



Total Market Return

The consistency of long-run CPI and RPI inflation series in the UK, and their relative suitability for use in calculating the actual historic long-run average equity market return in the UK on a 'real' basis

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Overview

Executive Summary

A key question that has emerged during the development of the RIIO-2 framework concerns the inflation measure that should be applied to deflate the historic long-run average realised nominal total equity market return (TMR) to give an estimate of TMR on a real basis. This is a question that has been considered by a number of previous reports, including from Frontier Economics, Oxera and NERA. These reports have reviewed the data sources from which a long-run CPI dataset in the Bank of England's Millennium dataset has recently been compiled, and have shown that this CPI dataset does not provide a reliable measure of historical CPI inflation back to 1900 (or before), and so should not be used as a basis of estimating the historic average real TMR.

However, Ofgem continues to prefer - on the basis that there have been changes in the details of the calculation of RPI from time to time over the past 50+ years - converting the historic average nominal returns to 'real' using this historic CPI series, instead of using the long-run RPI series which is also included in the Millennium dataset and has been published for many years by the ONS, Bank of England, and House of Commons library.

This report further explains the context in which the historical inflation dataset should be considered when estimating TMR in this way. It also draws together some of the documentary evidence which has previously been identified by NERA and Frontier, and describes some additional references from the ONS and from others (including the authors of original source of the CPI series values from 1950 to 1988) which further illustrate that the Millennium databook's CPI series should not be considered reliable or accurate. It then presents some new simple numerical analysis which shows that the historic CPI series is unreliable and inconsistent, in contrast to the historic RPI series. This addresses a gap in Ofgem's approach, which appears to assume that the historic CPI series includes values that were calculated or estimated in a way that is consistent with and compatible with actual CPI as calculated since it was introduced in 1996, without properly testing whether this is in fact the case.

Taken together, the source documents that are referenced and the numerical analysis described provide evidence that the historic CPI dataset is not sufficiently reliable or consistently-estimated to be used to deflate nominal historic returns data to estimate TMR on a real basis, and the long-run RPI dataset should be used instead.

Ofgem's use of the historic CPI dataset instead of the equivalent RPI series to deflate the average historic nominal returns data results in a downwards reduction to the estimated TMR by almost 1%. On the basis of the evidence referenced and collated in this report, use of the RPI series should be preferred, instead of using the CPI series, on the basis of both reliability and accuracy (e.g. the values from 1900 to 1950 much better represent RPI rather than CPI).

This report does not consider other ways of estimating a forward-looking TMR (e.g. using Dividend Growth Models) which Ofgem has proposed to use as cross-checks of their main estimate based on realised historic returns. It does, though identify in an Appendix two other considerations that, whilst not 'inflation' issues *per se*, should be taken into account when estimating TMR from historic average returns. These concern (i) the time periods across which average returns are calculated and (ii) an apparent source of bias in the most commonly used source(s) of data on long-run average returns. It is shown that:

- use of either an earlier or later start date for the long-run averages generally leads to higher values of realised average (real) return, and so consideration of averages since 1900 only will give a downwards-biased estimate.

- the source of long-run equity return data in the UK that is most commonly used by UK regulators is, from 1900 to 1954, based on the returns for only the 100 largest companies each year. The average returns on larger companies are known to be lower on average than those on smaller companies, and so the average return since 1900 that is calculated from this data is likely to underestimate the average realised return on the whole of the UK equity market (i.e. the total market return).

Therefore, both these additional factors would be expected to cause the average return since 1900 that is usually calculated by regulators to be a downwards-biased estimate of TMR.

Context – why is a long-run inflation series needed?

For RIIO-2 Ofgem's main method for estimating the required level of equity returns is the Capital Asset Pricing Model. This model uses a number of input parameters including an estimate of Total Market Return (TMR), and as in past price controls Ofgem has decided to estimate the TMR by considering the historical long-run average of market returns as this is "*the best single objective estimate of investors' expectations of the future*"¹, while also placing due weight on forward-looking approaches.

Ofgem has also decided to set future price controls including RIIO-2 relative to CPI (or CPIH), rather than RPI as in the past, and so a value of TMR relative to CPI (or CPIH) is now needed. Estimates of the average historical realised TMR are typically made first on a nominal basis, and this can be used to give an estimate on a real basis relative to CPI² in 2 main ways, either:

- by subtracting the historical average long-run rate of RPI inflation over the relevant period from the average nominal return, to give a real return relative to RPI, and then adding the expected forward-looking 'wedge' between RPI and CPI³ to convert the result to a real return relative to CPI; or
- by subtracting the historical average long-run rate of CPI inflation over the relevant period from the average nominal returns, to give an estimate of the real return relative to CPI directly.

Whilst the second of these approaches may be the more direct, the uncertainty in the expected average forward-looking wedge between RPI and CPI is low (subject to any material changes in their calculation methodology), and so **which of these methods is more robust and accurate will depend primarily on which of the historic data series for RPI and for CPI is more reliable and consistent when considered across the full time-frame covered by the historic return dataset.**

The UKRN (2018) cost of capital report ⁴ said that "*The historical timeseries for the RPI has been subject to significant changes in its data construction overtime (most notably in its treatment of*

¹ "RIIO-2 Sector Specific Methodology Decision – Finance", Ofgem, 24 May 2019, paragraphs 3.44/3.45 https://www.ofgem.gov.uk/system/files/docs/2019/05/riio-2_sector_specific_methodology_decision_-_finance.pdf

² The rest of this report refers to and focusses on CPI rather than CPIH as we are not aware of any long-term historic series for CPIH values

³ This wedge being estimated assuming RPI and CPI continue to be calculated as at present

⁴ "Estimating the cost of capital for implementation of price controls by UK Regulators", Wright, Burns, Mason and Pickford for the UKRN, March 2018, <https://www.ukrn.org.uk/wp-content/uploads/2018/06/2018-CoE-Study.pdf>

housing costs) which make it hard to use the RPI to derive consistent historic estimates of real returns. In contrast, the ONS and the Bank of England have published consistent historical estimates of the CPI. We understand from discussions with the ONS that similar long-term series for CPIH is also under development.” Consistent with this thinking, Ofgem now proposes to use the second method listed above, i.e. to subtract the average rate of CPI inflation from the average rate of nominal returns to give an estimate of the real return relative to CPI directly.

In choosing this approach, Ofgem, and the authors of the UKRN report which Ofgem have relied on, start from the presumption that a modelled ‘backseries’ of CPI values, which cover the years from 1950 to 1988 and are used for this section of the full historic CPI dataset, is reliable. However, this backseries was published by the ONS as “**work in progress**” and the ONS explained that “*these modelled estimates can only be considered as **broad indications of the level of the CPI series** at best and caution should be exercised when using these series*”⁵. Furthermore, the difference between these numbers and actual RPI values in these years appears then to be used to support the view that CPI and RPI converge as you move further back in time. This appears in turn to have been used by Ofgem/UKRN to justify a second presumption, that implied consumers’ expenditure deflators (CEDs) taken from the estimated National Accounts from 1900 to 1948 can simultaneously provide a good measure of both RPI and CPI in these years (or even that the CEDs better represent CPI than RPI). If, instead of starting from the first of these presumptions, Ofgem (and the UKRN report) had first questioned the reliability of the CPI backseries from 1950 to 1988 and tested this using analysis such as that presented in this report, both these presumptions would have been seen to be unsafe.

Ofgem (and the UKRN report) appears to have considered that the CPI backseries covering 1950 to 1988 was reliable and that CED deflators from 1900 to 1950 gave a good representation of CPI (as now calculated), without seeking to test or check this by comparing the deflators to CPI over the subsequent period for which actual CPI values and CED deflators on a basis comparable to those from 1900 to 1950 both exist (i.e. from 1988 to 2009). This report presents the results of such a check, which is found to show that Ofgem’s presumptions and approach will lead to an unreliable and downwards-biased estimate of TMR.

In making this assumption the UKRN report (and thus Ofgem) appears to attach weight⁶ to the fact that the CPI backseries is described as a ‘preferred CPI series’ and was published by the Bank of England (in its Millennium dataset)⁷, on the basis that they should ‘outsource’ the choice of preferred inflation measure to the Bank of England. However, this overlooks the following key points, and when these are taken into account there can be no presumption that the Millennium dataset values can be relied on in this context:

- the Millennium dataset contains a series of caveats that make clear the values within it cannot be relied on without carefully reviewing them and the sources from which they are taken. For example, the spreadsheet says that it should be viewed as “*work in progress*”, “*the Bank of England makes no representations or warranties as to the accuracy or completeness of the information*”; and perhaps most importantly “*users are always advised to consult the original sources as a crosscheck*”.

⁵ O’Neil and Ralph, “*Modelling a Back Series for the Consumer Price Index*”, ONS, released July 2014: <https://www.ebarchive.nationalarchives.gov.uk/20151014001752/http://www.ons.gov.uk/ons/rel/cpi/modelling-a-back-series-for-the-consumer-price-index/1950---2011/index.html>

⁶ See e.g. “*Estimating the cost of capital for implementation of price controls by UK Regulators*”, Wright, Burns, Mason and Pickford for the UKRN, March 2018, pages 30/31 and D-122, https://www.ukrn.org.uk/w_p-content/uploads/2018/06/2018-CoE-Study.pdf

⁷ Thomas, R and Dimsdale, N (2017) “*A Millennium of UK Data*”, Bank of England OBRA dataset,

- the 'preferred CPI' series is only 'preferred' in the sense that an alternative CPI series (the 'original CPI' series) is also included in the Millennium dataset: it does not indicate that this is preferred to the RPI series⁸. The 'original' and 'preferred' CPI series are identical from 1914 onwards, and (as explained in this report) when the source used for the 'preferred' series values from 1900 to 1914 is reviewed, it is found that this is an inflation estimate for the working-class only, covering c.52% of the expenditure of all households. These values are therefore not an estimate of inflation for the population as a whole, and if either of the CPI series were to be used, this should be the 'original' series, which has a more complete coverage and uses the same source for inflation values between 1900 and 1914 as from 1914 to 1950.

One example of the changes in RPI over time which Ofgem makes specific reference to is the increase in the 'formula effect' component of RPI around 2010. Ofgem's SSMD⁹ even presents a graph in Figure 4 to illustrate this, and refers to it in its letter of 31st December 2019 to the CMA¹⁰. However, this graph does not show the full difference between RPI and CPI. It instead shows just one component, and for reasons discussed by the OBR in 2015¹¹ the corresponding c.0.4% increase in RPI and thus the average 'RPI-CPI wedge' in 2010 which had been expected (and which Ofgem used in 2013 in the context of RIIO-ED1 to justify a 0.4% reduction in TMR) has not in fact materialised. This is illustrated by the table below; over 9 years have now elapsed since the changes in 2010, and the average wedge between RPI and CPI across this period is compared in this table to the corresponding average wedge prior to the change, both for the preceding 9 years and across the full period for which actual CPI values (or reliable estimates) exist (i.e. from 1988).

| | Arithmetic average Formula Effect ¹² | Arithmetic average of RPI - CPI ¹³ |
|--------------------------------------------------------------------------|----------------------------------------------------|--------------------------------------------------|
| 1988 to 2009 (from the Millennium databook's RPI & CPI values) | Not known | 0.70% |
| 2000 to 2009 | 0.35% | 0.76% |
| 2011 to 2019 | 0.67% | 0.79% |
| Increase between 2000-09 and 2011-19 | 0.32% | 0.03% |

⁸ To the contrary, the Bank of England's online 'Inflation calculator', which enables comparisons of changes in price over the long-term, uses the ONS's 'composite price index' series from 1750 onwards, and thus the same values as the Millennium dataset RPI series, including the actual published Retail Price Index since it started in 1947 to 2019: <https://www.bankofengland.co.uk/monetary-policy/inflation/inflation-calculator>, accessed 23/1/20

⁹ "RIIO-2 Sector Specific Methodology Decision – Finance", Ofgem, 24 May 2019, Figure 4, https://www.ofgem.gov.uk/system/files/docs/2019/05/riio-2_sector_specific_methodology_decision_-_finance.pdf

¹⁰ Ofgem's letter to the CMA of 31 December 2019, "NATS En-route Limited (NERL) RP3 Price Control Determination", https://assets.publishing.service.gov.uk/media/5e0f650340f0b6280cec1aa0/Ofgem_representation_letter_redacted.pdf

¹¹ "Economic and Fiscal Outlook", OBR, March 2015, see Box 3.3, <https://obr.uk/box/revised-assumption-for-the-long-run-wedge-between-rpi-and-cpi-inflation/>

¹² Averages of the impact of the formula effect on the 12-month percentage change in RPI in each month during the relevant time periods, taken from Table 35b in the ONS's January 2020 published spreadsheet of CPI and RPI values. The formula effect values from Table 35b are used here instead of those in the ONS's Tables 5a or 5b in order to allow a comparison of the formula effect before and after 2010 using data from a single source. (Note that Table 35b shows the impact on RPI of replacing the Carli averaging formula with the Jevons formula: in contrast the 'formula effect' values in tables 5a and 5b show what the impact on CPI and RPI would be of using the Carli averaging formula, and these overstate the true formula effect, i.e. the impact on RPI values.)

<https://www.ons.gov.uk/economy/inflationandpriceindices/datasets/consumerpriceinflation/current>.

¹³ *Ibid* (for averages from 2000 to 2009 and from 2011 to 2019, which are calculated from the RPI and CPI index values in tables 36 and 20a); for the index values used to calculate the average from 1988 to 2009 see instead Thomas, R and Dimsdale, N (2017) "A Millennium of UK Data", Bank of England OBRA dataset: <https://www.bankofengland.co.uk/statistics/research-datasets>

The lack of any step change in the difference between RPI and CPI in 2010 suggests that, to the extent that changes in RPI in 2010 might mean that this is an inconsistent measure over time, the same would be equally true of CPI.

The Historic CPI Dataseries used by Ofgem does not claim to be reliable

As noted above, the Bank of England does not claim the Millennium dataset provides reliable or accurate values and refers users of the data to the sources from which values are taken. When the sources of the CPI dataseries are reviewed, it is found that these also do not claim to give reliable or accurate values of CPI.

CPI has only been calculated since 1996, and reliable estimates only exist back to 1988 (as the detailed price data that would be needed to calculate actual CPI values in years prior to 1988 have not been retained¹⁴ by the ONS).

The preceding part of the Millennium databook CPI series (1950 to 1988) uses values from **an indicative ‘work in progress’ backseries of ‘modelled estimates’ of CPI produced in 2013 by the ONS**. Multiple reservations and concerns have been expressed regarding these values, not only in the 2014 paper itself which published and described this backseries¹⁵, but also in other ONS documents, and in a recent book on the history of inflation measures which was written by the authors of the ONS’s paper which published the backseries. These reservations are documented more fully in the main body of this report, but include the following:

- in the ONS paper itself, “*Modelling a Back Series for the Consumer Price Index*” by O’Neill and Ralph, released in 2014, reservations are expressed by the authors regarding the results which show that they did not consider the results could be relied upon. It is also clear that these values were not even an attempt to calculate actual CPI values during these years, but are just a modelled dataset that might or might not give values that are comparable to the CPI that would have been reported if CPI had actually been measured prior to 1988. For example¹⁶:
 - a. the covering page of the ONS paper says it describes “***work in progress on modelled back series for the CPI; further work is taking place and may result in changes to the series presented here.***”
 - b. The introduction explains that: “***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.***”
 - c. In Section 5 the paper explains that “***It is difficult to assess the accuracy of the series, as the true CPI can never be known. For that reason it is also worth emphasising that these modelled estimates can only be considered as broad***

¹⁴ O’Neill and Ralph, “*Modelling a Back Series for the Consumer Price Index*”, ONS, released July 2014 (<https://www.ebarchive.nationalarchives.gov.uk/20151014001752/http://www.ons.gov.uk/ons/rel/cpi/modelling-a-back-series-for-the-consumer-price-index/1950---2011/index.html>), see page 3 “... sufficient data to calculate the CPI do not exist prior to 1987” and footnote 3 “In order to estimate the CPI we would need access to price quotes and expenditure information for the years in question, none of which, in general, are available”

¹⁵ *Ibid*

¹⁶ Note that in these extracts, and in later extracts and quotations through this report, we have in some cases added emphasis in bold to aid the reader.

Indications of the level of the CPI series at best and caution should be exercised when using these series. For the same reason, these estimates are not National Statistics.

- d. On page 10 the paper notes that *“The ARIMA model utilised in this paper is one of a number of approaches investigated in the early stages of this research, and is chosen as it produces formula effects which look most realistic. **Other models may produce alternative formula effect backcasts.** In addition, we choose to include variables relating to the level of the RPI and incidences of recessions; however, there are a number of other effects, such as January effects, **which may be modelled and produce results which contrast with our own. Hence there are many ways in which the modelling approach taken might be augmented or re-designed with alternative series produced.**”*
- e. In addition, the results presented in the paper itself should themselves immediately call into question the reliability of the modelled values: for example, Table 1 in the ONS paper¹⁷ shows that the average contributions to the formula effect for different categories of spend are in several cases very different during the modelled period from those in the subsequent years (from 1988) during which actual values of RPI and CPI both existed, and in a number of cases these even change sign between the two periods. In commenting on this table, the paper itself notes that *“**This may demonstrate a potential weakness of the modelling technique employed in these series and emphasises the approximate nature of the backcasts.**”*
- Similarly, wherever the 2014 edition of the ONS’s *“Consumer Price Indices Technical Manual”* refers to the CPI modelled backseries, it observes that *“these are indicative, modelled figures which should be treated with some caution”*. This is in marked contrast to the discussion of the Retail Price Index in Chapter 10 in the Technical Manual, which explains that RPI is preferred to CPI for making long-term comparisons of the purchasing power of the pound. *“In the UK, the RPI has measured changes in the level of consumer prices since 1947. It is therefore preferred to other sources (such as the CPI which has a much shorter history), for comparing the purchasing power of the pound over this period.”*
 - Furthermore the authors of the ONS’s 2013 paper *“Modelling a Back Series for the Consumer Price Index”* (i.e. O’Neill and Ralph) have more recently written a book on the history of Inflation¹⁸. In this book they contrast the reliability of the historic time series for RPI and CPI in the following way: *“**There is another, different attribute of the [RPI] measure that came out of the RPI consultation – its value as a long-running measure produced on similar terms. The CPI, in contrast, was only introduced in 1996. To help with economic modelling, the CPI was calculated back to 1989 using price microdata that had been retained; the microdata for the period before 1989 had not been kept. Despite the lack of such data, ONS was asked to produce a version of the CPI back to 1950. To achieve this, a set of modelled series were produced using time series techniques (O’Neill and Ralph 2014).**” This shows that even the authors of the modelled backseries did not consider it to provide reliable estimates of CPI, at least in comparison to the RPI series which, in spite of the changes in its detailed construction over time which are described in detail in the book, they recognise has value as a ‘long-running measure produced on similar terms’.*
 - In addition, a recent statement on CPIH and CPI backseries from the ONS has reinforced that the existing CPI backseries cannot be relied upon, and furthermore the ONS is going to update these values (though it is unclear whether the resulting update will itself be able

¹⁷ *Ibid*

¹⁸ *“Inflation History and Measurement”*, O’Neill, Ralph and Smith, 2017, ISBN 978-3-319-64124-9, published by Palgrave Macmillan.

to give robust and reliable figures for CPI back to 1947)¹⁹. Referring to the existing backseries, the statement says “*The ONS previously published **indicative modelled estimates** for the CPI between 1947 and 1987. **These estimates are for analytical purposes only and are not intended for official uses.***”

Moving back further in time, the next section of the historic CPI data series from 1900²⁰ to 1950 uses implied Consumers’ Expenditure Deflators that are calculated from the estimated National Accounts published in 1972 by Feinstein²¹. (These values are also used for these years in the Millennium databook’s RPI series). Considering these deflators:

- In the light of the reservations expressed in the Bank of England Millennium dataset itself (see above), the fact that the deflators derived from Feinstein’s estimated National Accounts are used for the Millennium databook’s CPI series up to 1949 cannot be considered evidence that the Bank of England considered them a reliable estimate of CPI, especially when these same values were also used in the corresponding RPI series in these years. Rather, it merely indicates an absence of any other known sources of CPI values prior to 1950, and by itself it says nothing about whether the values better represent RPI or CPI.
- **Moreover, the ONS have recently confirmed to Oxera that these values are likely to be based on underlying series constructed using a methodology comparable to RPI, and so the consumers’ expenditure deflator series would contain the upward influence of the RPI formula effect, and so would overstate CPI inflation²².** Thus, these deflator values cannot be considered to give an indication of CPI values during these years, but can be considered representative of RPI.
- This conclusion is consistent with the discussion in the ONS’s “Consumer Price Indices Technical Manual” (2014 edition)²³, which explains that the deflators derived from Feinstein’s (1972) national accounts are used by the ONS in a longer-term series that was produced for longer term comparisons of RPI rather than CPI. The manual explains in the Retail Price Index chapter (Chapter 10) that RPI is preferred to CPI for making long-term comparisons of the purchasing power of the pound, noting that “*In the UK, the RPI has measured changes in the level of consumer prices since 1947. It is therefore preferred to other sources (such as the CPI which has a much shorter history), for comparing the purchasing power of the pound over this period.*”
- Consistent with this, the CED deflators derived from Feinstein’s estimated national accounts have in the past been consistently interpreted as comparable to RPI, not only by the ONS, but also by the House of Commons library²⁴ and the Bank of England²⁵. This corroborates the view that the deflators should be seen as comparable to RPI rather than CPI.

¹⁹ ONS statement “*Developing CPIH and CPI historical estimates between 1947 and 1987*”, 10/10/2019, https://www.ons.gov.uk/new_s/statementsandletters/developingcpihandcpihistoricalesimatesbetween1947and1987

²⁰ This is for the ‘original series’ in the Millennium databook – as explained above, for the ‘preferred series’ these deflator values are used from 1914 to 1950, with an inflation measure for the working class only being used from 1900 to 1914.

