[57] From these discussions, it is clear that investors and others considered both adjustments or alternatives to the formal RPI measure in forming their inflation expectations.

3.2. Conclusion: TMR deflated by CPI Must Be Adjusted Upwards If Applied in CPI Framework

In summary, Ofgem's hypothesis that it can use a RPI deflated TMR in a CPI framework without adjustment is a new hypothesis without any regulatory or academic support. It is also improbable that investors consider, without question, that the official index of inflation is the relevant or only measure of inflation in forming expectations of returns. We conclude that a real TMR deflated by RPI must be adjusted to reflect well-known differences between RPI and CPI where Ofgem switches to CPI indexation.

To estimate the equivalent *historical* TMR on a CPI-deflated basis, the historical RPI-deflated TMR should be adjusted using the historical RPI-CPI wedge. The wedge should be estimated from data post 1989 only, as no reliable CPI data exists prior to this period (as discussed in section 2.1). This supports a wedge of 71bps.[58]

For the purposes of determining a *forward-looking* CPI-deflated TMR for setting the cost of equity allowance at RIIO-2, the historical RPI-deflated TMR should be adjusted upwards by the *expected* RPI-CPI wedge, which is higher than the historical wedge at around 100 -130bps.[59] In doing so, the derived CPI-deflated TMR will provide the same nominal returns in expectations as using an RPI-deflated TMR, and therefore fulfill the legitimate expectations that any switch to CPI indexation will be revenue neutral.

company's nominal revenues. Source: Ofwat (December 2015) Water 2020: Regulatory framework for wholesale markets and PR19 price control review,p.125

[57] For example, since the 1970s, the RPI uses a combination of mortgage interest payments (MIPS) and house prices as a proxy for housing costs, which means that the RPI is heavily influenced by house prices and interest rates. The Treasury presented evidence to the RPI advisory committee in 1986 arguing that MIPS should be excluded from the index, as was already common practice in almost all other countries at the time. See Office for National Statistics (2018), Shortcomings of the Retail Prices Index as a measure of inflation, 8th March 2018, p.3; Department of Employment (1986), Retail Prices Index Advisory Committee, Methodological Issues Affecting the Retail Price Index, UK Government, July 1986, p.82; Lawson, N. (1989), UK Parliament – House of Commons – Commons Chamber, Oral Answers to Questions, National Finance, Inflation, 23 February 1989, vol. 147.

[58] See also: NERA (May 2018) Review of UKRN recommendations on the appropriate inflation index for estimating historical TMR, Section 4.4

[59] For example, the Bank of England estimates a forward-looking wedge of 130 bps. Bank of England (2015): Revised assumption for the long-run wedge between RPI and CPI inflation, Table A. Source: https://obr.uk/box/revised-assumption-for-the-long-run-wedge-between-rpi-and-cpi-inflation/. Ofwat has assumed a wedge for PR19 of 100 bps. Source: Ofwat (2017) Delivering Water 2020: Our methodology for the PR19 price control, Appendix 12, Aligning Risk and Return, p. 16

Qualifications, assumptions and limiting conditions

This report is for the exclusive use of the NERA Economic Consulting client named herein. This report is not intended for general circulation or publication, nor is it to be reproduced, quoted or distributed for any purpose without the prior written permission of NERA Economic Consulting. There are no third party beneficiaries with respect to this report, and NERA Economic Consulting does not accept any liability to any third party.

Information furnished by others, upon which all or portions of this report are based, is believed to be reliable but has not been independently verified, unless otherwise expressly indicated. Public information and industry and statistical data are from sources we deem to be reliable; however, we make no representation as to the accuracy or completeness of such information. The findings contained in this report may contain predictions based on current data and historical trends. Any such predictions are subject to inherent risks and uncertainties. NERA Economic Consulting accepts no responsibility for actual results or future events.

The opinions expressed in this report are valid only for the purpose stated herein and as of the date of this report. No obligation is assumed to revise this report to reflect changes, events or conditions, which occur subsequent to the date hereof.

All decisions in connection with the implementation or use of advice or recommendations contained in this report are the sole responsibility of the client. This report does not represent investment advice nor does it provide an opinion regarding the fairness of any transaction to any and all parties.

NERA
ECONOMIC CONSULTING

NERA Economic Consulting
Marble Arch House
66 Seymour Street
London, UK W1H 5BT