Cost of Capital: Total Market Return

October 2018

Europe Economics
Chancery House
53-64 Chancery Lane
London WC2A 1QU

Tel: (+44) (0) 20 7831 4717
Fax: (+44) (0) 20 7831 4515

www.europe-economics.com

Contents

1 Introduction

This report for Ofcom sets out Europe Economics' analysis of the Total Market Return component of the cost of capital. This work will feed into Ofcom's Business Connectivity Market Review (BCMR19), which will set prices for leased lines for a two-year period starting 1 April 2019.

The report is structured as follows:

- Section 2: Total Market Return. This section discusses our approach to estimating, and our estimates for, the total market return (TMR). It begins by reviewing Ofcom's past approach, a recent report commissioned by the UKRN, and regulatory precedents from other sectors. It then sets out our recommended methodology and our range estimates for the TMR.
- Section 3: Conclusions. This summarises our conclusions on the TMR.
- Section 4: Appendix. This explains our treatment of inflation in this report.

2 Total Market Return

This section is about the approach to estimating, and our estimates of, the total market return (TMR). It has the following structure:

- Ofcom's past approach – this summarises the approaches taken by Ofcom in BCMR16 and WLA18.
- Report for UKRN – this discusses a recent independent study commissioned by the UKRN.
- Regulatory precedents – this considers regulatory precedents on the TMR from other sectors.
- Our recommended methodology – this describes our current preferred methodology for estimating the TMR.
- Estimation of the TMR – this provides our current estimate for the TMR.

2.1 Ofcom's past approach

We describe below the approach taken by Ofcom to estimating the TMR in the 2016 BCMR and 2018 WLA.

2.1.1 2016 Business Connectivity Market Review (BCMR16)[1]

Neither the TMR nor the ERP is directly observable. Both are forward-looking variables relating to the expected return required by investors for investing in a diversified portfolio. On the grounds that the total returns earned by stock market investors have historically been less volatile than the premium earned over gilt yields, Ofcom started with estimates of the TMR and then calculated the ERP as a residual (by subtracting the risk-free rate). These estimates were then cross-checked with direct evidence on the ERP.

Ofcom's approach in BCMR16 was to consider both historical ex post and ex ante measures of the TMR. Historical ex post measures looked at arithmetic averages of real returns since 1900, based on different holding periods, which implied average annual returns in the region of 6.4 to 7.2 per cent. Historical ex ante estimates included: Fama and French's approach, which estimates the real TMR from the sum of long-run (1900 to 2014) average real dividend yields and the average real rate of dividend growth, and which provides an estimate for the real TMR in the order of 5.5 per cent; and the Dimson, Marsh and Staunton approach, which tries to infer investor expectations of returns by disaggregating historical equity premia into returns corresponding to investor expectations and returns relating to non-repeatable good or bad luck, and which estimates a real TMR in the range of 5.7 to 6.2 per cent.

In BCMR16, Ofcom used an RPI-deflated TMR of 6.1 per cent, which was in the range of the above estimates. This corresponded to a nominal TMR of 9.6 per cent (given an assumed RPI inflation of 3.3 per cent)[2].

In order to cross-check the calculated ERP Ofcom looked at evidence from: the average arithmetic premia that historically equity market investors obtained over gilts or treasury bills (estimated at 5 to 6 per cent in nominal terms); academic/user surveys (which provided a median estimate of 5 per cent, though less weight was placed on this evidence); forward looking estimates of the ERP (estimated at 4 to 7 per cent in nominal terms for the post financial crisis period, based on the Bank of England's estimates using the dividend growth model); and regulatory precedents (in the range of 5 to 5.5 per cent in real terms).

---

1 Ofcom (2016), "Business Connectivity Market Review". See Annex 30, available at: https://www.ofcom.org.uk/__data/assets/pdf_file/0032/54977/final-annexes-29-30.pdf

2 Ofcom (2016), "Business Connectivity Market Review". See Annex 30, paragraph A30.57, available at: https://www.ofcom.org.uk/__data/assets/pdf_file/0032/54977/final-annexes-29-30.pdf

2.1.2 2018 Wholesale local access market review (WLA18)[3]

In the WLA18 Statement, Ofcom maintained the TMR estimate of 6.1 per cent, as in the BCMR16 Statement. This was based on the mixed evidence provided by ex post and ex ante historical approaches used to estimate the TMR. Ofcom explained that, consistent with previous reviews, it places more weight on the arithmetic averages than geometric averages when looking at historical returns. This evidence on the TMR, coupled with Ofcom's decision to set a real risk-free rate of 0 per cent in that statement, implied an RPI-deflated ERP of 6.1 per cent.