²¹ “*National Income Expenditure and Output of the United Kingdom 1855 – 1965*”, C H Feinstein, Cambridge University Press, 1972, ISBN 0 521 07230 1

²² “*The cost of equity for RIIO-2*”, Q4 2019 update prepared by Oxera for Energy Networks Association, November 2019, see page 16, <https://www.oxera.com/wp-content/uploads/2018/01/Cost-of-equity-for-RIIO-2- Q4-2019-update.pdf>

²³ See the ONS’s 2014 “*Consumers Prices Technical Manual*”, <https://web.archive.nationalarchives.gov.uk/20160109133536/http://www.ons.gov.uk/ons/rel/cpi/consumer-price-indices---technical-manual/2014/index.html>

²⁴ See e.g. House of Commons Research paper “*Inflation: The value of the Pound 1750 – 2002*” which was published on 11/11/2003, <https://researchbriefings.files.parliament.uk/documents/RP03-82/RP03-82.pdf>

²⁵ See for example the Bank of England’s online ‘Inflation calculator’, <https://www.bankofengland.co.uk/monetary-policy/inflation/inflation-calculator>, accessed 23/1/20

Numerical Analysis and Results

The data sources used for the historic RPI and CPI series from 1900 to 2018 are the following. Considering first CPI:

- Values for years prior to 1950 are the Consumers' Expenditure Deflators (CEDs) calculated from Feinstein's (1972) estimated National Accounts (described above);
- Values of CPI from 1950 to 1988 are taken from the modelled backseries published by the ONS in 2014 as "work in progress" (also described above).
- Values from 1988 to 1996 are retrospectively calculated estimates from the ONS which were based on detailed price data that had been retained and so can be considered to be likely to be accurate and reliable;
- Values from 1996 onwards are actual published CPI values from the ONS.

In contrast, the RPI values are based on just 2 sources:

- From 1900 to 1948, the RPI values use the same CED deflators based on Feinstein's (1972) estimated National Accounts as the CPI series;
- The RPI values in all subsequent years are published values from the ONS (or its predecessor): from 1948 to 1956 these used the unofficial 'Index of Retail Prices' which was being developed during these years; and from 1956 onwards it uses the official published values of the Retail Price Index.

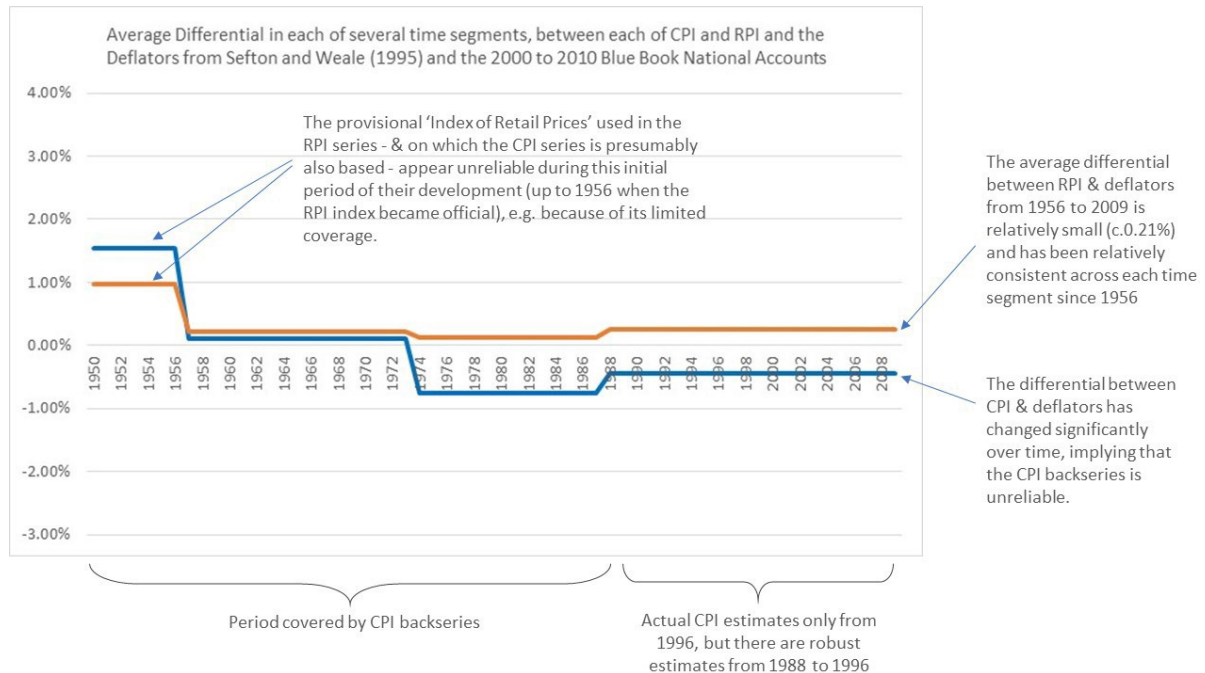
Thus, the historic RPI and CPI series both use the same set of Consumers' Expenditure deflators taken from National Accounts for the years from 1900 to c.1949. CED Deflators on a consistent basis to these appear also to be available for the years 1950 to 2009²⁶, and when these are compared to the RPI and CPI data series values in these years it is found that:

- i) across the full period (1988 to 2009) for which (a) deflators on this basis and (b) robust values of CPI (actuals or reliable estimates) both exist, the average value of these deflators is substantially higher than the average CPI;
- ii) the CED deflators from 1900 to 1950 (or indeed from 1950 to 1988) can't therefore be seen as a good indication of CPI as now calculated in those years (as the deflators are on average much higher than CPI from 1988 to 2009);
- iii) the CPI backseries from 1950 to 1988 appears inconsistent over time, suggesting it is unreliable; and
- iv) in contrast, the closer and more consistent agreement of the deflators and RPI that is observed, on average, across the full period of more than 50 years from 1956 (when the official RPI index was first introduced) until 2009²⁷ - in spite of the changes from time to time in the details of the calculation of RPI - gives confidence that the consistently-calculated CED deflators from 1900 to 1956 should be a good approximation to RPI.

²⁶ A change was made to the 'Blue Book' National Accounts between the 2010 and 2011 Editions, which means that equivalent consumers' expenditure deflators on a consistent basis are unfortunately not available for years after 2009.

²⁷ On average across each of three separate timeframes since 1956 considered, i.e. from 1957 to 1973; 1974 to 1987, and 1988 to 2009.

These results are illustrated by the following chart, in which the blue line compares the average differences between CPI and the deflators in each of several time-segments (i.e. 1950 to 1956, when the official RPI series was first introduced; 1957 to 1973, as 1974 seems to mark the start of a shift in the pattern of the modelled CPI backseries values²⁸; 1974 to 1987 covering the remainder of the CPI backseries; and from 1988 onwards, which are the only years for which accurate estimates of CPI or actual CPI values exist). The corresponding average differences between RPI and the deflators in each of these time segments is also shown (see the orange line in the chart).



As noted earlier, consumers' expenditure deflators on a consistent basis to these do not appear to be available for years after 2009, and so the above chart cannot be extended further and brought fully up-to-date. However, Ofgem/UKRN²⁹ appear to take the view that the CPI values since 1988 have been calculated on a consistent basis, and as shown by the Table above, there was no material change in 2010 in the average differential between RPI and CPI. It therefore follows from the level of agreement between RPI and CED deflators in the years prior to 2009 that is illustrated by the above chart that these deflators (in years prior to 2009) should equally be consistent with RPI as calculated since 2010.

Conclusions and Implications

This report supplements the earlier reports prepared by NERA, Frontier Economics and Oxera referred to above. These reports have reviewed the datasources used by the Bank of England's Millennium dataset and concluded that:

²⁸ See Figure 3 on page 13 of "Modelling a Back Series for the Consumer Price Index" by Robert O'Neill and Jeff Ralph, ONS, published in 2014

<https://www.ebarchive.nationalarchives.gov.uk/20151014001752/http://www.ons.gov.uk/ons/re/cpi/modelling-a-back-series-for-the-consumer-price-index/1950--2011/index.html>

²⁹ See e.g. "Estimating the cost of capital for implementation of price controls by UK Regulators", Wright, Burns, Mason and Pickford for the UKRN, March 2018, Table D.1 on page D-113 and pages D-120/121, <https://www.ukrn.org.uk/wp-content/uploads/2018/06/2018-CoE-Study.pdf>

- *“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”³⁰;*
- *“Given how the historic “CPI” data has been constructed ... it cannot possibly be regarded as consistent with actual published ONS CPI as it is presently prepared”³¹; and*
- *“It appears likely that both the measures of CPI inflation in the Millennium Data Book are upwardly biased estimates of the underlying CPI inflation.”³²*

This report now identifies additional references which show that the CPI dataseries should not be relied on. It then supports the conclusion that the CPI series should not be used when estimating TMR from historic returns data by providing new numerical analysis to show that the Bank of England’s Millennium databook CPI dataseries (both the ‘original’ series and the ‘preferred’ series) do not accurately or reliably give the values that CPI would have had if it actually had been measured over the long-term (i.e. from 1900 to 1988, where 1988 is the first year for which reliable CPI values actually exist). In contrast, this analysis adds support to the view that the Millennium databook’s long-run RPI series does provide a much better representation of RPI as it is now calculated across the full period under consideration (1899 to 2018). This undermines the validity of using the Millennium databook’s CPI series to deflate nominal historic realised equity returns to give an estimate of TMR on a ‘real’ basis, whilst providing support for use of the RPI series instead.

Whilst the analysis shows a good level of agreement, on average, between the consistently-formulated CED deflator series and RPI, it suggests a possible and very minor improvement to the Bank of England Millennium databook’s RPI series. This would involve replacing the RPI series values between 1948 and 1956, which currently use values of the unofficial ‘index of retail prices’ which was being developed and constantly revised during these years, with the CED deflator values taken from the same source as the Millennium databook’s RPI values in the preceding years (1900 to 1948). The impact on average RPI from 1900 to 2016 would, though, be small (a reduction of <0.1%). The case for making this change to the values from 1948 to 1956 would be supported by the 1998 edition of the ONS’s “Retail Prices Index Technical Manual”³³, which would also suggest that the RPI values in the series should be replaced by the deflators from 1956 to 1962 as well, though these additional changes (from 1956 to 1962) would have an immaterial impact on the overall average RPI from 1900 to 2016.

In addition, it could be argued that the numerical analysis in this report would suggest another minor adjustment to the RPI series, perhaps as a sensitivity, which would involve replacing the CED values from 1900 to 1948 (or to 1956) with the CED uplifted by 0.2% p.a. The overall impact on average RPI from 1900 to 2016 is again small (in this case an increase of c.0.1%).

³⁰ “Review of UKRN Report Recommendations on TMR”, a report by NERA for the Energy Network Association, 20 November 2018 (- this is referred to as consultancy report 7 in Ofgem’s May 2019 SSMD Finance Annex; see response documents on webpage <https://www.ofgem.gov.uk/publications-and-updates/rrio-2-sector-specific-methodology-consultation>, where the report is filed with the ENA’s response in the ‘A to E’ responses section)

³¹ “INFLATION IN THE CONTEXT OF REAL TMR”, a note for the ENA prepared by Phil Burns, supported by Mike Huggins, Rob Francis and Michael Yang of Frontier Economics, 13 March 2019 (see response documents on webpage <https://www.ofgem.gov.uk/publications-and-updates/rrio-2-sector-specific-methodology-consultation>, filed with the ENA’s response in the ‘A to E’ responses section)

³² “The cost of equity for RIIO-2”, Q4 2019 update prepared by Oxera for Energy Networks Association, November 2019, <https://www.oxera.com/wp-content/uploads/2018/01/Cost-of-equity-for-RIIO-2-Q4-2019-update.pdf>

³³ See “The Retail Prices Index Technical Manual”, 1998 edition, page 65; <https://www.ebarchive.nationalarchives.gov.uk/20100520003610/http://www.statistics.gov.uk/STATBASE/Product.asp?vlnk=2328>

The results and implications for estimates of TMR are illustrated by the following Tables, in which the best justified values are those based on RPI which are shown in yellow highlight, whereas for comparison the approach which Ofgem has used as the basis of its long-run historic average TMR estimate, starting from the Millennium dataset's CPI series, is highlighted in green. The tables show that Ofgem's approach to inflation will reduce the estimates of TMR based on long-run average returns by almost 1% relative to use of the best justified inflation series.

| | Long-run arithmetic average inflation (1900-2016) | Arithmetic average nominal UK market return from 1900-2016 (from DMS) ³⁴ | Implied TMR relative to CPI for RIIO-T2 |
|-------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|-------------------------------------------------------------------------------------|-----------------------------------------|
| BoE Millennium databook RPI series | 4.33% | 11.20% | 7.70%* |
| BoE Millennium databook RPI series – with values from 1948 to 1956 replaced by deflators (CEDs) | 4.26% | 11.20% | 7.77%* |
| BoE Millennium databook RPI series – with values from 1900 to 1956 increased by 0.2% (i.e. set equal to the CED + 0.2%) | 4.36% | 11.20% | 7.67%* |
| RPI back-series as estimated by Oxera ³⁵ | 4.32%+ to 4.63%+ | 11.20% | See Oxera report page 15 |
| BoE Millennium databook CPI preferred series | 4.10% | 11.20% | 6.82% |
| BoE Millennium databook CPI original series | 4.06% | 11.20% | 6.86% |

* These values are implied from the long-run average using the Millennium databook RPI series in the first row above, and Oxera's comment "The preliminary analysis indicated that the average inflation based on a restated RPI series over the period 1899–2016 could be up to 1bp lower or 30bp higher than if based on the official RPI series published by the ONS."

* Assuming a forward-looking wedge between RPI and CPI of 1.049%, consistent with Ofgem's working assumption in the RIIO-2 SSMD

³⁴ From "Credit Suisse Global Investment Returns Yearbook 2019" by Eroy Dimson, Paul Marsh and Mike Staunton, published in February 2019 by the Credit Suisse Research Institute, ISBN 978-3-9524302-8-6

³⁵ "The cost of equity for RIIO-2", Q4 2019 update prepared by Oxera for Energy Networks Association, November 2019, page 15, <https://www.oxera.com/wp-content/uploads/2018/01/Cost-of-equity-for-RIIO-2-Q4-2019-update.pdf>

| | Long-run geometric average inflation (1900-2016) | Geometric average nominal UK market return from 1900-2016 (from DMS ³⁶) | Implied geometric average historic market return relative to CPI | Implied TMR relative to CPI for RIIO-T2 (using Ofgem's 0.77% to 1.77% uplift)** |
|-------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-------------------------------------------------------------------------------------|------------------------------------------------------------------|---------------------------------------------------------------------------------|
| BoE Millennium databook RPI series | 4.17% | 9.38% | 6.10%* | 6.87% to 7.87% |
| BoE Millennium databook RPI series – with values from 1948 to 1956 replaced by deflators (CEDs) | 4.10% | 9.38% | 6.17%* | 6.94% to 7.94% |
| BoE Millennium databook RPI series – with values from 1900 to 1956 increased by 0.2% (i.e. set equal to the CED + 0.2%) | 4.20% | 9.38% | 6.07%* | 6.84% to 7.84% |
| RPI back-series as estimated by Oxera (see November update report page 15) | 4.16%+ to 4.47%+ | 9.38% | 5.80% to 6.11%* | See Oxera report page 15 |
| BoE Millennium databook CPI preferred series | 3.95% | 9.38% | 5.22% | 5.99% to 6.99% |
| BoE Millennium databook CPI original series | 3.91% | 9.38% | 5.26% | 6.03% to 7.03% |

* These values are implied from the long-run average using the Millennium databook RPI series in the first row above, and Oxera's comment "The preliminary analysis indicated that the average inflation based on a restated RPI series over the period 1899–2016 could be up to 1bp lower or 30bp higher than if based on the official RPI series published by the ONS."

* Assuming a forward-looking wedge between RPI and CR of 1.049%, consistent with Ofgem's working assumption in the RIIO-2 SSMD.

** These values have been produced on a consistent basis, i.e. using the same value of the 'geometric to arithmetic' uplift in each case as used by Ofgem in the SSMD, to illustrate most clearly the impact of the different inflation measures on estimated TMR. This does not mean that we agree with this level of uplift, especially the values in the bottom half of the range which are not consistent with reasonable estimates of holding periods. See the discussion of this in, for example, Oxera's 2018 and 2019 reports for the ENA, and NERA's April 2019 report for Scottish Power Transmission for further information. ³⁷

³⁶ From "Credit Suisse Global Investment Returns Yearbook 2019" by Eloy Dimson, Paul Marsh and Mike Staunton, published in February 2019 by the Credit Suisse Research Institute, ISBN 978-3-9524302-8-6

³⁷ "The cost of equity for RIIO-2: A review of the evidence" prepared by Oxera for the ENA, 28 February 2018 https://www.oxera.com/w_p-content/uploads/2018/07/ENA-cost-of-equity_2018-02-28.pdf; "The cost of equity for RIIO-2", Q4 2019 update prepared by Oxera for Energy Networks Association, November 2019 https://www.oxera.com/w_p-content/uploads/2018/01/Cost-of-equity-for-RIIO-2- Q4-2019-update.pdf; and "Cost of Equity for SPT in RIIO-T2: Report for Scottish Power Transmission plc", 19 April 2019, NERA, Section 2.3.1, pages 16 to 19 (see response documents on webpage <https://www.ofgem.gov.uk/publications-and-updates/riio-2-sector-specific-methodology-consultation>).

CONTEXT AND BACKGROUND

- 1) Previous price controls across many regulated industry sectors in the UK have been set on a 'real' basis relative to RPI, but a number of regulators, including Ofgem and Ofwat, are now considering a switch from RPI to CPI (or CPIH). In considering this change, it is important to distinguish between two separate questions:
 - First, what is now the preferred inflation index (RPI, CPI or CPIH) which should be used to inflate future allowed returns, RAV values, revenues, etc during a price control;
 - Second, what is the most robust basis for setting the allowed 'real' return relative to this preferred inflation index.
- 2) These two questions need to be considered and answered separately - i.e. the answer to one does not depend on the other - and it is the second of these questions that is the subject of this report. Although Ofgem has expressed an intention to switch to CPI (or CPIH) for inflating future revenues, the second question remains open. Ofgem's main method for estimating the required level of equity returns is the CAPM, and so a value for the Total Market Return (TMR) parameter expressed relative to CPI (or CPIH) is now needed.
- 3) The main and most objective method for estimating TMR is to calculate the average realised total market return over a long period (and in past price controls UK regulators have typically considered this average return over the period from 1899 to the present day). Consistent with this, Ofgem has decided that for RIIO-2 they will estimate the TMR by considering the historical long-run average of market returns as the best single objective estimate of investors' expectations of the future³⁸, with other (forward-looking) approaches being used as a cross-check. Since estimates of the average historical realised return are typically made first on a nominal basis, this figure needs to be converted to a 'real' basis by removing the component of nominal returns that is attributable to inflation.

What is the most robust basis for calculating the historic average realised return on a real basis?

- 4) If a real return relative to CPI is now needed, this can be estimated in 2 main ways, either:
 - a. by subtracting the average rate of RPI inflation over the relevant period (from 1899) from the average nominal returns, to give a real return relative to RPI, and then adding the expected forward-looking 'wedge' between RPI and CPI³⁹ to convert the result to a real return relative to CPI; or
 - b. by subtracting the average rate of CPI inflation since 1899 from the average rate of nominal returns, to give an estimate of the real return relative to CPI directly.
- 5) Whilst this second approach would appear the more direct, the uncertainty in the expected average forward-looking wedge between RPI and CPI (as each are currently calculated) is low⁴⁰, and so which of the methods is the more accurate - and should therefore be used - will depend primarily on which of the historic data series for RPI and for CPI is the more consistently estimated and reliable.

³⁸ "RIIO-2 Sector Specific Methodology Decision – Finance", Ofgem, 24 May 2019, paragraphs 3.44/3.45, 3.48 and 3.104, https://www.ofgem.gov.uk/system/files/docs/2019/05/riio-2_sector_specific_methodology_decision_-_finance.pdf

³⁹ Where this wedge is estimated assuming RPI and CPI continue to be calculated as at present

⁴⁰ The forward-looking wedge between RPI and CPI is generally expected to average around 1%, albeit fluctuations from year to year are to be expected, and the size of this wedge is obviously subject to any future changes in how they are calculated.

- 6) The UKRN (2018) cost of capital report⁴¹ said that “*The historical time series for the RPI has been subject to significant changes in its data construction over time (most notably in its treatment of housing costs) which make it hard to use the RPI to derive consistent historic estimates of real returns. In contrast, the ONS and the Bank of England have published consistent historical estimates of the CPI. We understand from discussions with the ONS that similar long-term series for CPIH is also under development.*” Ofgem and some other regulators, prompted by this UKRN report, have been considering switching from use of RPI to use of CPI to deflate the historic realised nominal equity market return to give the average realised return on a real basis as an estimate of Total Market Return (TMR). Consistent with this thinking, Ofgem now proposes⁴² to use the method (b) listed above, i.e. to subtract the average rate of CPI inflation from the average rate of nominal returns to give an estimate of the real return relative to CPI directly.
- 7) Since the timeseries of historic nominal equity returns that is most often used by UK regulators extends back to 1899 (albeit there are other sources which give information on returns during the 19th century, which should perhaps also be taken into account – see the Appendix to this report), Ofgem’s new approach depends on there being a reliable CPI series that extends back to 1899 at least. The only available CPI series covering the relevant timeframe appears to be that from the Bank of England’s Millennium databook⁴³.
- 8) However, the Bank of England (BoE) explicitly sets out a series of caveats in its Millennium dataset (from which both RPI and CPI series can be taken) that mean the values within it cannot be relied on without carefully reviewing them and the sources from which they are taken.
- 9) When, consistent with these caveats, the data sources from which the CPI series have been collated are reviewed, it quickly becomes apparent that it is not in fact the case that “*the ONS and the Bank of England have published consistent historical estimates of the CPI*” as claimed in the UKRN report (see discussion below in the section of this report headed “The Unreliability of the Sources used for the Millennium databook’s CPI series as a source of CPI values”). This error (together with the scale of the inconsistencies between the sources of CPI values in different timeframes which cause it) undermines the use of this series to deflate historic nominal returns to give an average real return relative to CPI⁴⁴. In contrast, in this context where a long-term time series is required, the use of the RPI series is found to be more reliable and defensible, as shown by the references and analysis in this report.
- 10) A recent (October 2019) statement on CPI and CPIH backseries from the ONS has reinforced that the CPI backseries values are merely indicative and cannot be relied upon, and moreover the ONS is going to replace the existing CPI backseries between 1947 and 1988

⁴¹ “*Estimating the cost of capital for implementation of price controls by UK Regulators*”, Wright, Burns, Mason and Pickford, March 2018, see page 30, https://www.ukrn.org.uk/w_p-content/uploads/2018/06/2018-CoE-Study.pdf

⁴² “*RIO-2 Sector Specific Methodology Decision – Finance*”, Ofgem, 24 May 2019, see e.g. paragraphs 3.73 and 3.76, https://www.ofgem.gov.uk/system/files/docs/2019/05/rrio-2_sector_specific_methodology_decision_-_finance.pdf

⁴³ Thomas, R and Dimsdale, N (2017) “*A Millennium of UK Data*”, Bank of England OBRA dataset, <https://www.bankofengland.co.uk/statistics/research-datasets>

⁴⁴ This conclusion is consistent with the findings of previous studies by NERA, Frontier Economics and Oxera: “*INFLATION IN THE CONTEXT OF REAL TMR*”, a note for the ENA prepared by Phil Burns, supported by Mike Huggins, Rob Francis and Michael Yang of Frontier Economics, 13 March 2019; see response documents on webpage <https://www.ofgem.gov.uk/publications-and-updates/rrio-2-sector-specific-methodology-consultation>, filed with the ENA’s response in the ‘A to E responses section’; “*Review of UKRN Report Recommendations on TMR*”, a report by NERA for the Energy Network Association, 20 November 2018 (- this is referred to as consultancy report 7 in Ofgem’s May 2019 SSMD Finance Annex and is also available from Ofgem’s website using the link above); and “*The cost of equity for RIO-2*”, Q4 2019 update prepared by Oxera for Energy Network Association, November 2019 https://www.oxera.com/w_p-content/uploads/2018/01/Cost-of-equity-for-RIO-2-Q4-2019-update.pdf

with new indicative estimates⁴⁵ (although it is unclear whether the resulting update will itself result in robust and reliable figures for CPI for these years, given that the underlying price data that would be needed to calculate reliable CPI values prior to 1988 has not been retained by the ONS):

- Referring to the existing CPI backseries, this statement says “*The ONS previously published indicative modelled estimates for the CPI between 1947 and 1987. These estimates are for analytical purposes only and are not intended for official uses.*”
- The paragraph then continues “*The models used were based on the subsequently revised CPI modelled data for 1988 to 1996. The ONS will therefore produce new indicative estimates for the CPI between 1947 and 1987 alongside the planned CPIH estimates, based on the corrected CPI data. This will give users a consistent set of modelled indices. These new estimates will be published by the end of 2020.*”

11) The March 2018 UKRN report also said, in appendix D, that:

- “*At the time of writing, long-term price indices measured on a consistent basis are only available for the CPI. Long-term CPIH indices are under-construction and we would anticipate will be available before any switch of the Bank of England target to CPIH.*” Whilst it remains the case that the long-term CPIH series has not yet, at the date of this report, been published, as explained above and demonstrated more fully below, it is not in fact the case that a long-term series on a consistent basis is available for CPI (as explained and illustrated later in this report);
- “*Changes to the underlying methodology mean that the RPI is not comparable overtime, whereas historical CPI estimates try to match current methodology. Historic equity returns deflated by RPI will therefore have limited informational content about future equity returns deflated by RPI.*” This appears to be the main concern in the UKRN report with using historic RPI values to convert historic nominal returns to a real basis. However, as the new numerical analysis in this report shows, in spite of the changes in the detailed methodology used to calculate RPI over time, the Bank of England’s RPI series appears to give a reliable series whose values, on average, agree well⁴⁶ with consumers’ expenditure deflators throughout the whole timeframe from 1956 to 2009, where the values of the deflators used for this comparison have been derived from National Accounts that were themselves prepared on a basis that is believed to be consistent with those compiled by Feinstein (1972) for the 1870-1965 period. By extension, therefore, the deflators from 1899 to 1956 that are derived from the Feinstein (1972) estimated National Accounts are also a good representation of RPI as it has been calculated subsequently, throughout the period from 1956 onwards.

The Bank of England’s Millennium Databook contains two very similar CPI Series

12) The Millennium databook actually contains two separate CPI series (called the ‘original’ series and the ‘preferred’ series). These are the same as each other from 1914 onwards, but the ‘preferred’ series uses a different source (Feinstein (1991)) for CPI values from 1882 to 1914.

- a. As explained in the footnote below⁴⁷, the Feinstein (1991) values covering 1882 to 1914 have limited coverage which means they do not represent an inflation measure

⁴⁵ ONS statement “*Developing CPIH and CPI historical estimates between 1947 and 1987*”, 10/10/2019, <https://www.ons.gov.uk/new/s/statementsandletters/developingcpihandcpihistoricalestimatesbetween1947and1987>

⁴⁶ The average difference between the consumers’ expenditure deflators and RPI from 1956 to 2009 is just 0.2%, with no clearly discernible trend over time. i.e. the average differences across the years in different timeframes (1957 to 1973; 1974 to 1987; and 1988 to 2009) appear largely consistent.

⁴⁷ The BoE’s ‘preferred’ series uses a different source for the years up to 1914, based on later work by Feinstein (1991), “*A new look at the cost of living 1870 – 1914*” by Charles Feinstein, included as Chapter 6

across the population as a whole, and so they should not be used as part of an inflation series that is used to deflate nominal equity market returns. (We note, though, that if Ofgem did prefer to use this Feinstein (1991) series for inflation values between 1882 and 1914, consistency would then dictate that the Cost of Living Index (COLI)⁴⁸, which also represents changes in working class expenditure, could then be used from 1914 to 1948. This would lead to significantly lower inflation values during these years than are currently being used, but the use of COLI has previously been rejected in some studies for exactly the same reason, i.e. because of its limited coverage, given that it applies to the expenditure of the working class only. What could clearly not be justified would be an asymmetric approach in which a working-class inflation measure is used when this is higher than the inflation for the population as a whole, but then the whole population inflation measure is used instead of the working-class measure in those years when the whole population inflation figure is higher.)

- b. In contrast, the 'original' CPI series uses the same source from 1900 to 1914 as from 1914 to 1949 (and indeed from 1870 to 1900 also), so if these values are suitable for these later years (i.e. 1914 to 1949), the same source can equally be used for the earlier years.
- c. In addition, use of a consistent source before and after 1914 avoids the risk that the Millennium databook's 'preferred' series double-counts the jump in inflation which took place around 1914 (also coinciding with the start of the first World War), because it uses different data sources prior to and after 1914.

- 13) For these reasons, if either of the Millennium databook CPI series were to be used to deflate nominal returns, it should be the 'original' series (albeit when averaged across the whole of the period from 1899 to 2018, the difference between the two series is obviously small). This is the conclusion that Ofwat has reached, for these reasons⁴⁹. Throughout the rest of this

within the book "New perspectives on the late Victorian economy" edited by James Foreman-Peck, ISBN 0-521-89085-3, published by Cambridge University Press. As is clear from the Feinstein (1991) paper itself, these cost of living estimates are less relevant and reliable in this context. They were compiled to answer a very specific question in social economic history, i.e. to investigate changes in the price of goods and services purchased by working-class households only. Therefore, they had limited coverage, relating only to working class households, who accounted for only 52% of total household expenditure (see Table 6.1 in the paper), and had a very different distribution of expenditure across different categories of spend from that for all households in aggregate (see Table 6.1). As the rate of change in the cost of different categories of expenditure was different, the inflation experienced by these working-class households – i.e. the change in the cost of living that they experienced – could be very different from that of the population as a whole. In contrast, the consumers' expenditure deflators derived from the Feinstein (1972) estimated national accounts apply to all households.

⁴⁸ It appears that, like the modern Retail Price Index, this early Cost of Living index was based on regular collection of prices and a weighting of expenditure on different types of commodity.

⁴⁹ See "PR19 Draft Determinations Cost of Capital Technical Appendix", Ofwat at July 2019, page 30. Ofwat also said in relation to the use of deflators derived from Feinstein's 1972 estimated National Accounts that "The implied deflator is constructed through analysis of the unofficial national accounts of the UK, which we consider to be closer to CPI than RPI by design. For instance, being a deflator, it is by definition not affected by the RPI 'formula effect', and we note that its coverage of housing-related expenditure in particular is closer to CPI than RPI." The first point that "deflators are not affected by the formula effect" is merely an assertion that is actually wrong - it depends on what inflation measures are used to convert actual prices to constant prices for certain categories of costs, and as noted elsewhere here in this report the ONS have agreed with Oxera that these are likely to be based on underlying series constructed using a methodology comparable to RPI. The second point raised, concerned with housing-related expenditure, would seem to be either not material or wrong (given the numerical evidence presented later in this report), noting in particular the comparison between deflators and CPI for the years from 1988 to 2009, during which reliable CPI values exist that can be compared to consumers' expenditure deflators that were calculated from national accounts that were put together on a Feinstein-like basis. In relation to the overall point in the first sentence that the deflators from the unofficial (Feinstein 1972) national accounts are closer to CPI than RPI, this is again just an assertion, and the numerical evidence presented later in this report shows not only that this appears wrong but also that the converse is true, i.e. the consumers' expenditure deflators from the unofficial National Accounts are more like RPI than CPI.

report, therefore, references to the Bank of England’s Millennium databook CPI series are (unless stated otherwise) to the ‘original’ series, and the so-called ‘preferred’ series is not considered further.

- 14) The BoE itself has expressly set out a number of caveats within the Millennium dataset, which mean that the values it contains should not be taken at face value and should not be used in an important application without carefully reviewing them and referring to the original data sources from which the values are taken. For example, the Millennium databook explains⁵⁰ that:
- a. *“the spreadsheet should be viewed as work in progress’ and is intended to be a shared research resource that will evolve and expand over time”;*
 - b. *“it should be noted the data do not represent official Bank of England data or National Statistics”;*
 - c. *“the Bank of England makes no representations or warranties as to the accuracy or completeness of the information”;*
 - d. *“the spreadsheet has been constructed on a ‘best endeavours’ basis ... some errors and omissions will undoubtedly remain in a spreadsheet of this size”;*
 - e. and perhaps most importantly **“users are always advised to consult the original sources as a crosscheck”**.
- 15) As explained below in the Section headed “The unreliability of the sources used for the Millennium databook’s CPI series as a source of CPI values”, when the original data sources from which the CPI series have been populated are scrutinised, for the values prior to 1988 it is found either that the values are not reliable, or they do not actually represent CPI at all.

Ofgem’s proposed approach to deflating historic nominal average returns and the rationale used by Ofgem to justify this

- 16) In summary, Ofgem proposes to deflate the long-run average nominal equity market return by the Bank of England Millennium databook’s CPI series to give an estimate of TMR on a real basis relative to CPI. In this respect, Ofgem’s approach builds on and references the March 2018 cost of capital report written for the UKRN⁵¹, which considered the different historic inflation measures in Appendix D, and said the following, in justifying this use of CPI to deflate historic returns data:
- a. *“At the time of writing, long-term price indices measured on a consistent basis are only available for the CPI.”* (see page D-109 point (i)(a))
 - b. *“Changes to the underlying methodology mean that the RPI is not comparable over time, whereas historical CPI estimates try to match current methodology. Historic equity returns deflated by RPI will therefore have limited informational content about future equity returns deflated by RPI.”* (see page D-109 point (i)(e))
 - c. *“We suggest shifting to using the Bank of England’s long-term CPI series when calculating real returns, rather than Dimson, Marsh and Staunton’s hybrid series.”* (or, indeed, rather than the long-run RPI series published by the Bank of England and the ONS) (see page D-110)
 - d. *“As well as being the most focused measure of inflation, as the Bank of England’s target measure, it is the measure which is likely to exhibit the greatest long-run stability. We would also argue that it is the measure that currently has the greatest backward and forward comparability. Although the Bank of England’s Millennium data sets include estimates for both RPI and CPI going back in history, the CPI estimates are on*

⁵⁰ Thomas, R and Dimsdale, N (2017) “A Millennium of UK Data”, Bank of England OBRA dataset, <https://www.bankofengland.co.uk/statistics/research-datasets>; see the “Disclaimers” sheet and the “Front Page” sheet

⁵¹ “Estimating the cost of capital for implementation of price controls by UK Regulators”, Wright, Burns, Mason and Pickford, March 2018, <https://www.ukrn.org.uk/wp-content/uploads/2018/06/2018-CoE-Study.pdf>

more a consistent basis whereas the RPI indices match the various switches of methodology since 1947. We also have a double check in the form of ONS estimates, whereas the ONS do not publish estimates pre-1947 for the RPI. This enables us to construct very long-term real return series for UK assets on a consistent basis.” (see page D-111)

- e. In considering “How should nominal asset price returns be deflated in order to derive real returns” the report says “Rather than make ad hoc adjustments we believe that it makes sense to use an index which is consistent.” (see page D-120)
- f. In considering how consistent future measures of inflation are with historic inflation, the report says “Provided a CPI/CPIH is used we’re not too concerned. As demonstrated in MMW the measured real return on equities in the US is relatively stable. If there were large shifts in inflation biases over time we would anticipate that this would generate greater variation in measured real returns on equities. Since we do not observe this we are reasonably relaxed that the biases remain relatively stable overtime. By contrast we are more concerned if RPI is used to estimate real returns. The difference between UK CPI and UK RPI was 0.14% over the C20th. This had risen to 0.7% over 2000-16 (according to Bank of England estimates). It is now projected to be over 1% by the OBR. This suggests that the difference between RPI and true inflation has not been stable over time and we would therefore be concerned that RPI measured real return on equity would not be stable.” (see page D-122)

- 17) Unfortunately, these comments appear to be based on a number of misconceptions and/or misunderstandings, which undermine the justification of the proposed switch to use of CPI to deflate historic nominal returns which relies on these views:
- a. As shown later in this report, it is not the case that “long-term price indices measured on a consistent basis” are available for CPI.
 - b. We also show in this report that the historical CPI estimates do not appear to give values that would be consistent with values if calculated on a basis that is consistent with the current methodology.
 - c. The evidence we have identified would support switching from the inflation measure used by Dimson, Marsh and Staunton (DMS)⁵² to the Millennium databook’s RPI series⁵³ rather than the Millennium databook’s CPI series (if any switch is to be made).
 - d. It is not the case that CPI is the measure which is likely to exhibit the greatest long-run stability, as it does not have the greatest backward comparability. The numerical analysis in this report, and a review of the sources from which these values are drawn, show that the England’s Millennium RPI series is on a more comparable basis over time than the corresponding CPI series. The UKRN report also appears to be mistaken in suggesting that “We also have a double check in the form of ONS estimates, whereas the ONS do not publish estimates pre-1947 for the RPI.” To the contrary, as documented later in this report, the ONS have for many years published a long-run RPI series and composite inflation series estimates (back to 1800) which uses RPI values, but do not publish any equivalent long-run series for CPI. In fact, the only CPI values prior to 1988 that are published by the ONS appear to be some indicative modelled estimates which only go back to 1950. (The unreliability of these CPI estimates is discussed and illustrated later in this report.)
 - e. We recognise that there have been changes in the detailed methodology used to calculate RPI over time, but these changes are narrower and more specific in nature than the fundamental differences in the approaches used by the different sources of

⁵² This refers to the UK inflation series used, for example, in Table 75 in the “Credit Suisse Global Investment Returns Yearbook 2019” by Eroy Dimson, Paul Marsh and Mike Staunton, published in February 2019 by the Credit Suisse Research Institute, ISBN 978-3-9524302-8-6, or the equivalent series in earlier editions of the yearbook.

⁵³ Although as explained elsewhere in this report, as well as switching to the RPI series throughout, there is also a case for attaching some weight to the results from switching to the RPI series in most years but the lower ‘Cost of Living Index’ values from 1914 to 1948, as these may be a better estimate of RPI in these years.

- the CPI values for different time segments in the Millennium databook series, as explained and illustrated later in this report.
- f. The UKRN report's main concern with use of the RPI series appears to be built on the following misunderstanding: *"The difference between UK CPI and UK RPI was 0.14% over the C20th. This had risen to 0.7% over 2000-16 (according to Bank of England estimates). It is now projected to be over 1% by the OBR. This suggests that the difference between RPI and true inflation has not been stable overtime and we would therefore be concerned that RPI measured real return on equity would not be stable."* It is misleading to describe the CPI values as "Bank of England estimates", as they are values that are taken from other sources by other authors (as documented later in this report) which either do not represent CPI at all or are expressly stated to be unreliable. More importantly though, the concern expressed here is based on the incorrect presumption that the Millennium databook's CPI series is reliable and consistently based, and so when this is compared to the corresponding RPI series it shows that the RPI series is unreliable and unstable. In fact, it shows the converse: as explained in this report, the CPI series is the more inconsistent, for which reliable values produced on a comparable basis do not exist, and so the changes referred to here (the 0.14% average difference increasing to 0.7%) actually merely highlights the unreliability of the CPI series.
- 18) Nevertheless, Ofgem set out and explained the approach they intended to take in the July 2018 RIIO-2 Framework decision⁵⁴, which:
 - a. set out that Ofgem *"will estimate the expected market return by considering the historical long-run average of market returns as the best objective estimate of investors' expectations of the future. We will take full account of the findings of the Competition Commission in Northern Ireland Electricity(2014) as well as the forward-looking approaches indicated recently by regulators such as Ofwat and CAA"* (see paragraph 6.41)⁵⁵; and
 - b. said Ofgem *"have accepted the recommendations from the UKRN study in respect of the estimation of risk-free rates and total market returns. For the latter, we will aim to be consistent with (and take full account of) recent determinations from competition authorities and other regulators ..."* (see paragraph 6.44). Thus, in determining which inflation measure should be used to deflate nominal equity return, Ofgem was relying on the views set out in the cost of capital report written for the UKRN.
 - 19) Consistent with this, Ofgem's December 2018 RIIO-2 SSMD consultation⁵⁶ explained the proposed approach more fully, and confirmed the use of TMR values that were consistent with deflating historical nominal returns by the Millennium databook's CPI series (rather than its RPI series or the DMS inflation series⁵⁷). This discussion noted that some of the earlier consultation responses had made detailed arguments about how the long-run outturn average TMR should be calculated, including issues about outturn and expected inflation (see paragraphs 3.58 and 3.59(b)). However, Ofgem had confirmed with one of the authors of the UKRN report that the estimated TMR in that study (6% to 7%) had been expressed relative to CPI (see paragraph 3.61). Ofgem also gave a number of updates to their view of TMR, including the following points:

⁵⁴ "RIIO-2 Framework Decision", Ofgem, July 2018, https://www.ofgem.gov.uk/system/files/docs/2018/07/riio-2_july_decision_document_final_300718.pdf

⁵⁵ The Framework consultation had noted at paragraph 7.33.4 that the findings of the Competition Commission in Northern Ireland Electricity (2014) as well as the forward-looking approaches indicated recently by regulators had suggested that 6.5% (**relative to RPI**) is probably at the top end of reasonable estimates of the expected market return.

⁵⁶ "RIIO-2 Sector Specific Methodology Annex: Finance", Ofgem consultation, 18 December 2018 https://www.ofgem.gov.uk/system/files/docs/2018/12/riio-2_finance_annex.pdf

⁵⁷ The 'DMS inflation series' here refers to the UK inflation series used, for example, in Table 75 in the "Credit Suisse Global Investment Returns Yearbook 2019" by Eroy Dimson, Paul Marsh and Mike Staunton, published in February 2019 by the Credit Suisse Research Institute, ISBN 978-3-9524302-8-6, or the equivalent series in earlier editions of the yearbook

- a. *“Whilst we understand company arguments that the UKRN study appears to reduce real returns by 1% by stating real returns on a CPI basis instead of an RPI basis, we note that most measures of inflation are relatively similar over the period of the 20th century and that 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, rather than the expected value of inflation”* (see paragraph 3.81). In the light of this acknowledgment of the lack of CPI values for the majority of the 20th century, it is hard to understand how use of the long-run CPI series from 1899 onwards to deflate the average long-run nominal returns data could be justified. As we show later in this report, these CPI values do not appear to represent CPI as it has been calculated more recently, and so should not be used to deflate the nominal realised return values. It is also not a meaningful statement to suggest that *“most measures of inflation are relatively similar over the period of the 20th century”*: this is presumably referring to the use of the same values in the Millennium databook’s RPI and CPI series from 1900 to 1950⁵⁸, but as explained below these better represent RPI and they appear to be used also in the Millennium databook CPI series simply because no values of CPI exist for these years. There can be no implication from this that *“most measures of inflation are relatively similar”* for the majority of the 20th Century. In fact, the main alternative to the RPI series inflation values that is available during the 20th Century is the Cost of Living Index (COLI) which is available from 1914 to 1948, and on average this had materially lower values of inflation than the Millennium databook’s RPI (and indeed CPI) series in these years⁵⁹. **The existence of these lower inflation values should not be disregarded and some weight should be given to the overall results if they were used instead of the values in the Millennium databook** – it should be noted that they were used as the inflation values in the Central Statistical Office’s *“Retail Prices 1914-1990”*⁶⁰ publication, which was itself then referenced by the ONS in official publications up to August 2001 (at least) as the source of values for the first half of the 20th Century to be used in conjunction with the values of RPI in later years⁶¹.
- b. Ofgem also draws attention to a reconciliation of changes in its TMR estimates since advice it had previously received in 2003 and 2006 (see Appendix 2 in the Ofgem’s Sector Specific Methodology consultation)⁶². This shows that changing to the use of the Millennium databook’s CPI dataserie (from RPI or the inflation series previously used by DMS⁶³) has a material impact on the estimated TMR, accounting for c. 100bps of the estimated 150 bps reduction (see page 91 in this consultation). The resulting TMR estimate is therefore only justified if the CPI dataserie, which has been used in deriving it, can be shown to consist of reliable and consistently-based values.