2.2 Report for UKRN

The report for the UKRN looked at estimates made by UK regulatory bodies on the TMR.[4] The report noted that, unlike estimates for the risk-free rate, regulatory bodies' estimates for the TMR are in line with estimates reached using the Mason, Miles and Wright (MMW) methodology (the earlier report commissioned in 2003 by UK economic regulators and the Office of Fair Trading).[5]

MMW proposed a methodology in which the TMR (i.e. the expected real return on investments in the equities of a firm with a CAPM beta of precisely one) should be assumed constant and set in light of realised historic real returns in a range of stock markets over long timeframes.

The UKRN report further considered three alternative approaches:

- Alternative A: assume the ERP is stable.
- Alternative B: update the estimate of the TMR (and hence the ERP) in line with econometric evidence on return predictability.
- Alternative C: estimate the TMR using alternative models such as the Dividend Discount Model.

After considering the three alternative approaches, the UKRN report makes the following recommendation, on the grounds of implementability and defensibility:

> "We recommend that regulators should continue to base their estimate of the [TMR] on long-run historic averages, taking into account both UK and international evidence, as originally proposed in MMW. We suggest a modest downward adjustment of the original range proposed by MMW, to a range of 6-7%, primarily reflecting a smaller adjustment from geometric to arithmetic returns."

2.3 Regulatory precedents

We have examined the most recent regulatory precedent from other UK regulated sectors to understand the approaches taken to setting the TMR and the ERP. Specifically we have looked at the Utility Regulator's RT6 price control.

We have also considered the following three proposed approaches that have been published recently (although these are not final decisions):

- PwC's recommendations to the CAA in relation to the Heathrow price control review (H7).
- Ofwat's early view on the cost of capital for the 2019 price review (PR19), set out in its final methodology document published in December 2017.
- Ofgem's proposed approach to RIIO-2 price controls.

---

3 Ofcom (2018), "Wholesale local access market review". See Annex 20, available at: https://www.ofcom.org.uk/__data/assets/pdf_file/0020/112493/wla-statement-annexes-17-27.pdf

4 The report for the UKRN uses the term the expected market return, or EMR (rather than TMR).

5 Wright, S., Mason, R., and D. Miles (2003), "A study into certain aspects of the cost of capital for regulated utilities in the UK". Available at: http://www.bbk.ac.uk/ems/faculty/wright/pdf/mason%20miles%20wright

The approach of regulators has typically been to estimate the TMR (as it is seen to be more stable than the ERP), and then calculate the ERP as the difference between the TMR and the risk-free rate. Hence the discussion below focuses on regulators' approaches to estimating the TMR.

There are three broad categories of approach to estimating the TMR: historical ex post approaches; historical ex ante approaches; and forward-looking approaches. Evidence from regulatory precedent suggests that regulators typically look at all of these approaches, although they differ in the weight placed on each approach in reaching a final estimate of the TMR. More specifically, we find that:

- Ofwat PR19 – Ofwat opted for a point estimate within the ranges estimated using the historical ex ante and forward-looking approaches.
- Ofgem RIIO-2 – Ofgem considered the historical ex post approach as the best objective estimate of investor expectations, but said it will consider the other strands of evidence.
- CAA H7 – PwC in its advice to the CAA suggested placing more weight on historical ex ante approaches. The CAA itself said it would carefully consider the weighting of different approaches.
- Utility Regulator RT6 – the Utility Regulator looked at historical ex post returns, but used the argument that expected equity returns have moved down in tandem with lower interest rates to claim that the estimates from the ex post approach are likely to sit at the top of an acceptable range for the TMR.

Table 2.1 below summarises recent regulatory precedents on the TMR. It can be seen that in recent cases that have favoured ex ante and/or forward-looking approaches, i.e. Ofwat and PwC's advice to the CAA, estimates for the TMR are lower (below 6 per cent), while earlier regulatory precedents show the TMR consistently above 6 per cent.

Table 2.1: Regulatory precedent on TMR (assumed to be real terms except where otherwise specified)

Regulator	Sector	Year	Control Period	Nominal	Real	RPI - Deflated
Ofcom	Telecoms	2018	2018 - 2021	9.20%		6.10%
Ofgem (CEPA's recommendation to Ofgem)	Energy & power	2018	2021 - 2028			5.0% -6.5%
Ofwat (early view)*	Water & sewerage	2017	2020 - 2025	8.60%	6.47%	5.44%
CAA (PWC's recommendation to CAA)	Airports	2017	2020 - 2024	8.0% - 8.6%		5.1% - 5.6%
Ofcom	Telecoms	2016	-	9.60%		6.10%
Utility Regulator	Gas	2016	2017 - 2022			6.50%
CMA	Water	2015	2015 - 2020			6.5% (5.0% - 6.5%)
Ofcom	Telecoms	2015	2015 - 2018	9.60%		6.10%
CAA	Airports	2014	2014 - 2019			6.25% (6.25% - 6.75%)
CAA	Air traffic control	2014	2014 - 2019			6.25% (6.25% - 6.75%)
CC	NI Electricity	2014	2013 - 2017			6.5% (5.0% - 6.5%)

Regulator	Sector	Year	Control Period	Nominal	Real	RPI - Deflated
Ofcom	Telecoms	2014	2015 - 2018	9.50%		6.10%
Ofwat	Water & sewerage	2014	2015 - 2020			6.75% (6.25% - 6.75%)
Utility Regulator	Water & sewerage	2014	2015 - 2021			6.50% (6.25% - 7.25%)
ORR	Rail network	2013	2014 - 2019			6.75%

* Note that Europe Economics' recommendation to Ofwat for PR19 was for a point estimate of 6.75 per cent real.[6]
NB. Ranges shown in parentheses.