20) Ofgem’s May 2019 RIIO-2 SSMD decision⁶⁴ then confirmed that for RIIO-2 TMR would be estimated *“by considering the historical long-run average of mark et returns as the best single objective estimate of investors’ expectations of the future”* whilst also *“placing due weight on*

⁵⁸ If instead, or as well, it depends on comparison of RPI to the Millennium databook CPI values from 1950 to 1988, this also is no justification for claiming that *“most measures of inflation are relatively similar”* in these years, as the CPI values are simply modelled estimates that were at best broadly indicative.

⁵⁹ As noted above, it appears that the Cost-of-Living Index (COLI), like the modern Retail Price Index, was based on regular collection of prices and a weighting of expenditure on different types of commodity

⁶⁰ *“Retail Prices Indices”*, Central Statistical Office, ISBN 0116204990, see pages 7 and 101, and page 6 where the values are described as the ‘official indices’

⁶¹ See for example *“Focus on Consumer Price Indices”*, August 2001, ONS, available online, see Tables 11 and 14

⁶² *“RIIO-2 Sector Specific Methodology Annex: Finance”*, Ofgem consultation, 18 December 2018

https://www.ofgem.gov.uk/system/files/docs/2018/12/riio-2_finance_annex.pdf

⁶³ This refers to the UK inflation series used, for example, in Table 70 in the *“Credit Suisse Global Investment Returns Sourcebook 2013”* by Elroy Dimson, Paul Marsh and Mike Staunton, published in February 2013 by the Credit Suisse Research Institute, ISBN 978-3-9523513-9-0

⁶⁴ Ofgem’s decision document *“RIIO-2 Sector Specific Methodology Decision – Finance”*, 24 May 2019,

https://www.ofgem.gov.uk/system/files/docs/2019/05/riio-2_sector_specific_methodology_decision_-_finance.pdf

cross-checks” (see e.g. paragraphs 3.44/3.45, 3.48 and 3.104). This document included Ofgem’s comments in reply to various consultation responses that had been submitted, including consultants reports which had considered the inflation measure that should be used to deflate nominal historic equity market returns. These reports are documented in the next section below, and Ofgem’s response to these reports is then described in the subsequent section.

- 21) Ofgem also appeared to gain comfort for their approach (including use of the historic CPI series) from comparisons to outturn real returns in US\$ terms (see e.g. paragraph 3.47). However, such comparisons don’t actually give any insight into which of the different inflation series (RPI or CPI) are more consistently-based and reliable, as there is no reason for a perfect 1:1 alignment between realised returns when expressed in different currencies⁶⁵. As for whether the actual values of returns in US\$ terms in the US and elsewhere would support Ofgem’s approach, we refer later in this report to a study by Aon (authored by Derry Pickford, one of the authors of the UKRN report) which concluded that “a long-term expected real USD geometric return of around 6.5% on both global and UK equities is reasonable”. As this is a geometric average, on a like-for-like basis it is >1% higher than the mid-point of Ofgem’s TMR range, and so does not support Ofgem’s approach.

Previous Studies have shown the Millennium Databook’s historic CPI timeseries are not reliable

- 22) A number of previous studies have considered these historic series and the original data sources they are compiled from and shown that the Millennium databook CPI series are not reliable, as they draw on sources which in some cases make explicitly clear that the data values are not to be relied upon, and in other cases do not represent CPI at all:
- Frontier Economics’ report “*Inflation in the Context of Real TMR*”⁶⁶, A note for the ENA, prepared by Phil Burns, supported by Mike Huggins, Rob Francis and Michael Yang, 13 March 2019. (This is referred to as consultancy report 15 in the Ofgem SSMD Finance Annex)
 - Nera’s report “*Review of UKRN Report Recommendations on TMR*” for the Energy Network Association, 20 November 2018⁶⁷. (This is referred to as consultancy report 7 in the Ofgem SSMD Finance Annex.)
 - NERA’s report “*Review of UKRN recommendations on the appropriate inflation index for estimating historical TMR*”, prepared for National Grid, 1 May 2018⁶⁸

⁶⁵ The “*Credit Suisse Global Investment Returns Yearbook 2019*” by Dimson, Marsh and Staunton, published in February 2019, ISBN 978-3-9524302-8-6 shows at Table 6 that the arithmetic mean of exchange rate changes for many countries are high; and Figure 11 shows that long-run average annualized equity returns in many countries are different when expressed in local currency and US\$ terms, as well as being different from one country to another.

⁶⁶ “*INFLATION IN THE CONTEXT OF REAL TMR*”, a note for the ENA prepared by Phil Burns, supported by Mike Huggins, Rob Francis and Michael Yang of Frontier Economics, 13 March 2019; see response documents on webpage <https://www.ofgem.gov.uk/publications-and-updates/rrio-2-sector-specific-methodology-consultation>, filed with the ENA’s response in the ‘A to E’ responses section

⁶⁷ “*Review of UKRN Report Recommendations on TMR*”, a report by NERA for the Energy Network Association, 20 November 2018 (- this is referred to as consultancy report 7 in Ofgem’s May 2019 SSMD Finance Annex; see response documents on webpage <https://www.ofgem.gov.uk/publications-and-updates/rrio-2-sector-specific-methodology-consultation>, filed with the ENA’s response in the ‘A to E’ responses section)

⁶⁸ “*Review of UKRN recommendations on the appropriate inflation index for estimating historical TMR*”, NERA, May 2018, attached at appendix 5 to the NGET and NGG response accessed via the following link: <https://www.ofgem.gov.uk/publications-and-updates/rrio-2-framework-consultation>

- d. Oxera's report "*The cost of equity for RIIO-2*", Q4 2019 update prepared by Oxera for Energy Networks Association, November 2019.⁶⁹

23) Key points from these studies included the following:

- a. ***“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.”***
- b. NERA also *“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.”*
- c. Frontier's report notes that:
- *“In making its estimation of TMR Ofgem has effectively chosen to place very material weight on one unreliable source of historical evidence on inflation, i.e. the BoE Millennium dataset”*
 - *“Given how the historic “CPI” data has been constructed”, i.e. how the Bank of England’s Millennium databook CPI series has been constructed, “it cannot possibly be regarded as consistent with actual published ONS CPI as it is presently prepared. Quite simply, there can be no presumption of consistency between the two.”*
 - *“the historical data that Pickford [in the UKRN report] and Ofgem use is not a historical run of CPI data at all. It is based on a dataset developed by Bank of England researchers to mark the 50th anniversary of BoE bulletins. The Bank of England sets out clear caveats in the dataset.”*

24) Oxera's (2019) report notes that:

- a. A key issue that arises when deciding on an appropriate real TMR relative to CPI (or CPIH) for RIIO-2 from historical evidence concerns identification of the appropriate inflation series for calculating the historical real return.
- b. One way is to deflate the nominal average TMR by the historical RPI inflation from the ONS (or Bank of England) and then apply an uplift equal to the forecast CPI-RPI wedge to obtain CPI-real returns, and an alternative is to deflate the nominal average return by estimates of historical CPI inflation using a “proxy” for historical CPI inflation taken from the Bank of England publication ‘A millennium of macroeconomic data for the UK’.
- c. Oxera recognise that the method for calculating RPI inflation has evolved over time, but continue as follows: *“However, relying on RPI inflation (as opposed to CPI inflation) has an important advantage: the historical time series for RPI is longer, with actual data published since 1947 and estimates for the period 1870–1947 based on the 1947 definition of the RPI. On the other hand, the historical CPI series in the Bank of England’s Millennium dataset is a ‘backcast’ (i.e. estimated) series, as there is no actual data for CPI before 1988. This means that, all else equal, the historical CPI inflation series will be less accurate than the historical RPI series, as it relies on estimates rather than outturn values. For this reason, we believe that it is more accurate to use the RPI inflation series, while adjusting for changes in methodology that have occurred in the past”* (see page 15).
- d. Oxera conclude from this that the use of the historic RPI series is preferred to use of CPI, but to address the known changes in RPI in the past they also describe the following: *“The Oxera report for Heathrow Airport investigated what the historical RPI series might look like if restated using today’s RPI calculation methodology. The report used statistical analysis in combination with an investigation of how the RPI methodology has changed over time to identify structural breaks in the level and rate of*

⁶⁹ *The cost of equity for RIIO-2*, Q4 2019 update prepared by Oxera for Energy Networks Association, November 2019 <https://www.oxera.com/wp-content/uploads/2018/01/Cost-of-equity-for-RIIO-2-Q4-2019-update.pdf>

change in the RPI series. The preliminary analysis indicated that the average inflation based on a restated RPI series over the period 1899–2016 could be up to 1bp lower or 30bp higher than if based on the official RPI series published by the ONS” (see page 15). Whatever point in this range is chosen, the resulting forward-looking estimates of TMR would be higher if the historic level of nominal returns is deflated using this adjusted historic RPI series than using the Millennium databook’s CPI series (and they would generally be close to the TMR estimate that would result if the Millennium databook’s RPI series was used without adjustment).

- e. In relation to the ‘original’ and ‘preferred’ CPI series in the Millennium databook, Oxera say “These series have been developed for research purposes and do not constitute official Bank of England data or National Statistics. Both indices represent an amalgamation of different datasets, and, more importantly, as pointed out before, both rely on back casted data prior to 1988, unlike the RPI series, which relies on actual data from 1947. **It appears likely that both the measures of CPI inflation in the Millennium Data Book are upwardly biased estimates of the underlying CPI inflation**” (see page 16) and “Prior to 1950, the CPI series are based on the Consumption Expenditure Deflator (CED) series from Feinstein (1972) or Feinstein (1991). These CED series pre-date the publication of CPI in 1997, and are therefore likely to be based on underlying series constructed using a methodology comparable to RPI. **The CED series would therefore include at least some of the upward biases from the RPI formula effect, which would overstate CPI inflation. We have discussed this hypothesis with the ONS, who expressed their agreement with this interpretation**” (again see page 16). Oxera conclude that “**Overall, it appears that the true average CPI inflation over the period 1899–2018 is likely to be lower than the average of either the ‘original methodology’ or the ‘preferred measure’ CPI series in the Millennium Data Book**” (see page 17).

- 25) It is also notable that at least half of the authors of the March 2018 UKRN report no longer support either the use of the CPI series or the consequences of using this series to work out real returns:
 - a. Phil Burns, of Frontier Economics, who co-wrote the consultancy report 15 referred to in the previous paragraph; and
 - b. Derry Pickford, co-author of the March 2019 Aon report “*Is the UK an “averagely lucky country?”*”, which Ofgem lists as consultancy report 17 in the Ofgem SSMD Finance Annex. This report concludes that “*a long-term expected real USD geometric return of around 6.5% on both global and UK equities is reasonable*”. Once an appropriate geometric to arithmetic uplift is applied, and even using Ofgem’s figure for this i.e. 0.77% to 1.77% (although others including Oxera⁷⁰ and NERA⁷¹ would support higher values, particularly for the low end of this range), this gives an implied TMR relative to CPI of at least 7.3% to 8.3%, which is more than 1% higher than Ofgem’s interpretation of the corresponding range in the UKRN report (6% to 7%, which Ofgem says is on a real basis relative to CPI).

- 26) This new report (see for example the section below headed “The unreliability of the sources used for the Millennium databook’s CPI value are taken”) complements these earlier studies by further reviewing the sources from which the CPI values are taken, as well as giving some additional references which show that the CPI values are not considered reliable.

⁷⁰ “The cost of equity for RIIO-2”, Q4 2019 update prepared by Oxera for Energy Networks Association, November 2019, <https://www.oxera.com/w p-content/uploads/2018/01/Cost-of-equity-for-RIIO-2- Q4-2019-update.pdf>

⁷¹ See for example “The cost of capital for SPT in RIIO-T2”, report by NERA for Scottish Power Transmission plc, 29 November 2019, pages 9 and 10; <https://www.spenergynetworks.co.uk/userfiles/file/RIIO-T2 Annex 9 SPT WACC report. pdf>

Ofgem's Response to these Previous Studies

- 27) Ofgem has not yet had opportunity to respond publicly to the latest (November 2019) report by Oxera. Ofgem did provide comments in response to the reports by NERA and Frontier (and the consultation responses from networks), but as shown below these comments fail properly to address the points that had been made to Ofgem⁷²:
- a. The overriding response is that Ofgem “are not persuaded that outturn inflation data from the Bank of England is unreliable” (see Ofgem Para 3.73). Whilst this may strictly be true, in relation the Millennium databook’s CPI series it only applies to the values since 1988 (or even since 1996), as across more than ¾ of the relevant timeframe (the first 88 or 96 years of the full timeframe from 1900 to 2016) the databook values for CPI are not actual ‘outturn’ values at all (as explained later in this report). Thus, this statement gives no basis for supporting use of the Millennium databook’s CPI series when estimating long-run average realised returns on a real basis, and would instead give more support to use of the RPI series which does consist of outturn values from 1948 onwards.
 - b. In response to the recognition that “NERA argue that RPI data should be used to analyse historical real TMR as the Millennium dataset CPI is unreliable” Ofgem says “NERA’s argument assumes that RPI and CPI are, in their respective approaches to measuring inflation, consistent overtime.” (see page 130). However, this is not correct: NERA’s report shows that the sources used for estimates of CPI in earlier periods do not reliably or accurately represent CPI⁷³, and it is because of these inconsistencies in the CPI values that RPI rather than CPI should be used to deflate the historical series of nominal returns. Ofgem also focuses on inconsistencies in the inflation measure used by DMS⁷⁴ in different timeframes (see page 130), but this is not relevant to the relative merits of the Millennium databook’s RPI and CPI series, where the CPI series is (as explained below) based on datasources that give values that are compiled in completely different ways and are found to be inconsistent.
 - c. “In our view, the unbiased approach is to find the best measure/s of inflation, both ex-post and ex-ante, for the purposes of accurately estimating the Total Mark et Return” (see page 130). This seems a reasonable proposition, but Ofgem fails to apply this approach as the RPI series is a more reliable series containing more comparable values than the Millennium databook’s CPI series, as shown in this report.
 - d. In responding to Frontier’s report, Ofgem says “Real returns are the best estimation of real returns, and can be interpreted relative to the best available measure of inflation. Frontier appear to assume that the best ex-ante measure of inflation is, currently, RPI. However, we disagree on this point” (see page 142). Whilst this may have been Ofgem’s view at the time of the SSMD, as noted above, this report shows that the historic RPI series is actually a more reliable long-term series than the CPI series. Ofgem also refers in this context to the following “We also show that returns on a US dollar (\$) basis, for both UK and World regions, were lower than the sterling returns on a UK basis. This gives comfort that UK-specific inflation estimations, as referred to by Frontier, are not materially affecting the work ing assumption for RIIO-2” (see page 141). As noted above, this comparison does not inform which historic inflation series (RPI or CPI) is more consistent; and as Aon showed, a review of returns on a US\$

⁷² Ofgem’s decision document “RIIO-2 Sector Specific Methodology Decision – Finance”, 24 May 2019, https://www.ofgem.gov.uk/system/files/docs/2019/05/riio-2_sector_specific_methodology_decision_-_finance.pdf

⁷³ See pages 7 to 9 in NERA’s report “Review of UKRN Report Recommendations on TMR”, a report by NERA for the Energy Network Association, 20 November 2018 (- this is referred to as consultancy report 7 in Ofgem’s May 2019 SSMD Finance Annex; see response documents on webpage <https://www.ofgem.gov.uk/publications-and-updates/riio-2-sector-specific-methodology-consultation>, filed with the ENA’s response in the ‘A to E’ responses section).

⁷⁴ This refers to the UK inflation series used in Table 75 in the “Credit Suisse Global Investment Returns Yearbook 2019” by Elroy Dimson, Paul Marsh and Mike Staunton, published in February 2019 by the Credit Suisse Research Institute, ISBN 978-3-9524302-8-6, as well as those in earlier editions of the yearbook.

- basis from different countries over different timeframes would support a value of TMR that is more than 1% higher than the mid-point of the TMR range proposed by Ofgem.
- e. Ofgem notes that “NERA also appear to disagree on this point, by making an adjustment for a structural change in RPI – see Consultancy Report 11” and illustrate changes in the formula effect in 2010 (see page 142 and Figure 4 at paragraph 3.81). This refers to the changes in the RPI-CPI wedge which were expected to occur in 2010, following changes to inflation data collection routines. However, there is now a reasonably-long track record of RPI and CPI values since 2010 (9 years) and the average RPI-CPI wedge has been seen not to have increased in 2010 by the amount that had been expected:

| | Arithmetic average Formula Effect ⁷⁵ | Arithmetic average of RPI - CPI ⁷⁶ |
|-------------------------------------------------------------------------|-------------------------------------------------|-----------------------------------------------|
| 1988 to 2009 (from the Millennium databook’s RPI and CPI series) | Not known | 0.70% |
| 2000 to 2009 | 0.35% | 0.76% |
| 2011 to 2019 | 0.67% | 0.79% |
| Increase between 2000-09 and 2011-19 | 0.32% | 0.03% |

The c.0.4% increase in the formula effect that had been expected in 2010 had been expected to give a corresponding increase in the average total RPI-CPI wedge of around 0.4% (i.e. from 1.0% to 1.4%), but as shown by the table above the actual difference between the averages of RPI and CPI from 2011 to the end of 2019 has been c.0.8%, which is less than 0.1% higher than the difference in their averages in earlier years (1988 to 2009) throughout the whole timeframe up to the start of 2010 for which reliable CPI values are available (i.e. from 1988). The observed average RPI-CPI wedge from 2011 to 2019 is also quite close to the average future difference between RPI and CPI (as they are currently calculated) that is now expected, which in recent years has typically been estimated to be around 1%, for example as discussed in the OBR’s March 2015 ‘Economic and Fiscal Outlook’⁷⁷, and as more recently estimated by Ofgem and Ofwat as well as the OBR⁷⁸.

- f. Ofgem also said, in response to the report by Aon, that “AON noted that the DMS data may underestimate outturn inflation. ...” Whilst it is the case that DMS use an inflation

⁷⁵ Averages of the impact of the formula effect on the 12-month percentage change in RPI in each month during the relevant time periods, taken from Table 35b in the ONS’s January 2020 published spreadsheet of CPI and RPI values. The formula effect values from Table 35b are used here instead of those in the ONS’s Tables 5a or 5b in order to allow a comparison of the formula effect before and after 2010 using data from a single source. (Note that Table 35b shows the impact on RPI of replacing the Carli averaging formula with the Jevons formula: in contrast the ‘formula effect’ values in tables 5a and 5b show what the impact on CPI and CPIH would be of using the Carli averaging formula, and these overstate the true formula effect, i.e. the impact on RPI values.)

<https://www.ons.gov.uk/economy/inflationandpriceindices/datasets/consumerpriceinflation/current>

⁷⁶ *Ibid* (for averages from 2000 to 2009 and from 2011 to 2019, which are calculated from the RPI and CPI index values in tables 36 and 20a); and for the index values used to calculate the average from 1988 to 2009 see Thomas, R and Dimsdale, N (2017) “A Millennium of UK Data”, Bank of England OBRA dataset, <https://www.bankofengland.co.uk/statistics/research-datasets>.

⁷⁷ “Economic and Fiscal Outlook”, OBR, March 2015, see Box 3.3 on pages 60 to 62, <https://obr.uk/box/revised-assumption-for-the-long-run-wedge-between-rpi-and-cpi-inflation/>

⁷⁸ Ofgem’s decision document “R10-2 Sector Specific Methodology Decision – Finance”, 24 May 2019, https://www.ofgem.gov.uk/system/files/docs/2019/05/r10-2_sector_specific_methodology_decision_-_finance.pdf, paragraph 1.10 includes an estimate of 1.049% based on OBR forecasts for the year 2023; Ofwat’s “PR19 Final Determinations Allowed return on capital technical appendix”, December 2019, assumes a 1.00% difference between RPI and CPI(H), see e.g. section 2.1; the OBR’s latest “Economic and fiscal outlook” from March 2019 (see Table 3.8) forecasts an average difference of 1.0% from 2020 to 2023; and the OBR’s latest “Fiscal sustainability report” from July 2018 uses a long-term RPI assumption calculated from CPI plus 1.0% (see Table 3.3).

measure⁷⁹ in the first half of the 20th century which is lower than the Bank of England's RPI or CPI series, the main focus of this report is the relative reliability and consistency of the basis used to calculate these RPI and CPI series over time, and the inflation measure preferred by Dimson, March and Staunton (DMS) is not relevant to this. It does, though, show that another, lower inflation measure is available during these years, where this measure, like inflation indices since 1950, was based on regular collection of prices and a weighting of expenditure on different types of commodity⁸⁰.

| | DMS Inflation Series ⁸¹ | Millennium databook RPI (and 'original' CPI) series |
|-----------------------------------------|------------------------------------|-----------------------------------------------------|
| Geometric average, 1900 - 1948 | 1.94% | 2.62% |
| Arithmetic averages, 1900 - 1948 | 2.25% | 2.87% |

- 28) Also on the inflation issue, Ofgem said (at paragraph 3.98), “*We disagree with SPEN, ENWL and NPG that 100bps is missing from the reconciliation – this is described separately in the consultation with additional information provided in this document with regards to how RPI and CPI have changed over time. The issue here, as described above, is that RPI is not a consistent measure over time, so it is wrong to assume that RPI post 2010 is similar to RPI pre 2010 (see formula effect in Figure 4 above).*” Whilst we recognise that there have been changes in the detailed RPI methodology over time, the bigger issue, as illustrated in the sections of this report that follow, is that Ofgem has assumed that the values that are used for CPI has been a consistent measure over time (since 1900). However, the different sources from which these values are taken make clear that the values have been compiled on a completely different basis in each of three timeframes (1900 to 1950, 1950 to 1988 and since 1988), and so the CPI series cannot be assumed to be comparable across the whole timeframe. In addition, the numerical analysis in this report provides support to the view that the sources used for the RPI series calculate values in a more comparable way than for CPI across the full 118 years since 1900.
- 29) Finally, Ofgem referred in passing to the recommendations of the ‘Johnson review’⁸² from 2015, which said that “*Government and regulators should work towards ending the use of the RPI as soon as practicable. Where they decide to keep using it the UK Statistics Authority should ask them to set out clearly and publicly their reasons for doing so.*” However, the concerns with RPI in this context appeared to relate to use of RPI as a forward-going measure of inflation, which would include whether future price controls should be indexed to RPI or CPI. As explained in the first section of this report (“Context and Introduction”) above, this is a separate question from how long-run average realised returns should be deflated from nominal to real, which Ofgem has recognised should use the more consistent measure of inflation over the relevant timeframe. RPI is shown in this report to be more reliable than CPI as a long-run inflation measure over the past 118 (or more) years for use in deflating the long-run average nominal returns, and the resulting real return (relative to RPI) can then be converted to a forward-looking TMR on a real basis relative to CPI by adding the expected

⁷⁹ For the UK, the “*Credit Suisse Global Investment Returns Yearbook 2019*” by Eroy Dimson, Paul Marsh and Mike Staunton, published in February 2019, ISBN 978-3-9524302-8-6) uses inflation calculated from the ‘retail price index (RPI)’ from 1900 to 1948 (see page 212). From end 1914 to end 1946 these values seem consistent with the Cost of Living Index (COLI) values in Table 84 of the Central Statistical Office publication “*Retail Prices 1914 – 1990*”, ISBN 0116204990.

⁸⁰ Moreover, as noted earlier, the existence of these lower inflation values should not be disregarded and some weight should be given to the overall results that would be obtained if they were used instead of the values in the Millennium databook in these years, given that COLI values were used in the long-term consumer prices series in official publications up to 2001 at least.

⁸¹ The ‘DMS inflation series’ here refers to the UK inflation series used in Table 75, for example, in the “*Credit Suisse Global Investment Returns Yearbook 2019*” by Eroy Dimson, Paul Marsh and Mike Staunton, published in February 2019 by the Credit Suisse Research Institute, ISBN 978-3-9524302-8-6

⁸² “*UK Consumer Price Statistics: A review*” by Paul Johnson, January 2015

future wedge between RPI and CPI as they are currently calculated (c.1% on average), to give a figure that can be used for a new price control that is set relative to CPI, consistent with Johnson's recommendation.

- 30) This report addresses these Ofgem responses by providing further information to show that the historic RPI series is more reliable and is derived from sources that calculate values that are more comparable than the CPI series, and so the historic RPI series is "*the best measure of inflation, both ex-post and ex-ante, for the purposes of accurately estimating the Total Market Return*" and is "*the best available measure of inflation*", consistent with Ofgem's desired characteristics for the inflation measure used.

THE UNRELIABILITY OF THE SOURCES USED FOR THE MILLENNIUM DATABOOK'S CPI SERIES AS A SOURCE OF CPI VALUES

- 31) The 'original' CPI series in the BoE Millennium databook from 1899 draws on four underlying sources from 1899 onwards:
- 1899 to 1949 – deflators derived from the estimated National Accounts prepared by Feinstein (1972)
 - 1950 to 1988 – a 'work in progress' series of 'modelled estimates' of CPI produced in 2013 by the ONS
 - 1988 to 1996 – retrospectively calculated CPI values based on detailed price data that had been retained by the ONS
 - 1996 onwards – actual CPI values
- 32) This section considers the suitability and reliability of each of these sources as a measure of CPI on a consistent and comparable basis.

1899 to 1949 – Deflators calculated from the Feinstein (1972) estimated National Accounts

- 33) The early part of the series uses implied consumers' expenditure deflators that are calculated from Feinstein's (1972) estimated National Accounts (which are also used in the Millennium databook's RPI series). However, in the light of the reservations expressed in the Bank of England Millennium dataset itself (see above), the fact that the deflators derived from Feinstein's estimated National Accounts are used for the Millennium databook's CPI series up to 1949 cannot be considered evidence that the Bank of England considered them a reliable estimate of CPI, especially when these same values were also used in the corresponding RPI series in these years. Rather, it merely indicates an absence of any other known sources of CPI values prior to 1950, and by itself it says nothing about whether the values better represent RPI or CPI.
- 34) Moreover, the ONS have recently confirmed to Oxera⁸³ that these values are likely to be based on underlying series constructed using a methodology comparable to RPI, and so the consumers' expenditure deflator series would contain the upward influence of the RPI formula effect, and so would overstate CPI inflation. It follows that these deflator values cannot be considered to give an indication of CPI values during these years, but can be considered representative of RPI.⁸⁴
- 35) This conclusion is consistent with the discussion in the ONS's "*Consumer Price Indices Technical Manual*" (2014 edition), which explains that the deflators derived from Feinstein's (1972) national accounts are used by the ONS in a longer-term series that was produced for longer term comparisons of RPI rather than CPI. The manual explains in the Retail Price Index chapter (Chapter 10) that RPI is preferred to CPI for making long-term comparisons of

⁸³ "The cost of equity for RIIO-2", Q4 2019 update prepared by Oxera for Energy Networks Association November 2019, see page 16, <https://www.oxera.com/w p-content/uploads/2018/01/Cost-of-equity-for-RIIO-2-Q4-2019-update.pdf>

⁸⁴ This is consistent with the use of these deflators derived from Feinstein (1972) in the ONS's own long-term RPI series, as described for example in "*Consumer Price Inflation since 1750*", by Jim O'Donoghue and Louise Goulding (ONS) and Grahame Allen (House of Commons Library), from ONS's Economic Trends 604 (March 2004), <https://www.earchive.nationalarchives.gov.uk/20151014013731/http://www.ons.gov.uk/ons/rel/elmr/economic-trends--discontinued-/no--604--march-2004/index.html>

the purchasing power of the pound, noting that ***“In the UK, the RPI has measured changes in the level of consumer prices since 1947. It is therefore preferred to other sources (such as the CPI which has a much shorter history), for comparing the purchasing power of the pound over this period.”***⁸⁵ It then describes how the implied consumers’ expenditure deflator for years prior to 1947 (derived from Feinstein’s estimated national accounts) was used to enable longer term comparisons of the purchasing power of the pound by combining it with RPI in later years rather than CPI (see Section 10.7.4 on page 84, and the comment on page 85 in the technical manual in the 2014 version, which reads *“For comparisons with years prior to 1947, a composite index back to 1800 is available ...”*). The manual also explains that for these longer-term comparisons, for years prior to 1947 *“The implied consumers’ expenditure deflator is preferred to the COLI, mainly due to the latter’s relatively limited coverage in terms of both products and population, together with concern about the quality of the weights.”*⁸⁶

- 36) As explained further below, the deflators derived from Feinstein’s estimated national accounts have in the past been consistently interpreted as comparable to RPI, not only by the ONS, but also by the House of Commons library and the Bank of England. This corroborates the view that the deflators can be seen as comparable to RPI rather than CPI.

1950 to 1988 – an indicative ‘work in progress’ series of ‘modelled estimates’ of CPI produced in 2013 by the ONS

- 37) The next part of the series (1950 to 1988) uses a backseries of CPI values published by the ONS in 2014, but multiple reservations and concerns have been expressed regarding these values, including in the 2014 paper itself which published and described this backseries⁸⁷; in other ONS documents; and in a recent book on the history of inflation measures which was written by the authors of the ONS’s paper.
- 38) Considering first the ONS paper itself, *“Modelling a Back Series for the Consumer Price Index”* by O’Neill and Ralph, released in 2014, multiple reservations are expressed by the authors regarding the results, as listed below, which show that they did not consider the results could be relied upon. It is also apparent from this paper that this data series for CPI from 1950 to 1988, which is now key to some regulators’ TMR estimates given its use in the BoE Millennium dataset, is not even an attempt to calculate actual CPI values during these years, but is just a modelled dataset that might or might not give values that are comparable to the CPI that would have been reported if CPI had actually been measured prior to 1988.
- a. in large font on the covering page this paper says it describes ***“work in progress on modelled back series for the CPI; further work is taking place and may result in changes to the series presented here.”*** This provides an immediate warning to readers of the paper that the values should not be considered reliable.
 - b. There are then the following comments in the Introduction to the paper, on pages 2 and 3: ***“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. (In order to estimate the CPI we would need access to price quotes and expenditure information for the years in question, none of which, in general,***

⁸⁵ *“Consumer Price Indices Technical Manual 2014 Edition”*, ONS, page 84, <https://www.ebarcive.nationalarchives.gov.uk/20160109133536/http://www.ons.gov.uk/ons/rel/cpi/consumer-price-indices---technical-manual/2014/index.html>

⁸⁶ *Ibid*, pages 84 and 85, see Section 10.7.4 which has the heading *“Internal Purchasing Power of the Pound (RPI only)”*

⁸⁷ O’Neill and Ralph, *“Modelling a Back Series for the Consumer Price Index”*, ONS, released July 2014

are available). The modelled estimates described in this paper provide an estimate of a consistent series for the primary inflation measure used in the UK over a period for which no such measure was previously available. **Because of the assumptions made in their construction, these estimates are not National Statistics.**"

- c. On page 7, at the start of Section 5 which gives an "Analysis of Backcast Series – Component Indices", the paper explains that "In this section the results of the estimation procedure are analysed in order to make a broad assessment of whether or not the estimates appear reasonable. **It is difficult to assess the accuracy of the series, as the true CPI can never be known. For that reason, it is also worth emphasising that these modelled estimates can only be considered as broad indications of the level of the CPI series at best and caution should be exercised when using these series. For the same reason, these estimates are not National Statistics.**"
- d. The paper then makes the comment at the bottom of page 7 that "From the limited evidence available it appears that our estimates of the CPI series are **not unrealistic, though it is difficult to make any stronger claims for the series presented.**"
- e. On page 10 the paper notes that "The ARIMA model utilised in this paper is one of a number of approaches investigated in the early stages of this research, and is chosen as it produces formula effects which look most realistic. **Other models may produce alternative formula effect backcasts. In addition, we choose to include variables relating to the level of the RPI and incidences of recessions; however, there are a number of other effects, such as January effects, which may be modelled and produce results which contrast with our own. Hence there are many ways in which the modelling approach taken might be augmented or re-designed with alternative series produced.**
Several other issues also present themselves; for example, the design of a series of weights to be used to combine the component indices into an all-items CPI and the definition of our recession variable. **By pointing out these choices we hope to emphasise that the series constructed here represents only one realisation of a back series of this length for CPI. It does, however, provide a plausible series which is available for use as a standard so that there is consistency among users in the source of historic CPI data.**"⁸⁸
- f. In addition, the results presented in the paper itself should themselves immediately call into question the reliability of the modelled values: for example, Table 1 in the ONS paper⁸⁹ shows that the average contributions to the formula effect for different categories of spend are in several cases very different during the modelled period from those in the subsequent years (from 1988) during which actual values of RPI and CPI both existed, and in a number of cases these even change sign between the two periods. In commenting on this table, the paper itself notes that "**This may demonstrate a potential weakness of the modelling technique employed in these series and emphasises the approximate nature of the backcasts.**"

- 39) Similarly, wherever the 2014 edition of the ONS's "Consumer Price Indices Technical Manual" refers to the CPI modelled backseries, it observes that "these are indicative, modelled figures which should be treated with some caution". This is in marked contrast to the discussion of

⁸⁸ Further insight into the unreliability of applying these kinds of models to produce an estimated backseries for CPI can be gained by considering the comments in the ONS's December 2018 release of "Consumer Prices Index including owner occupiers' housing costs (CPIH) historical series: 1988 to 2004", <https://www.ons.gov.uk/economy/inflationandpriceindices/articles/consumerpricesindexincludingowneroccupiershousingcostshistoricalseries/1988to2004> Annex C describes an attempt to apply time series models to create an historical series for just one component of CPIH, Owner Occupier Housing, and amongst other things notes "the poor accuracy of the model-based backcasts" and that "Users should therefore be aware of the poor quality of the back series and are encouraged not to use it unless necessary".

⁸⁹ O'Neill and Ralph, "Modelling a Back Series for the Consumer Price Index", ONS, released July 2014 (<https://www.ebarchive.nationalarchives.gov.uk/20151014001752/>)

the Retail Price Index in Chapter 10 in the Technical Manual, which explains that RPI is preferred to CPI for making long-term comparisons of the purchasing power of the pound. ***“In the UK, the RPI has measured changes in the level of consumer prices since 1947. It is therefore preferred to other sources (such as the CPI which has a much shorter history), for comparing the purchasing power of the pound over this period.”*** Also in this chapter of the manual which deals with RPI, the ONS says *“For comparisons with years prior to 1947, a composite index back to 1800 is available ...”*: this uses the implied deflator for consumers’ expenditure (derived from Feinstein’s (1972) estimated National Accounts) for years up to 1947, and then in later years uses the Retail Price Index. This series continues to be published and updated, appearing as the ONS’s ‘Composite Price Index’ shown on table 49 of each month’s consumer price inflation dataset (which contains current and past values of RPI, CPI and CPIH) from the ONS. Since the ONS has chosen to link the consumers’ expenditure deflators to the subsequent values of RPI, rather than to CPI values (from 1988) and the modelled CPI backseries (from 1950 to 1988), the ONS is implicitly confirming that the implied deflators derived from Feinstein (1972) can be taken as compatible with the values of RPI in later years.

- 40) Furthermore, the authors of the ONS’s 2013 paper *“Modelling a Back Series for the Consumer Price Index”* (i.e. O’Neill and Ralph) have more recently co-written a book on the history of Inflation⁹⁰. It is telling that in this book they contrast the reliability of the historic time series for RPI and CPI in the following way: ***“There is another, different attribute of the [RPI] measure that came out of the RPI consultation – its value as a long-running measure produced on similar terms. The CPI, in contrast, was only introduced in 1996. To help with economic modelling, the CPI was calculated back to 1989 using price microdata that had been retained; the microdata for the period before 1989 had not been kept. Despite the lack of such data, ONS was asked to produce a version of the CPI back to 1950. To achieve this, a set of modelled series were produced using time series techniques (O’Neill and Ralph 2014).”***
- 41) This shows that even the authors of the modelled backseries did not consider it to provide reliable estimates of CPI, at least in comparison to the RPI series which, in spite of the changes in its detailed construction over time which are described in detail in the book, they recognise has value as a *‘long-running measure produced on similar terms’*.
- 42) In addition, a recent update on CPIH and CPI backseries from the ONS has reinforced that the CPI backseries cannot be relied upon, and furthermore the ONS is going to update these values (though it is unclear whether the resulting update will itself be able to give robust and reliable figure for CPI back to 1947)⁹¹:
 - ***“The ONS previously published indicative modelled estimates for the CPI between 1947 and 1987. These estimates are for analytical purposes only and are not intended for official uses.”***
 - The paragraph then continues *“The models used were based on the subsequently revised CPI modelled data for 1988 to 1996. The ONS will therefore produce new indicative estimates for the CPI between 1947 and 1987 alongside the planned CPIH estimates, based on the corrected CPI data. This will give users a consistent set of modelled indices. These new estimates will be published by the end of 2020.”*

⁹⁰ *“Inflation History and Measurement”*, O’Neill, Ralph and Smith, 2017, ISBN 978-3-319-64124-9, published by Palgrave Macmillan.

⁹¹ ONS statement *“Developing CPIH and CPI historical estimates between 1947 and 1987”*, 10/10/2019, <https://www.ons.gov.uk/new/s/statementsandletters/developingcpihandcpihistoricalestimatesbetween1947and1987>

CPI Values from 1988 onwards

- 43) Even the values of CPI from 1988 to 1996 had to be calculated or estimated retrospectively by the ONS, and the ONS has stated that even these “*should be treated with some caution*” (and indeed they were subject to some minor revisions when errors were recently discovered in them⁹²), but they can probably be considered reasonably reliable and accurate as they are calculated from individual prices data that had been retained.
- 44) The values of CPI from 1996 onwards are actual published values, so can be relied upon.

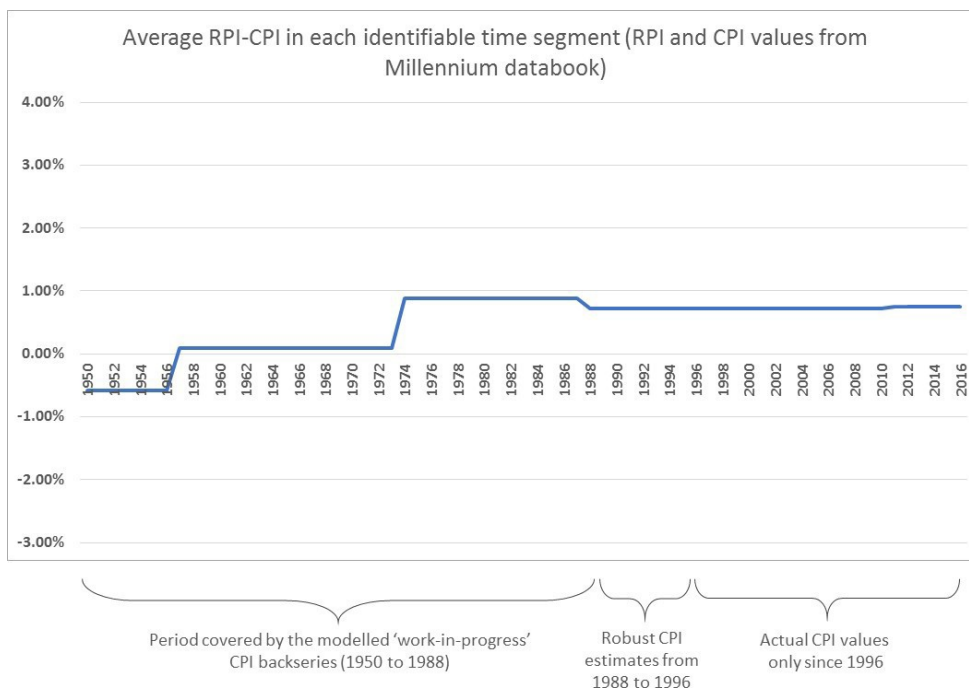
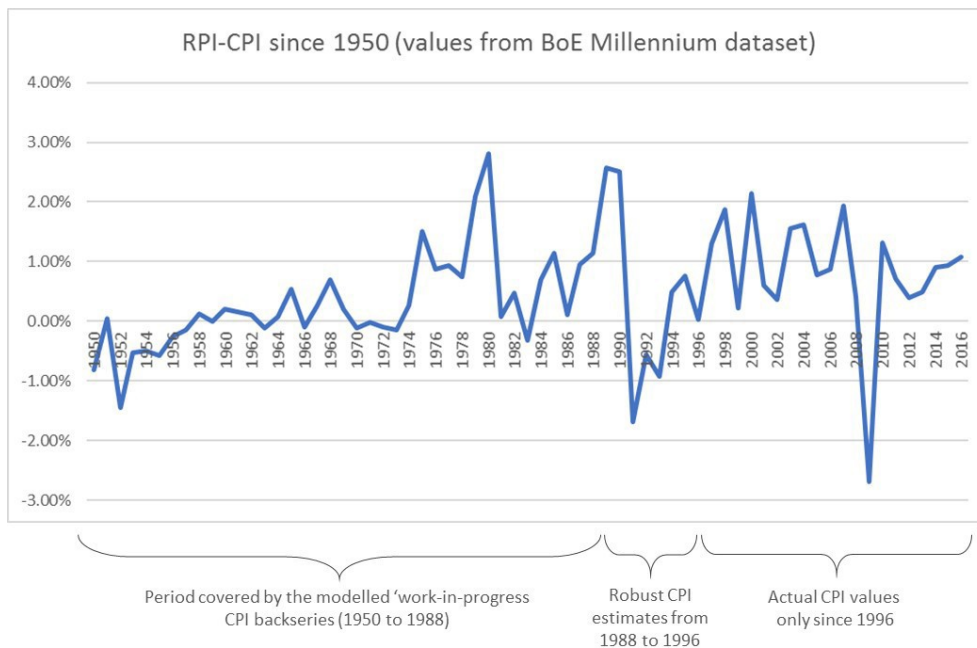
Conclusion on the reliability of the sources from which the Millennium Databook’s CPI series is drawn

- 45) In conclusion, the references and information reviewed above show that there are only reliable values of CPI from 1988 onwards, with significant doubts over the values used in the Millennium databook’s CPI series for 1900 to 1949 and for 1950 to 1988.

⁹² *Ibid.*

FURTHER INDICATIONS THAT THE VALUES OF THE CPI BACKSERIES DO NOT APPEAR RELIABLE

- 46) The following charts gives a comparison between the Millennium databook's RPI and CPI datasets since 1950. There is no merit in extending the comparison further back, as the same inflation values are used by the Millennium databook for both, these being the implied consumers' expenditure deflators derived from Feinstein's unofficial National Accounts, published in 1972.



- 47) The second of these charts shows that the average differential between the BoE Millennium databook's CPI and RPI series has changed significantly over time. In particular, the average

difference during the years covered by the modelled CPI backseries (1950 to 1988) is inconsistent: as you move further back in time, it falls from an average of almost 1% (c.0.9%) between 1974 and 1988 to an average close to zero (c.0.1%) from 1957 to 1973, and then becoming negative prior to 1956 (i.e. the modelled CPI series is higher than the RPI series up to and including 1956)⁹³. Given that the formula effect (related to use of Carli averaging in RPI but not in CPI) would have applied throughout, the absence of a material positive difference between RPI and CPI prior to 1974 should immediately cast significant doubt over the reliability of the backcast CPI values.

- 48) The backcast series was estimated by a modelling approach, which did not even seek to estimate CPI from underlying detailed price data (as this no longer exists), but instead sought to estimate the CPI from the components of RPI by estimating the formula effect for each category of expenditure separately using a time series modelling approach. The 2013 paper which describes this approach⁹⁴ explains that different formulations of these models could give different results.
- 49) In addition, the results presented in the paper itself should themselves immediately call into question the reliability of the modelled values: for example, Table 1 in the ONS paper⁹⁵ shows that the average contributions to the formula effect for different categories of spend are in several cases very different during the modelled period from those in the subsequent years (from 1988) during which actual values of RPI and CPI both existed, and in a number of cases these even change sign between the two periods. In commenting on this table, the paper itself notes that “*This may demonstrate a potential weakness of the modelling technique employed in these series and emphasises the approximate nature of the backcasts.*”
- 50) Whilst the paper says that the results for the modelled CPI series “*can only be considered as broad indications of the level of the CPI series at best*”, even this limited claim for the reliability of the values should be seen in the context of the other reservations expressed in the paper, listed above. Furthermore, even if the overall modelled values can be considered a ‘broad indication’ of CPI, this does not mean that the differences between the modelled CPI values and RPI values during these years would be reasonable: these differentials are much smaller than the average RPI (or average CPI), and thus a level of accuracy that might be considered acceptable in relation to the CPI values themselves would be much more likely to be considered unreasonable if seen in relation to the size of the implied RPI-CPI wedge.
- 51) Given the modelling approach used for the backcast, it might be expected that the further back in time you go from 1988 (when reasonably reliable values of CPI first exist), the less reliable and accurate will be the modelled series. It may also be the case that there should be doubts over the modelling approach used in the calculation of the CPI backseries from 1950 to 1988.⁹⁶ Furthermore, given that the CPI was modelled from the components of RPI

⁹³ It can be seen from O’Neill and Ralph, “*Modelling a Back Series for the Consumer Price Index*”, ONS, released July 2014 that the modelled CPI backseries results in a different pattern of RPI-CPI before and after 1974 – see e.g. Figure 3. To best reflect this, in this report the values prior to 1974 and starting in 1974 are considered separately.

<https://www.ebarhive.nationalarchives.gov.uk/20151014001752/http://www.ons.gov.uk/ons/rel/cpi/modelling-a-back-series-for-the-consumer-price-index/1950---2011/index.html>.

⁹⁴ O’Neill and Ralph, “*Modelling a Back Series for the Consumer Price Index*”, ONS, released July 2014 <https://www.ebarhive.nationalarchives.gov.uk/20151014001752/http://www.ons.gov.uk/ons/rel/cpi/modelling-a-back-series-for-the-consumer-price-index/1950---2011/index.html>

⁹⁵ *Ibid*

⁹⁶ Further insight into the unreliability of applying these kinds of models to produce an estimated backseries for CPI can be gained by considering the comments in the ONS’s December 2018 release of “*Consumer Prices Index including owner occupiers’ housing costs (CPIH) historical series: 1988 to 2004*”, <https://www.ons.gov.uk/economy/inflationandpriceindices/articles/consumerpricesindexincludingowneroccupiershousingcostshistoricalseries/1988to2004>. Annex C describes an attempt to apply time series models to

by estimating the formula effect for each category of expenditure, it seems implausible that CPI and RPI tend towards each other as you move back in time, with CPI then becoming higher than RPI in the earliest years of the back-series⁹⁷, given the formula effect which results from the use of the Carli averaging formula at the lowest level of aggregation in the RPI but not in CPI. These reservations would add support to the implication from the above charts that the CPI backseries, particularly prior to 1974, is not reliable.

create an historical series for just one component of CPIH, Owner Occupier Housing, and amongst other things notes *“the poor accuracy of the model-based backcasts”* and that *“Users should therefore be aware of the poor quality of the back series and are encouraged not to use it unless necessary”*.

⁹⁷ Note that there was no recession between 1948 and 1955, GDP increased significantly from 1948 to 1956, and inflation was positive, so the formula effect across these years would not be expected to be negative.

FURTHER ASSESSMENT OF THE IMPLIED CONSUMERS' EXPENDITURE (CED) DEFLATORS CALCULATED FROM FEINSTEIN'S (1972) ESTIMATED NATIONAL ACCOUNTS

- 52) From 1900 to 1949, the Millennium databook's CPI series is based on implied consumers' expenditure deflators that are calculated from the estimated National Accounts produced by Feinstein (1972).
- a. These deflators are derived from the unofficial National Accounts compiled by Feinstein (1972), and they actually extend forward to 1965 and back to 1870. Note that Feinstein explains that the first and second objectives of his 1972 publication⁹⁸ were "*to provide a complete set of national accounts for the interwar years and to present these in a form which is, as nearly as possible, consistent in concept and definition with the post-war estimates published by the Central Statistical Office*" and "*to extend the estimates to cover the years before 1914 ...*". Furthermore, Feinstein notes that "*1965 was chosen as the terminal date, partly as a matter of convenience, but mainly on the grounds of reliability. Experience has shown that all estimates in the annual CSO Blue Books on National Income and Expenditure are liable to be altered, but figures for the most recent years are particularly subject to revision as more comprehensive and accurate information becomes available. The post 1946 estimates are readily available in the Blue Books and are reproduced here only in order to provide a single source for long-run national income series*".
 - b. Feinstein's National Accounts were then extended further forward to 1990 by Sefton and Weale (1995)⁹⁹, who used values in the Blue Book National Accounts publications up to the 1993 edition, together with the values from Feinstein (1972). (Sefton and Weale's book was a follow-up to the Feinstein (1972) publication, both being published as part of a series entitled "*Studies in the National Income and Expenditure of the United Kingdom*".)
 - c. It is then possible to extend this series further forward still, up to 2009, using the household consumption expenditure deflators¹⁰⁰ (parameter YBFS, Table 1.4) in the official Blue Book National Accounts that were published in subsequent years (from 2000 up to 2010).
 - d. **It is not though possible to extend this series further forward beyond 2009, as a substantive change was made in the methodology used for the National Accounts between the publication of the 2010 and 2011 Blue Books¹⁰¹. Thus, National Accounts CED deflators for years after 2009 are not available on a basis that is comparable to the Feinstein (covering up to 1965) or Sefton and Weale (covering up to 1990) publications.**
 - i. As explained on page 2 in the 2007 Edition of the Consumer Prices Indices Technical Manual, "*For many purposes, comparisons overtime are more useful when the effect of price changes is eliminated. For instance, estimates are made of gross domestic product (GDP) and its main components in each period, revalued at the average prices in a selected year. The RPI and its components are used to adjust current levels of household final consumption expenditure and other economic series to produce a constant price series. This is typically done by deflating (dividing) estimates of expenditure at current prices by appropriate*

⁹⁸ "National Income Expenditure and Output of the United Kingdom 1855 – 1965", C H Feinstein, Cambridge University Press, 1972, ISBN 0 521 07230 1, see Chapter 1 page 1.

⁹⁹ "Reconciliation of National Income and Expenditure; Balanced Estimates of National Income for the United Kingdom 1920 – 1990", 1995, by James Sefton and Martin Weale, ISBN 0-521-49635-7, published by Cambridge University Press.

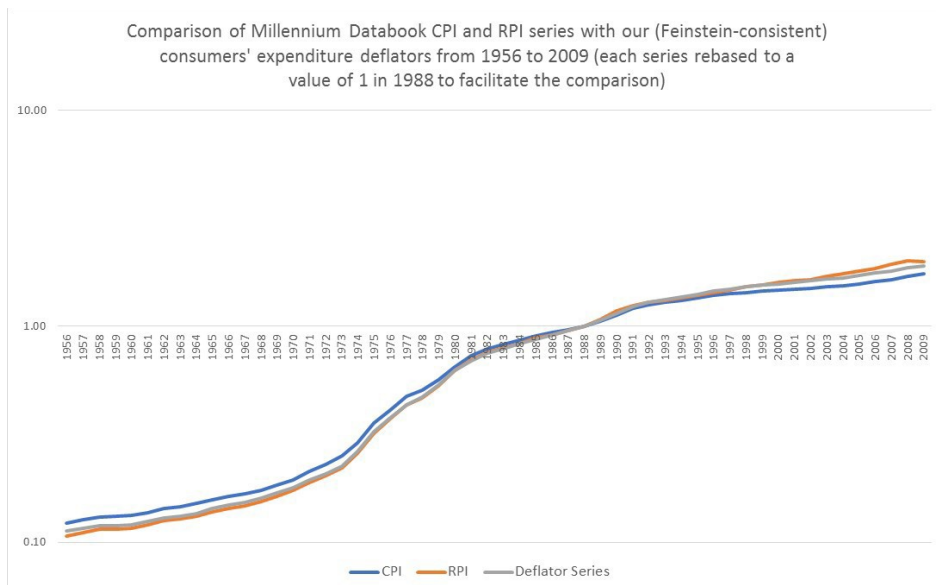
¹⁰⁰ YBFS is the implied deflator relating to the final consumption expenditure deflator for households (HH) and non-profit institutions serving households (NPISH), but the expenditure by NPISH is relatively very small (see e.g. Table 1.3 in the 2003 Blue Book) and so will not materially influence the value of YBFS

¹⁰¹ This was a change from using components of RPI to deflate some elements of the current price series to using components of CPI instead.

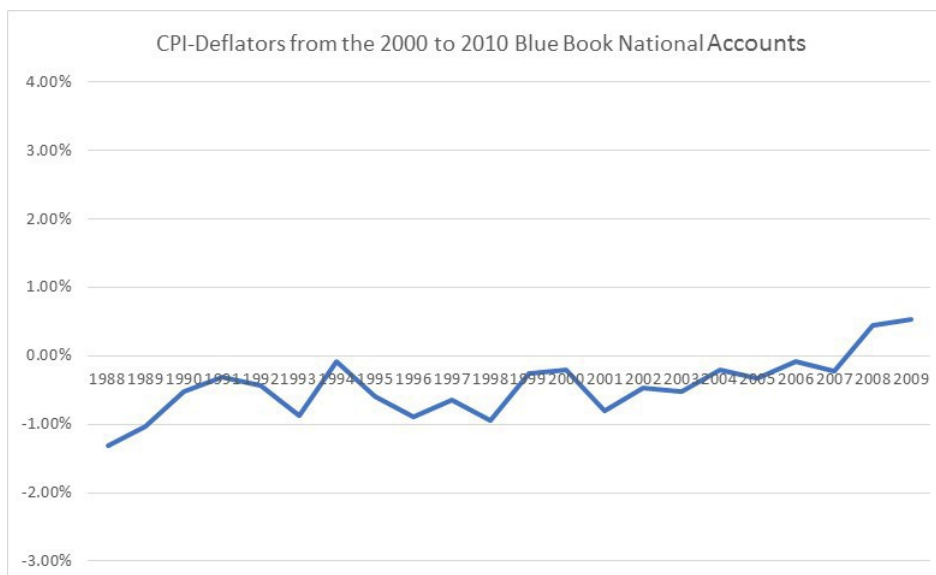
price indices, derived from the RPI.” However, the approach was changed for the 2011 Blue Book, as explained at page 1 in the 2014 Consumers Prices Indices Technical Manual “Since October 2011 the CPI has been used for deflating consumer spending within the National Accounts”.

- ii. The 2014 Manual also explains (see page 1) that “**Historically, the RPI had been used as the basis for the Government’s inflation target, deflation in the National Accounts and to index various prices and incomes including tax allowances, state benefits and pensions.**” This supports the view that consumers’ expenditure deflators in National Accounts prior to 2010 should *prima facie* be considered comparable to RPI but not to CPI.
 - e. The consistent basis of these different sources (Feinstein 1972, Sefton and Weale 1995, and Blue Books prior to 2010) is confirmed or supported by the following observations:
 - i. Sefton and Weale’s values for the years from 1920 to 1948 for consumers’ expenditure in current price and constant prices, from which the deflators (CEDs) are calculated, seem close to, though slightly different from, those in Feinstein’s original 1972 publication, though these minor differences have no material effect on the implied deflators that would be calculated for the consumers’ expenditure. (The geometric average CED deflator from 1920 to 1948 based on Sefton and Weale (Tables A.8 and A.10) is 0.72% p.a., whereas from Feinstein (1972) (Tables 2 and 5) it is 0.70% p.a.¹⁰²)
 - ii. Secondly, if you exclude the last couple of years (1989 and 1990) in Sefton and Weale’s study (consistent with Feinstein’s approach and given that, as Feinstein explained – see the quotation in point (a) above - the last couple of years of data in the Blue Book publications are those which are particularly subject to revision in subsequent years’ Blue Books), the geometric average consumer expenditure deflators calculated from Sefton and Weale’s tables agree closely across the years of overlap with those calculated from the YBFS parameter, for example in:
 - the 2000 Blue Book (4.80% c.f. 4.76% p.a. across 1982 to 1988); and
 - the 2002 Blue Book (4.79% c.f. 4.75% p.a. across 1984 to 1988).
- 53) Therefore, it is possible, using these sources, to compile an inflation series based on consumers’ expenditure deflators that are derived from National Accounts (a combination of Feinstein’s estimates to 1948, then Sefton and Weale’s collated values up to 1988, and then actual Blue Book National Accounts) that were prepared on a basis that appears consistent and so gives consistently-based results for the whole period from 1870 to 2009. For the period from 1900 to 1948 these deflators are also consistent with the values in the Millennium databook CPI and RPI series, as the deflators derived from the Feinstein (1972) National Accounts were used for both the RPI and CPI series during these years.
- 54) A simple comparison of this resulting composite National Accounts deflator series to the Millennium databook RPI and CPI series, from 1956 (when the official RPI series was first introduced) to 2009 (the last year for which deflator values on a consistent Feinstein-like basis are available) is shown below. (This uses a logarithmic scale so changes in both parts of the graph are shown more clearly.) This immediately suggests that the composite deflator series is more comparable to RPI than CPI.

¹⁰² During the remaining years of overlap for the two sources, i.e. from 1948 to 1965, Feinstein (1972) and Sefton and Weale (1995) express the ‘constant prices’ expenditure in a different cost base, so the resulting deflators might be expected to be less directly comparable. The geometric average consumers’ expenditure deflators from 1948 to 1965 nevertheless still agree well, being 3.24% p.a. from Feinstein and 3.31% p.a. from Sefton and Weale.



55) More importantly, a comparison between this resulting 'national accounts deflator' series for consumers' expenditure and actual CPI values during the years that both of these are available can be made, and will more directly show whether the deflators based on Feinstein (1972) are a good representation of actual CPI. As CPI values exist from 1996 onwards, and reliable estimates are available from 1988, this comparison should be made in the first instance across the years from 1988 to 2009, which are the years for which values for both CPI and Feinstein-consistent deflators exist. This is shown in the following graph: the average difference from 1988 to 2009 is c. -0.44%, i.e. CPI is c. 0.44% on average lower than the National Accounts deflators (and this average difference would increase to c. -0.54% if the atypical and apparently anomalous values for 2008 and 2009, in the immediate aftermath of the Global Financial Crisis, were excluded).

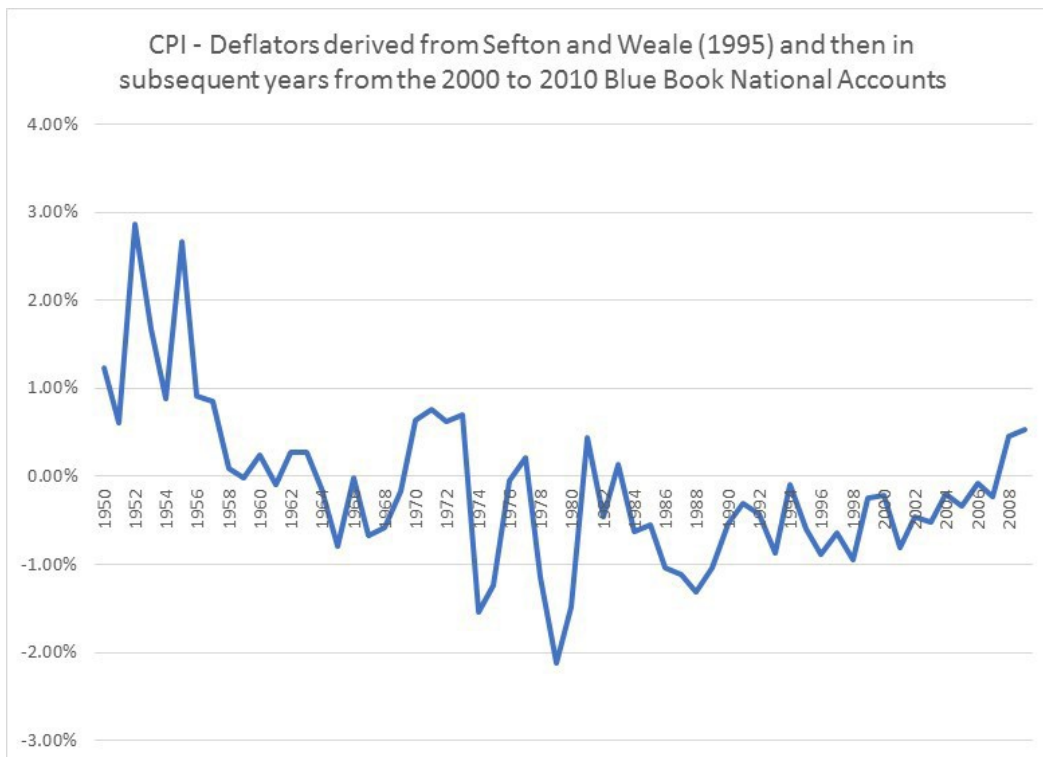


Note that the 2008 and 2009 values, which appear atypical/anomalous, occur in the aftermath of the Global Financial Crisis, during a period when house prices (which are excluded from CPI) were falling.

56) This shows that consumers' expenditure deflators derived from these National Accounts, which were prepared in a form that is believed to be consistent with the Feinstein (1972) National Accounts, do not give a good indication of the likely level of CPI as it has actually been calculated since 1988, and would instead materially overestimate the level of CPI. It follows that the deflators derived from Feinstein's National Accounts (and used in the

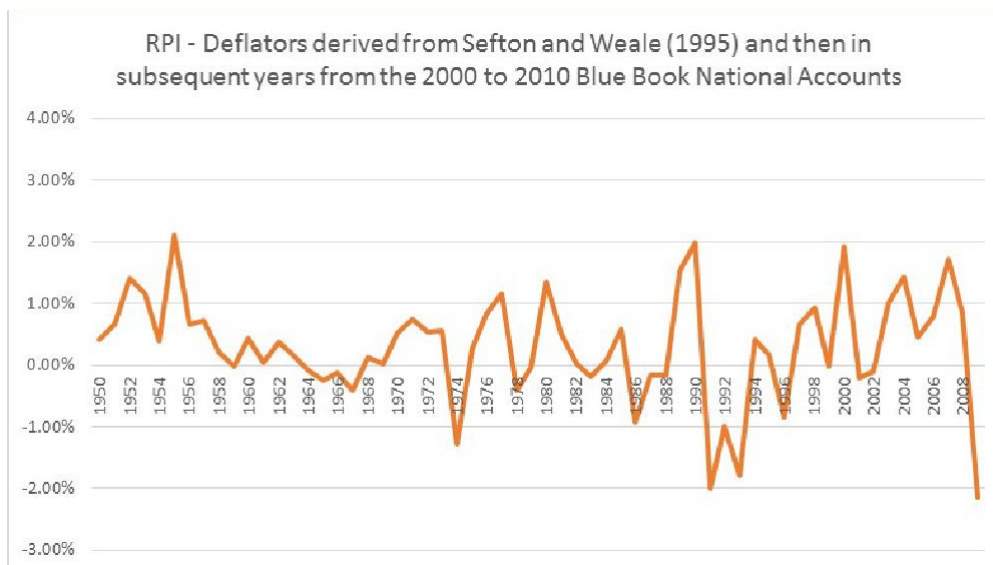
Millennium databok's RPI and CPI series up to 1949), which were prepared in 1972 in a way that was consistent with the (then) Blue Books, are unlikely to give a reasonable estimate of CPI, and CPI will instead be expected to be appreciably smaller than these deflators.

- 57) A similar comparison of the CPI 'work-in-progress' backseries covering 1950 to 1988 to deflators derived from these consistently prepared National Accounts can then be used to give further insight into the reliability of the modelled CPI backseries. This is illustrated in the following chart, which extends the above graph back to 1950 using the CPI backseries and values for consumers' expenditure deflators from Sefton and Weale (1995).

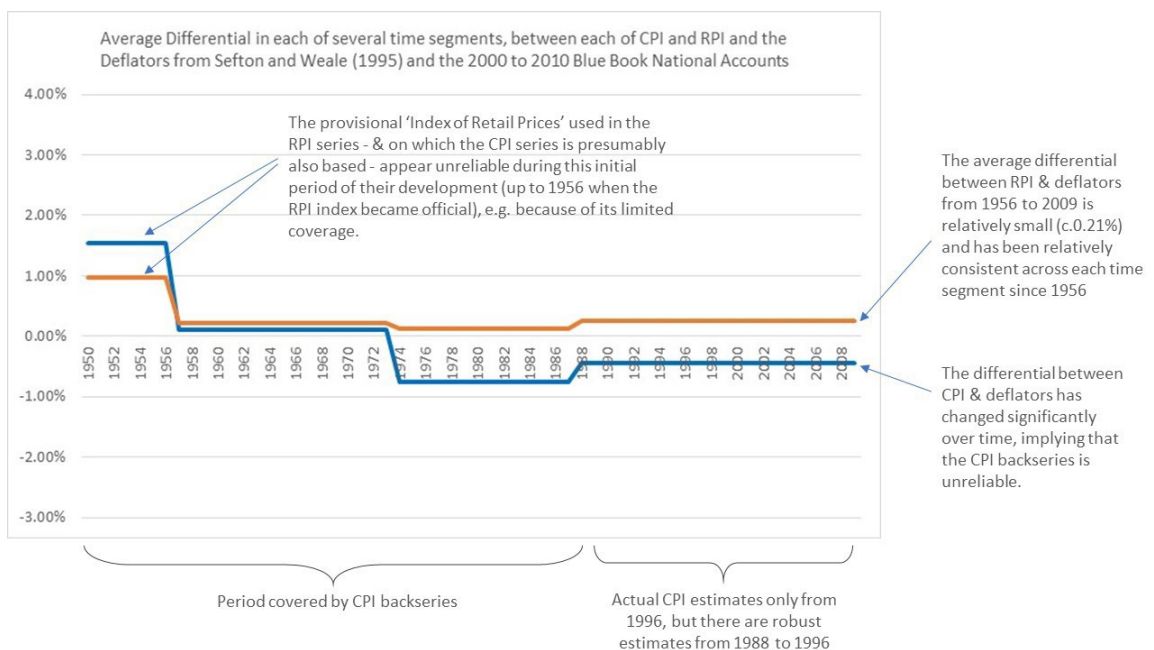


Note that the 2008 and 2009 values, which appear anomalous/atypical, occur in the aftermath of the Global Financial Crisis, during a period when house prices (which are excluded from CPI) were falling.

- 58) Whilst there are fluctuations from year to year in the differential between the CPI series and the deflators, and these fluctuations were somewhat greater prior to 1988 during the years of the modelled 'work-in-progress' CPI back-series, there does seem to be an underlying trend to these values. The equivalent chart of RPI - deflators has similar fluctuations but, since the official RPI series first commenced in 1956, there is no similar discernible trend in the average difference between RPI and the deflators:



59) The trend referred to above is shown more clearly by the blue line in the following chart, which compares the average differences between CPI and the deflators in each of several time-segments (i.e. 1950 to 1956, when the official RPI series was first introduced; 1957 to 1973, given that (as noted earlier) 1974 seems to mark the start of a shift in the pattern of the modelled CPI backseries values¹⁰³; 1974 to 1987 covering the remainder of the CPI backseries; and 1988 onwards, which are the only years for which accurate estimates of CPI or actual CPI values exist). The corresponding average differences between RPI and the deflators in each of these time segments is also shown (see the orange line in the chart):



60) What these graphs show is that the CPI modelled backseries from 1950 to 1988 is not consistent with the consumers' expenditure deflators derived from National Accounts, the

¹⁰³ See Figure 3 in O'Neill and Ralph, "Modelling a Back Series for the Consumer Price Index", ONS, released July 2014

(<https://www.earchive.nationalarchives.gov.uk/20151014001752/http://www.ons.gov.uk/ons/rel/cpi/modelling-a-back-series-for-the-consumer-price-index/1950---2011/index.html>)

average difference between the two has varied significantly over time during the years covered by the backseries, and these differences are not consistent with the differences in the more recent years (from 1988 to 2009) during which actual values of Feinstein-compatible National Accounts and reliable values of CPI both exist. This strongly supports the conclusion that the CPI backseries does not give a reliable or consistent dataset, that was illustrated earlier in this report by the comparison of RPI and CPI values, as well as by the multiple references that were documented above that explained why the CPI modelled backseries should not be relied upon. This is especially so now the ONS has stated that the CPI backseries estimates from 1950 to 1988 are going to be replaced by new indicative estimates¹⁰⁴.

- 61) In contrast:
 - a. the comparison in the chart above of RPI to the deflators derived from National Accounts (Sefton and Weale and the 2000 to 2010 Blue Books) reveals that, for each of the 3 time segments covering the period of >50 years from 1956 to 2009, the average difference between the RPI and deflator series has been small and relatively consistent;
 - b. the observation of a small average differential between RPI and CED deflators from 1956 to 2009, with no clearly discernible trend over >50 years, implies that the deflators from Feinstein's estimated National Accounts prior to 1956 (going back to 1870, & derived in a consistent way with those in Sefton & Weale) can be used as a good proxy for RPI prior to 1956 (although based on the analysis in this report there may be case for increasing the values of CED deflators derived from Feinstein's National Accounts from 1870 to 1956 by c.0.2% when using these values as estimates of RPI during these years).

- 62) In addition, the greater consistency between the average CED deflators and RPI, across each of the time periods considered covering the protracted period from 1956 to 2009, lends further weight to the confirmation recently received by Oxera¹⁰⁵ from the ONS that the deflators for earlier years that are derived from the Feinstein (1972) estimated national accounts are likely to be based on underlying series constructed using a methodology comparable to RPI, and will include at least some of the formula effect. This would also seem consistent with the statement in the 2014 Consumers Prices Indices Technical Manual that historically the RPI had been used as the basis for deflation in the National Accounts¹⁰⁶. Together, these imply that CED deflators derived from Feinstein (1972) should be seen as RPI-like rather than CPI-like and should be considered consistent with RPI.

- 63) It follows that the deflators that are derived from the Feinstein (1972) unofficial National Accounts, and which are used in both the RPI and CPI series in the Bank of England's Millennium databooks for the years prior to 1948, should not be taken as a proxy for CPI, and should instead be seen as a proxy for RPI (although as noted above there may be case for increasing the values of (CED) deflators derived from Feinstein's National Accounts from 1870 to 1956 by c.0.2% p.a. when using these values as estimates of RPI during these years).

¹⁰⁴ ONS statement "Developing CPIH and CPI historical estimates between 1947 and 1987", 10/10/2019 <https://www.ons.gov.uk/new/s/statementsandletters/developingcpihandcpihistoricalesimatesbetween1947and1987>

¹⁰⁵ "The cost of equity for RIIO-2", Q4 2019 update prepared by Oxera for Energy Networks Association, November 2019, see page 16, <https://www.oxera.com/wp-content/uploads/2018/01/Cost-of-equity-for-RIIO-2-Q4-2019-update.pdf>

¹⁰⁶ "Consumer Price Indices Technical Manual 2014 Edition", ONS, page 1, <https://www.earchive.nationalarchives.gov.uk/20160109133536/http://www.ons.gov.uk/ons/rel/cpi/consumer-price-indices---technical-manual/2014/index.html>

THE CONCLUSION THAT THE CED DEFLATORS DERIVED FROM FEINSTEIN'S (1972) NATIONAL ACCOUNTS ARE A GOOD MEASURE OF RPI IS CONSISTENT WITH THE WAY THAT THESE DEFLATORS HAVE PREVIOUSLY BEEN USED

- 64) The conclusion that the consumers' expenditure deflators that are derived from the Feinstein (1972) unofficial National Accounts give a good representation of RPI during the relevant years is perhaps not surprising, given the carefully considered use that has previously been made of these deflators, i.e. the values of the deflators have been used for the period prior to 1948 and then combined with RPI in subsequent years to give a long-run inflation series on a consistent and compatible basis. This approach has been documented over many years in a number of different sources and as already noted above has been supported by the ONS, the Bank of England and the House of Commons Library.
- 65) The 2004 ONS paper "*Consumer price Inflation from 1750*" by O'Donoghue, Goulding and Allen¹⁰⁷ describes the construction of the long-term inflation series, including the use of the deflators up to 1948 and then RPI subsequently. The paper explains why the deflators (rather than COLI) were chosen for the period up to 1947, to be combined with the values of RPI in subsequent years.
- 66) This use of the deflators as a measure of RPI is still, at the date of this report, supported by the ONS: the ONS's own long-run series of inflation is still based on RPI since 1947, and deflators derived from Feinstein (1972) before then. The inflation spreadsheet published each month by the ONS has a series at Table 49 called "*Composite Price Index: 1800 to 2018*" which is still being updated, and this has identical values to the O'Donoghue paper from 1900 to 2003, with RPI continuing to be used for subsequent years (2003-2018) as it was for the preceding years.
- 67) There is also a series called "*Retail Prices Index: Long Run Series 1947 to 2019*", that is published separately by ONS, as well as the series that is published in the inflation spreadsheet each month¹⁰⁸.
- 68) The House of Commons Research paper "*Inflation: The value of the Pound 1750 – 2002*" which was published on 11/11/2003 also uses deflators calculated from Feinstein's National Accounts for the period up to 1947 and then RPI subsequently. These values were also still used in the updated 29 May 2012 House of Commons Research paper "*Inflation: The value of the Pound 1750 – 2011*". The paper explains that "*this new price index was agreed between the Office for National Statistics, the Bank of England and the Library*".
- 69) The Bank of England's online 'Inflation calculator', which enables comparisons of changes in prices over the long-term to be made, uses the ONS's 'composite price index' series from 1750 onwards, and thus the same deflator values up to 1947, and from then onwards the actual published Retail Price Index.¹⁰⁹
- 70) The 2014 edition of the ONS's "*Consumer Price Indices Technical Manual*" explains that the deflators derived from Feinstein's national accounts are **used by the ONS in a long-term series that was produced for longer term comparisons of RPI rather than CPI**. The

¹⁰⁷ ONS paper "*Consumer price Inflation from 1750*", O'Donoghue, Goulding and Allen, 2004: <http://www.ons.gov.uk/ons/rel/cpi/consumer-price-indices/1750--2003/composite-consumer-price-index-with-description-and-assessment-of-source-data.pdf>

¹⁰⁸ "*Retail Prices Index: Long run series: 1947 to 2019*", ONS, <https://www.ons.gov.uk/economy/inflationandpriceindices/timeseries/cdco/mm23>

¹⁰⁹ <https://www.bankofengland.co.uk/monetary-policy/inflation/inflation-calculator>

manual explains in Chapter 10 (which considers the Retail Price Index) that RPI is preferred to CPI for making long-term comparisons of the purchasing power of the pound, noting that ***“In the UK, the RPI has measured changes in the level of consumer prices since 1947. It is therefore preferred to other sources (such as the CPI which has a much shorter history), for comparing the purchasing power of the pound over this period.”***¹¹⁰ It then describes how the implied consumers’ expenditure deflator for years prior to 1947 (which were derived from Feinstein’s estimated national accounts) was used to enable longer term comparisons of the purchasing power of the pound by combining it with RPI in later years rather than CPI (see Section 10.7.4 on page 84, and the comment on page 85 in the technical manual in the 2014 version, which reads *“For comparisons with years prior to 1947, a composite index back to 1800 is available ...”*). The manual also explains that for these longer-term comparisons, for years prior to 1947, *“The implied consumers’ expenditure deflator is preferred to the COLI, mainly due to the latter’s relatively limited coverage in terms of both products and population, together with concern about the quality of the weights.”*¹¹¹

¹¹⁰ “Consumer Price Indices Technical Manual 2014 Edition”, ONS, page 84, <https://www.ebarchive.nationalarchives.gov.uk/20160109133536/http://www.ons.gov.uk/ons/rel/cpi/consumer-price-indices---technical-manual/2014/index.html>

¹¹¹ *Ibid*, pages 84 and 85, see Section 10.7.4 which has the heading “Internal Purchasing Power of the Pound (RPI only)”

PROPOSED MINOR IMPROVEMENT TO THE MILLENNIUM DATABOOK RPI SERIES FROM 1948 TO 1956

- 71) The chart above also illustrates that the values of the unofficial 'index of retail prices' from 1948 to 1956, which are used for the ONS and BoE's RPI series and are also therefore the basis of the modelled CPI backseries during these years, appear unreliable during these years, and they do not appear to have been produced on a comparable basis to the values of the official RPI series in later years. This period from 1948 to 1956 was a time during which the index was being developed and frequently revised prior to it becoming the official RPI series in 1956. Annex A in the ONS (2014) paper by O'Neill and Ralph¹¹² shows that several categories of expenditure were first included in RPI in 1956. Other changes in 1956¹¹³ included a wider updating of weights (rather than using weights based on pre-war data); inclusion of a wider range of items in the index; the first serious attempt to measure owner-occupiers' housing costs; and an extension to the range of households represented in the index (expansion of scope of households included in the RPI from working classes to all wage earners, but excluding very high and low-earning households).
- 72) The scope of these changes in 1956, when the official RPI series started, would suggest that the values of the interim index from 1948 to 1956 are not on a comparable basis to the official RPI in subsequent years. When this observation is combined with the pattern revealed by the chart above, and in the light of the closer agreement on average between RPI and the consumers' expenditure deflators from 1956 onwards compared to that from 1950 to 1956, it suggests that instead of using the unofficial 'Index of Retail Prices' from 1948 to 1956, it would be more reliable to use deflators derived from the Feinstein (1972) National Accounts from 1948 up to 1956, this being the same approach and source that was used for the preceding period, with values from this source already being used in the Millennium databook's (and the ONS's) RPI series back to 1870.
- 73) The impact on the overall average RPI from 1899 to 2016 would, though, be small (a reduction of <0.1% p.a.).
- 74) The case for making this change would be supported by the views expressed in the 1998 edition of the ONS's "*The Retail Price Indices Technical Manual*". This considered whether RPI or the Consumers Expenditure Deflator should be used when assessing changes in the internal purchasing power of the pound, and concluded that "*Generally the RPI is preferred as the basis for estimating changes in the purchasing power of the pound, but for certain longer term comparisons covering the period 1938 to 1962, it is more appropriate to use the CED.*"¹¹⁴ (This reference would therefore also support replacing the values in the long-run RPI series with the deflators from 1956 to 1962 as well as from 1948 to 1956, although these additional changes (i.e. from 1956 to 1962) would have an immaterial impact on the overall average RPI from 1900 to 2016.)

¹¹² O'Neill and Ralph, "Modelling a Back Series for the Consumer Price Index", ONS, released July 2014 <https://www.ebarchive.nationalarchives.gov.uk/20151014001752/http://www.ons.gov.uk/ons/rel/cpi/modelling-a-back-series-for-the-consumer-price-index/1950---2011/index.html>

¹¹³ See "*Inflation History and Measurement*" by O'Neill, Ralph and Smith, 2017, pages 131 to 142, ISBN 978-3-319-64124-9, published by Palgrave Macmillan; and Appendix A in the ONS' 2014 "*Consumers Prices Technical Manual*" for a discussion of these changes <https://www.ebarchive.nationalarchives.gov.uk/20160109133536/http://www.ons.gov.uk/ons/rel/cpi/consumer-price-indices---technical-manual/2014/index.html>

¹¹⁴ "*The Retail Prices Index Technical Manual 1998 Edition*", ONS, available online, see page 65.

COMPARISON TO A MODELLED HISTORIC RPI SERIES RECENTLY PRODUCED BY OXERA

- 75) The geometric and arithmetic averages of the long-run RPI series in the Bank of England Millennium databook from 1899 to 2016 are respectively 4.17% and 4.33%.
- 76) If the adjustment suggested above is made to the series, i.e. the values of the 'Index of Retail Prices' from 1948 to 1956 are replaced with consumers' expenditure deflators from Feinstein (or Sefton and Weale), the long-run averages from 1899 to 2016 fall by <0.1% to 4.10% and 4.26% respectively.
- 77) The graphs and results presented above show that the Millennium databook's RPI series is well-founded, but on average, across the whole period since the official RPI index was first introduced (1956) and for which National Accounts appear to be available on a substantively consistent basis (i.e. up to 2009), the RPI values have on average been c.0.2% higher than the deflators (CEDs). This suggests that for the years 1899 to 1956, during which RPI is (or should be) estimated from the CED values, a small upwards adjustment of c.0.2% p.a. may be justified when estimating RPI from these deflators. If this adjustment was made, it would increase the geometric and arithmetic average RPI from 1899 to 2016 from 4.10% and 4.26% to 4.20% and 4.36% respectively.
- 78) As described earlier, Oxera have recently investigated what the historical RPI series might look like if restated using today's RPI calculation methodology in a report for Heathrow Airport¹¹⁵. The report used statistical analysis in combination with an investigation of how the RPI methodology has changed over time to identify structural breaks in the level and rate of change in the RPI series. The preliminary analysis indicated that the average inflation based on a restated RPI series over the period 1899–2016 could be up to 1bp lower or 30bp higher than if based on the official RPI series published by the ONS. This suggests that on a geometric average basis, the average RPI would be between 4.16% and 4.47% (and on an arithmetic average basis between 4.32% and 4.63%).
- 79) Thus, the estimates of historic average RPI implied by the analysis of consumers' expenditure deflators in this report are very close to the unadjusted values based on the RPI series in the Millennium databook, and lie within the range recently estimated using a different approach by Oxera.

¹¹⁵ See page 15 in "*The cost of equity for RIIO-2*", Q4 2019 update prepared by Oxera for Energy Networks Association, November 2019, <https://www.oxera.com/wp-content/uploads/2018/01/Cost-of-equity-for-RIIO-2-Q4-2019-update.pdf>

CONCLUSIONS

- 80) The graphs and results presented above show that the Millennium databook's RPI series is well-founded. Notwithstanding the changes from time to time in the detailed construction and composition of RPI since the official series first started in 1956, once year-to-year fluctuations and timing differences are averaged out, it has agreed well with the Consumers Expenditure Deflators derived from National Accounts, across the whole period for which National Accounts appear to be available on a substantively consistent basis (i.e. up to 2009).
- 81) Since the estimated National Accounts from Feinstein (1972) were also prepared on this basis, the high level agreement between RPI and deflators across the extended period starting in 1956 gives confidence that the deflators (CEDs) that are calculated from Feinstein's (1972) publication (from 1870 up to 1956) will give a reliable series for RPI values in these earlier years, and will give values that are compatible with the official RPI series that has been published since 1956 (although based on the analysis in this report, a small upwards adjustment of c.0.2% p.a. to estimate RPI during these years from these deflators may be justified).
- 82) This observation that the average level of the official RPI series across each of the separate time segments considered has followed the National Accounts deflators derived from Sefton and Weale and Blue Book National Accounts adds weight to the comments that Oxera received from the ONS that these deflator series were likely to be based on underlying series that were constructed using a methodology comparable to RPI, which would support the view that consumers' expenditure deflators derived from Feinstein's estimated national accounts should be seen as similar to RPI rather than CPI.
- 83) It is also consistent with the way that these deflators have been described and used by the ONS and others previously (O'Donoghue et al (2004), the 2014 Consumers Prices Technical Manual, the House of Commons library publication "*Inflation: The Value of the Pound*", etc)
- 84) Therefore, consistent with the ONS' and House of Commons' own long-term inflation series, the most robust and consistently formulated inflation series covering the period from 1899 is an RPI series which is constructed from:
 - a. Published RPI from 1956 onwards (when the official measure was introduced);
 - b. Consumers' Expenditure Deflators from Feinstein's (1972) unofficial National Accounts, from 1870 to 1948, possibly increased by a small upwards adjustment of c.0.2% p.a. during these years;
 - c. From 1948 to 1956, either consumers' expenditure deflators derived from the National Accounts or the unofficial 'Index of Retail Prices' could be used. The ONS's long-term inflation series uses the 'Index of Retail prices', but it should be noted that this index was being developed and revised throughout this period prior to it becoming the official RPI measure in 1956. Given this, and that the analysis in this report suggests that the deflators are more reliable than the unofficial 'Index of Retail Prices' series during these years (i.e. more comparable to the official RPI as calculated in subsequent years), it would seem preferable to use the deflators in these years, consistent with the approach and data source that is already used in the RPI series from 1900 to 1948.
 - d. Use of deflators (CEDs) instead of RPI could also be justified from 1956 to 1962, given the view expressed by the ONS in its 1998 edition of the Retail Prices Index Technical Manual that (CED) deflators should be used from 1948 to 1962 (and RPI subsequently), though the overall impact of this additional change on the average RPI from 1899 to the present day would be minimal.
- 85) In contrast, there is no comparable long-term CPI series:

- a. The CPI backseries covering 1950 to 1988 is unreliable and should not be used – as evidenced by the caveats and reservations documented in the paper which explained and accompanied these estimates, as well as in other ONS documents; and by the significant variations over time (even when averaged across several years) in the differentials between national accounts deflators and the CPI series as you move from 1950 to 2009.
- b. There are no reliable values for CPI from 1950 to 1988: the publication itself giving these backseries values doesn't claim they are reliable and recognises that different models can give different results; the values in the paper don't appear to stand up to scrutiny (see e.g. the values in Table 1 of the ONS's paper which compares components of the formula effect during the 'modelled' period and the years when actual values exist); and the comparison described above of the CPI backseries to national accounts consumers' expenditure deflators suggests that the CPI backseries values are not credible. A consideration of the suitability and reliability of ARIMA modelling for this backseries would cast further doubt over the resulting CPI estimates from 1950 to 1988, particularly in the earlier years of the series.
- c. Furthermore, the ONS has recently stated publicly that the CPI backseries is now going to be revised with "*new indicative estimates for the CPI between 1947 and 1987*", though as these values will still only be 'indicative' it is far from clear whether even these updated values, when available, could be relied upon in price controls when setting TMR.
- d. In any case there are no values at all for CPI prior to 1950: available inflation measures for these years are either the COLI (not used by O'Donoghue et al because of its limited coverage in terms of both products and population, together with concern about the quality of the weights used to produce the aggregate index); Feinstein (1991) which only gives values for working class households and only up to 1914; and implied consumers' expenditure deflators covering 1870 to 1965 derived from Feinstein's (1972) estimated National Accounts, which appear to be the best series but to give good estimates of RPI rather than CPI.
- e. As far as we are aware, the only place that has tried to document a long-term series for CPI going back before 1950 is the BoE Millennium databook – but this contains multiple caveats, refers the reader to original data sources, doesn't claim the values are robust, and would appear only to use the Feinstein deflators for the CPI series prior to 1950 because there is nothing else available, and without considering whether they more accurately represent RPI rather than CPI.
- f. Although the ONS may now be planning to produce a long-run series for CPIH going back to 1750, it is unclear how reliable this will be, given that the necessary underlying price data that would be needed to calculate CPI and CPIH values properly even from 1950 to 1988 has not been retained and does not exist¹¹⁶.

- 86) Ofgem's rationale for using CPI appears to be based on the assumptions that:
- a. a long-term series of CPI values (back to 1900) exists, and gives the values that CPI would have had if it had been calculated on a consistent basis throughout this whole period; whereas
 - b. in contrast, because the detailed formulation of RPI has changed from time to time, a long-term RPI series does not give values in past time-periods that are those which would have been calculated using today's formulation of RPI.

However, the analysis and discussion in this report shows that these assumptions are misconceived. To the contrary, reliable CPI values only exist (and can only exist) since 1988, as the CPI backseries is unreliable and the data needed to calculate accurate values prior to

¹¹⁶ O'Neill and Ralph, "Modelling a Back Series for the Consumer Price Index", ONS, released July 2014 (<https://www.ebarhive.nationalarchives.gov.uk/20151014001752/> <http://www.ons.gov.uk/ons/rel/cpi/modelling-a-back-series-for-the-consumer-price-index/1950---2011/index.html>), see page 3 "... sufficient data to calculate the CPI do not exist prior to 1987" and footnote 3 "In order to estimate the CPI we would need access to price quotes and expenditure information for the years in question, none of which, in general, are available"

1988 does not exist; and the national accounts deflators (CEDs) prior to 1950 do not represent CPI but instead give estimates of RPI¹¹⁷ (because, for example, they will incorporate at least some of the formula effect).

- 87) The misconception in Ofgem's approach, and in the UKRN report on which it is based, is that it starts from the presumption that the CPI backseries from 1950 to 1988 is reliable: and in addition it then uses the difference between these numbers and actual RPI values in these years as 'evidence' that CPI and RPI converge as you move further back in time. This appears then to have been used to justify a second presumption, that deflators (CEDs) from 1900 to 1948 can simultaneously provide a good measure of both RPI and CPI in these years (or even that the CEDs better represent CPI than RPI). If, instead of starting from the first of these presumptions, Ofgem (and the UKRN report) had first questioned the reliability of the CPI backseries from 1950 to 1988 and tested this using analysis such as that presented in this report - consistent with the recommendation in the Bank of England's Millennium databook that original sources should be checked - these presumptions would both have been seen to be unsafe.
- 88) As a consequence, as an inflation series is required from 1900 to the present day in order to deflate the historic series of nominal equity market returns to give the average realised return on a real basis, the RPI series is the right series to use, and this will give a real return relative to RPI. The RPI series has been shown in this report to be a more reliable long-term series than the CPI series and so in this context (i.e. to deflate historic nominal returns) its use is better justified. As explained above the deflators (CEDs) derived from Feinstein (for the period up to 1949) represent RPI rather than CPI, and in relation to the period from 1950 to 1988 even the authors of the ONS's CPI backseries (O'Neill and Ralph) recognise in their recent book that "*There is another, different attribute of the [RPI] measure that came out of the RPI consultation – its value as a long-running measure produced on similar terms.*"
- 89) It follows that if an estimate of the averaged realised equity return (TMR) is required on a real basis relative to CPI, for example in setting the RIIO-2 price control, the most accurate and reliable approach is first to calculate the long-term historic real return relative to RPI using the long-term RPI series¹¹⁸ (as this has been shown to be more reliable and consistently-based than the corresponding CPI series), and then to add the expected forward-looking RPI-CPI wedge¹¹⁹.

¹¹⁷ Though when estimating RPI from the consumers' expenditure deflators in the years up to 1950 (or 1956), the numerical analysis in this report suggests that a small upwards adjustment of c.0.2% p.a. may be justified,

¹¹⁸ i.e. this long-term RPI series needs to be subtracted from the average historic returns on a nominal basis to give the long-run average return on a real basis relative to RPI

¹¹⁹ Where this wedge is estimated assuming no future material changes in how CPI and RPI are calculated.

IMPLICATIONS - THE IMPACT ON THE ESTIMATED TMR

- 90) The results and implications for estimates of TMR are illustrated by the following Tables, in which the best justified values are those based on RPI which are shown in yellow highlight. For ease of comparison the approach which Ofgem has used as the basis of their TMR estimate, starting from the Millennium dataset's CPI series, is highlighted in green. The tables show that Ofgem's approach to inflation will reduce the estimates of TMR based on long-run average returns by almost 1% relative to use of the best justified inflation series.

| | Long-run arithmetic average inflation (1900-2016) | Arithmetic average nominal UK market return from 1900-2016 (from DMS) ¹²⁰ | Implied TMR relative to CPI for RIIO-T2 |
|--------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|--------------------------------------------------------------------------------------|-----------------------------------------|
| BoE Millennium databook RPI series | 4.33% | 11.20% | 7.70%* |
| BoE Millennium databook RPI series – with values from 1948 to 1956 replaced by deflators (CEDs) | 4.26% | 11.20% | 7.77%* |
| BoE Millennium databook RPI series – with values from 1900 to 1956 increased by 0.2% (i.e. set equal to the CEDs + 0.2%) | 4.36% | 11.20% | 7.67%* |
| RPI back-series as estimated by Oxera ¹²¹ | 4.32% ⁺ to 4.63% ⁺ | 11.20% | See Oxera report page 15 |
| BoE Millennium databook CPI preferred series | 4.10% | 11.20% | 6.82% |
| BoE Millennium databook CPI original series | 4.06% | 11.20% | 6.86% |

⁺ These values are implied from the long-run average using the Millennium databook RPI series in the first row above, and Oxera's comment "The preliminary analysis indicated that the average inflation based on a restated RPI series over the period 1899–2016 could be up to 1bp lower or 30bp higher than if based on the official RPI series published by the ONS."

* Assuming a forward-looking wedge between RR and CR of 1.049%, consistent with Ofgem's working assumption in the RIIO-2 SSMD

¹²⁰ From "Credit Suisse Global Investment Returns Yearbook 2019" by Elroy Dimson, Paul Marsh and Mike Staunton, published in February 2019 by the Credit Suisse Research Institute, ISBN 978-3-9524302-8-6

¹²¹ "The cost of equity for RIIO-2", Q4 2019 update prepared by Oxera for Energy Networks Association, November 2019, page 15; <https://www.oxera.com/wp-content/uploads/2018/01/Cost-of-equity-for-RIIO-2-Q4-2019-update.pdf>

| | Long-run geometric average inflation (1900-2016) | Geometric average nominal UK market return from 1900-2016 (from DMS) ¹²² | Implied geometric average historic market return relative to CPI | Implied TMR relative to CPI for RIIO-T2 (using Ofgem's 0.77% to 1.77% uplift)** |
|--------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-------------------------------------------------------------------------------------|------------------------------------------------------------------|---------------------------------------------------------------------------------|
| BoE Millennium databook RPI series | 4.17% | 9.38% | 6.10%* | 6.87% to 7.87% |
| BoE Millennium databook RPI series – with values from 1948 to 1956 replaced by deflators (CEDs) | 4.10% | 9.38% | 6.17%* | 6.94% to 7.94% |
| BoE Millennium databook RPI series – with values from 1900 to 1956 increased by 0.2% (i.e. set equal to the CEDs + 0.2%) | 4.20% | 9.38% | 6.07%* | 6.84% to 7.84% |
| RPI back-series as estimated by Oxera ¹²³ | 4.16% ⁺ to 4.47% ⁺ | 9.38% | 5.80%* to 6.11%* | See Oxera report page 15 |
| BoE Millennium databook CPI preferred series | 3.95% | 9.38% | 5.22% | 5.99% to 6.99% |
| BoE Millennium databook CPI original series | 3.91% | 9.38% | 5.26% | 6.03% to 7.03% |

⁺ These values are implied from the long-run average using the Millennium databook RPI series in the first row above, and Oxera's comment "The preliminary analysis indicated that the average inflation based on a restated RPI series over the period 1899–2016 could be up to 1bp lower or 30bp higher than if based on the official RPI series published by the ONS."

* Assuming a forward-looking wedge between RR and CR of 1.049%, consistent with Ofgem's working assumption in the RIIO-2 SSMD.

** These values have been produced on a consistent basis, i.e. using the same value of the 'geometric to arithmetic' uplift in each case as used by Ofgem in the SSMD, to illustrate most clearly the impact of the different inflation measures on estimated TMR. This does not mean that we agree with this level of uplift, especially the values in the bottom half of the range which are not consistent with reasonable estimates of holding periods. See the discussion of this in, for example, Oxera's 2018 and 2019 reports for the ENA, and NERA's April 2019 report for Scottish Power Transmission for further information ¹²⁴.

91) The above tables show that once the RPI series values from 1948 to 1956 are replaced by deflators (CEDs) from national accounts (as explained and justified above), the implied TMR is 7.77% (real relative to CPI) if based on the arithmetic long-run average return since 1900. Alternatively, based on the corresponding geometric average since 1900, even using Ofgem's value for the geometric to arithmetic uplift (0.77% to 1.77%), the implied real TMR relative to CPI is 6.94% to 7.94% ¹²⁵, although using these 'uplift' values would appear to give

¹²² From "Credit Suisse Global Investment Returns Yearbook 2019" by Eroy Dimson, Paul Marsh and Mike Staunton, published in February 2019 by the Credit Suisse Research Institute, ISBN 978-3-9524302-8-6

¹²³ "The cost of equity for RIIO-2", Q4 2019 update prepared by Oxera for Energy Networks Association, November 2019, page 15; <https://www.oxera.com/wp-content/uploads/2018/01/Cost-of-equity-for-RIIO-2-Q4-2019-update.pdf>

¹²⁴ "The cost of equity for RIIO-2: A review of the evidence" prepared by Oxera for the ENA, 28 February 2018, <https://www.oxera.com/wp-content/uploads/2018/07/ENA-cost-of-equity-2018-02-28.pdf>; and "The cost of equity for RIIO-2", Q4 2019 update prepared by Oxera for Energy Networks Association, November 2019, <https://www.oxera.com/wp-content/uploads/2018/01/Cost-of-equity-for-RIIO-2-Q4-2019-update.pdf>; and "Cost of Equity for SPT in RIIO-T2: Report for Scottish Power Transmission plc", 19 April 2019, NERA, Section 2.3.1, pages 16 to 19 (see response documents on webpage <https://www.ofgem.gov.uk/publications-and-updates/riio-2-sector-specific-methodology-consultation>).

¹²⁵ Using Ofgem's 1.049% assumption for the forward-looking RPI-CPI wedge.

underestimates of the TMR¹²⁶. This contrasts with Ofgem's range for TMR in the May 2019 Sector Specific Methodology Decision (SSMD), which was from 6.25% to 6.75% (real relative to CPI).

- 92) These values would, though, appear to support and be broadly consistent with the range of 7.4% to 8.1% relative to CPI(H) based on long-run average equity returns data, derived by Oxera using their "adjusted" historic RPI series, as discussed in Oxera's recent report for the ENA¹²⁷.
- 93) Fundamentally, a large part of the difference between these values and those in Ofgem's SSMD relates to (i) whether the ONS's modelled CPI backseries values for the years from 1950 to 1988 that were published as work-in-progress in 2013 or 2014 can be treated as reliable; and (ii) whether the implied consumers' expenditure deflators derived from Feinstein's estimated National Accounts represent RPI or CPI. This report shows that the backseries cannot be relied on, and these national accounts deflators appear to much better represent RPI rather than CPI.

¹²⁶ See for example the discussion of 'Cooper's methodology' on page 18 of "*The cost of equity for RIIO-2*", Q4 2019 update prepared by Oxera for Energy Networks Association, November 2019, <https://www.oxera.com/wp-content/uploads/2018/01/Cost-of-equity-for-RIIO-2-Q4-2019-update.pdf>

¹²⁷ *Ibid*, see pages 15 and 18.

APPENDIX - TWO FURTHER CONSIDERATIONS THAT SHOULD BE TAKEN INTO ACCOUNT WHEN ESTIMATING TMR FROM LONG-RUN AVERAGE EQUITY MARKET RETURNS

Average returns over longer and shorter timeframes

- A.1) The values of average market return presented in the main body of this report are based on average equity market returns in the UK since 1899 only. However, as shown in the Table below, use of either an earlier or later starting date for the long-run averages leads to higher values of average realised return. There is no rational justification for choosing a start date for the averaging which gives the lowest value of long-run averages, and it is therefore clear that use of the averages from end 1899 only does not give a balanced view of the true level of the long-run realised average return.
- A.2) If the evidence that is now available that relates to different averaging periods is taken into account, the overall geometric average should be increased by at least 0.3% to 0.5%. When this is added to the 6.94% to 7.94% range relative to CPI from the final section of the main body of this report (or Oxera's estimated range, i.e. 7.4% to 8.1%), the resulting range for the long-run realised average return is at least 7.3% to 8.3% relative to CPI (though higher values, particularly for the bottom end of this range, could be justified).

| Timeframe | Sources | Geometric Average Real Return in the UK across timeframe shown (real c.f. Millennium dataset's RPI series) |
|--------------------------------------------------------------------------------|----------------------------------|------------------------------------------------------------------------------------------------------------|
| <i>Considering longer averages than using DMS only:</i> | | |
| 1805-2016 | GFD to 1914, then DMS | 5.4% |
| 1830-2016 | GFD to 1900, then DMS | 5.3% |
| 1830-2016 | Campbell et al to 1900, then DMS | 5.2% |
| 1850-2016 | GFD to 1900, then DMS | 5.4% |
| 1850-2016 | Campbell et al to 1900, then DMS | 5.4% |
| 1870-2016 | GFD to 1900, then DMS | 5.2% |
| 1870-2016 | Campbell et al to 1900, then DMS | 5.2% |
| <i>Considering the full DMS dataset only:</i> | | |
| end 1899-end 2016 | DMS | 5.01% |
| <i>Considering shorter averages than using the full DMS dataset from 1899:</i> | | |
| end 1909-end 2016 | DMS | 5.3% |
| end 1919-end 2016 | DMS | 6.0% |
| end 1929-end 2016 | DMS | 5.7% |
| end 1939-end 2016 | DMS | 6.0% |
| end 1949-end 2016 | DMS | 7.0% |

Sources:

- DMS refers to the "Credit Suisse Global Investment Returns Yearbook 2019" by Eroy Dimson, Paul Marsh and Mike Staunton, published in February 2019 by the Credit Suisse Research Institute, ISBN 978-3-9524302-8-6; nominal returns from DMS are here shown deflated by the Millennium databook RPI inflation series.
- GFD refers to the February 2019 paper "Stocks for the Very Long Run: The UK-100 and 327 Years of British Equity History" by Global Financial Data (<http://www.gfdblog.com/GFD/Blog/stocks-for-very-long-run-uk-100-327-years-of-british-equity->); the figures shown in this table based on GFD's paper are calculated from values read off the chart shown as Figure 6 in the paper, or (in the case of the first row above) from Table 1, in each case then combined with nominal returns information from DMS from 1900 (or 1914) to 2016, and then deflated by the Millennium databook RPI inflation series.
- Campbell et al refers to "Before the Cult of Equity: New Monthly Indices of the British Share Market 1829-1929", May 2019, by Gareth Campbell (Queen's University Belfast), Richard S Grossman (Wesleyan University), and John D Turner (Queen's University Belfast), taking data from Panel C of Table 1 for 'All equities' on the London market (albeit the results based on the returns for UK-focussed businesses only are similar) (http://www.quech.org.uk/uploads/1/0/5/5/10558478/w_p19-

[01.pdf](#)). In each case the nominal returns to 1900 are combined with nominal returns information from 1900 to 2016 from DMS (i.e. the “*Credit Suisse Global Investment Returns Yearbook 2019*” by Elroy Dimson, Paul Marsh and Mike Staunton, published in February 2019 by the Credit Suisse Research Institute, ISBN 978-3-9524302-8-6), and then deflated by the Millennium databook RPI inflation series.

A.3) The impact of averaging realised equity market returns across shorter or longer timeframes than from 1900 only is seen to follow a similar pattern in the US, as shown by the table below. Again, the average from 1900 appears close to the lowest value, such that averages which have either an earlier or later start date are generally somewhat higher, and so use of the realised average return from 1900 only as an indication of TMR will give a downwards-biased estimate of the true long-run average return.

| Timeframe | Sources | Geometric Average Real Return in the US across the timeframe shown (Real relative to US Inflation) |
|-------------------|--------------------------|----------------------------------------------------------------------------------------------------|
| 1802-2016 | Siegel to 2002; then DMS | 6.8% |
| 1872-2018 | Schiller | 6.8% |
| end 1899-end 2016 | DMS | 6.38% |
| end 1909-end 2016 | DMS | 6.11% |
| end 1919-end 2016 | DMS | 7.04% |
| end 1929-end 2016 | DMS | 6.22% |
| end 1939-end 2016 | DMS | 6.81% |
| end 1949-end 2016 | DMS | 7.24% |

Sources:

- Siegel refers to “*Stock Market*” by Prof J Siegel, University of Pennsylvania’s Wharton School, at <http://www.econlib.org/library/enc/stockmarket.html>
- Schiller refers to a dataset, available online, from which the annualised total returns from 1872 to Feb 2019 can be derived. See for example the online article “*U.S. Stock Market Returns – 1870s to present*”, dated 25/3/18. (<https://themeasureofapl.com/us-stock-market-returns-1870s-to-present/>)
- DMS refers to the “*Credit Suisse Global Investment Returns Yearbook 2019*” by Elroy Dimson, Paul Marsh and Mike Staunton, published in February 2019 by the Credit Suisse Research Institute, ISBN 978-3-9524302-8-6

A.4) The relevance and impact of considering different averaging periods and the resulting 7.3% to 8.3% result presented above can also be seen to be consistent with a 2019 report by Aon¹²⁸, referred to as consultancy report 17 in Ofgem’s SSMD Finance Annex. Ofgem notes that one of the authors of this report was Derry Pickford, who wrote the Appendix D in the earlier March 2018 UKRN report. This was the section of the UKRN report which considered the different inflation measures in the Bank of England’s Millennium databook, and so led to Ofgem’s proposed approach of deflating historic nominal returns using the BoE’s CPI series. The Aon report concludes that **the best estimate for the long-run realised return is 6.5% real on a geometric average basis. (Note that Ofgem incorrectly interprets this 6.5% figure in their May 2019 SSMD Finance annex to be an arithmetic average – see Ofgem’s first comment in response to Consultancy report 17 in the SSMD Finance Annex - and so appeared to view the report as supporting their 6.25% to 6.75% TMR range, when in fact it is a geometric average and so supports a range that is appreciably higher than this.) Even using Ofgem’s value for the uplift that should be added to geometric return averages when estimating TMR (0.77% to 1.77%), once this**

¹²⁸ Aon report “*Is the UK an “averagely lucky country?”*” by Derry Pickford and John Chung, 6th March 2019. See the response documents on webpage <https://www.ofgem.gov.uk/publications-and-updates/rrio-2-sector-specific-methodology-consultation>, filed with the ‘NGET NGG’ response in the ‘F to R’ responses section.

is added to the geometric average value in the Aon report, it also gives a range from 7.3% to 8.3% (relative to CPI).

An apparent source of bias in the most commonly used data sources

- A.5) Even if the calculated value of realised real return is based on averages since the end of 1899 only, using the DMS/Credit Suisse databook values of nominal returns, deflated by the historic RPI (or CPI) inflation series, there is a further reason to think that the result will be an underestimate of the average realised return on the whole of the UK equity market. This is because the DMS estimate of equity returns in the UK is based on the returns of the 100 largest companies only from 1899 to 1954¹²⁹. The total returns on these largest companies would have been expected, on average, to be lower than those on smaller companies: this widely recognised difference is known as the 'size effect'. As a result, the UK returns given by the DMS/Credit Suisse databook for these 55 years are not really a measure of Total Market Return in the UK during these years but would be expected to underestimate it.
- There is a chapter on the "size effect", not just in the UK but also in other countries, including the US, in Elroy Dimson, Paul Marsh and Mike Staunton's 2002 book "*Triumph of the Optimists*" for example¹³⁰. Whilst there may be some view that the size effect fell initially after it was first discovered in the 1980s (this could well be an expected result from the effect becoming widely publicised), it has since (e.g. since 1999) been more prominent again. In any case, what matters in this context is the size of the effect during the first half of the 20th Century.
 - Whilst it is hard to find data that can be used to accurately to quantify the effect during the first half of the 20th century, an indication that it is not immaterial is shown in "*Triumph of the Optimists*"¹³¹ at Figure 9-4 on page 129. This compares the annualised return on the 'equally weighted' index of the top 100 companies with the 'market-cap weighted' index of the same companies, and whilst neither include the smaller companies (i.e. those outside the top 100) which have higher returns on average, DMS note that over the first fifty-five years of the last century the annualised return on the equally weighted top one hundred index was c.½ percent a year higher than its capitalisation weighted counterpart, suggesting a small but positive size effect.
 - Another indication of the size effect (albeit covering a later timeframe) comes from Chart 18 in the 2013 edition of the DMS/Credit Suisse databook¹³²: this shows that the NSCI index, covering the companies that make up the bottom 10% by size of the London Market Cap grew by 15.3% p.a. from 1955 to 2012, c.f. 12.4% for the UK market a whole. This suggests that excluding the NSCI index constituents would have reduced the apparent whole market return by c.0.32%. If the next smallest companies making up the next 10% of the whole market cap were also excluded, the overall impact on calculated average return would be expected to be somewhat larger, perhaps c.0.5% to 0.65%.
 - Because the top-100 companies make up a large part of the whole market capitalisation in the UK (perhaps c.80% now, albeit probably somewhat lower from

¹²⁹ DMS describe their approach and data sources for the UK on pages 210 to 212 of the 2019 edition of the "*Credit Suisse Global Investment Returns Yearbook*" (published in February 2019 by Credit Suisse Research Institute, ISBN 978-3-9524302-8-6). Page 211 explains that for the first 55 years, from 1899 to 1954, the DMS estimate of total equity return each year relates to the largest 100 companies in the UK rather than the whole UK market.

¹³⁰ "*Triumph of the Optimists: 101 Years of Global Investment Returns*" by Elroy Dimson, Paul Marsh and Mike Staunton, published by Princeton University Press, 2002, ISBN 0-691-09194-3.

¹³¹ *Ibid.*

¹³² "*Credit Suisse Global Investment Returns Sourcebook 2013*" by Elroy Dimson, Paul Marsh and Mike Staunton, published in February 2013 by the Credit Suisse Research Institute, ISBN 978-3-9523513-9-0.

1900 to 1954, possibly in the 50% to 60% range) the effect might not be so large as to invalidate the use of the DMS equity return information, but an estimate of the effect should nevertheless be made and taken into account when estimating TMR. For example, if the average differential between total return on the top-100 companies and on the whole market from 1899 to 1954 was between 0.5% and 1.0% say (though this will depend in part on what share of the whole market cap is covered by the top 100 companies only), the 'size effect' would cause the 117 year geometric average from 1899 to 2016 from DMS to be 0.23% to 0.46% too low as a representation of the average return on the whole of the UK equity market.

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