We note the recent decline in the TMR figures proposed by some regulators (below 6 per cent). However, this should not necessarily be interpreted as an indication that real TMRs have fallen. The reason is that almost all of the most recent figures above are RPI-deflated TMRs, and the RPI-CPI wedge has been growing over time (as explained in the Appendix). So, if the real TMR were invariant, one would expect the RPI-deflated TMR to be falling, owing to the rising wedge. Moreover, as presented in the Appendix, the OBR and Bank of England forecasts for the long-run wedge of 1.0 and 1.3 per cent respectively suggest that the current observed RPI-CPI wedge could rise still further, which could in turn lead to the RPI-deflated TMR falling further (for a given real TMR).

2.4 Our recommended methodology

We recommend a "decomposition" approach to estimating the TMR — that is to say, we advise estimating the TMR directly from relevant market data and then decomposing this into the risk-free rate and the ERP. (This is as opposed to a "build-up" approach in which the components – the risk-free rate and the ERP – are estimated separately and then summed to give the TMR.) This is because empirically the total returns earned by investors have historically been more stable than the components of the TMR,[7] thus meaning that the TMR can be estimated with greater confidence.

We propose to consider evidence from the following:

- Average historical returns (a historical ex-post approach).
- A market-wide Dividend Growth Model (a forward-looking approach).

We describe each in more detail in turn.

2.4.1 Average historical returns

We support the use of the historical ex post approach which makes use of long-run average historical returns to estimate the TMR. Our source for long-term average historical returns, as used by many regulators, is the Global Investment Returns Yearbook. The latest edition provides annual equity returns data from 1900 to 2017.[8]

---

6 Europe Economics (2017), "PR19 – Initial Assessment of the Cost of Capital". Available at: https://www.ofwat.gov.uk/wp-content/uploads/2017/12/Europe-Economics-Final-report.pdf

7 See, for example: Smithers & Co (2003), "A Study into Certain Aspects of the Cost of Capital for Regulated Utilities in the UK". Pages 31-33. Available at: http://www.bbk.ac.uk/ems/faculty/wright/pdf/mason%20miles%20wright

8 Dimson, E., Marsh, P. and M. Staunton (2002), "Triumph of the Optimists". Princeton University Press. Reported in: Credit Suisse (2018), "Credit Suisse Global Investment Returns Yearbook 2018". Available in hard copy only. A short summary edition of the 2017 yearbook is available online at: https://publications.credit-suisse.com/tasks/render/file/?fileID=B8FDD84D-A4CD-D983-12840F52F61BA0B4

The rationale for using this long time period (as long a time period as possible) is that it maximises the amount of information available on which to form a forward-looking estimate, i.e. an expectation about future market returns. The benefit of having as much information as possible is that the total market return, by definition, includes risky assets, and therefore the actual outturn in any one year is a poor indicator of expected returns in the future. By the same logic, even a sample of returns over one or two decades may provide a relatively inaccurate estimate of expected future market returns.

By using very long-run series of returns, we aim to capture a significant portion of the total probability distribution of returns that an investor today might account for in decisions about the future. While this is termed a historical ex post approach, this term can be misleading. Instead what is happening is that the approach makes use of historical data as a basis for estimating the future. In effect, we are treating each historical data point as an independent, random draw from the probability distribution of returns. (This is in line with the assumption of weak market efficiency which underlies the CAPM, which implies that returns in different time periods will not be serially correlated.)[9] Thus, assuming the future distribution of potential returns is the same as in the past (an assumption which is inherent in using ex post returns to estimate the TMR), then the larger the sample of independent draws (i.e. historic data points) that we have, the more accurate a model we can form of the true underlying distribution, which can in turn be used to model the future.

It is by this same logic that in our view the correct way to calculate the expected return from past data, when it is used to construct a probability distribution of the future (we consider possible alternative uses of that data below), is by using the arithmetic average (rather than the geometric average), since the expected return of a given probability distribution is the arithmetic mean. The use of geometric averaging would be straightforwardly inconsistent with the concept we have set out for how historic data are being used — i.e. as a sample from which to construct a distribution of possible future out-turns.

If, however, the interpretation of this use of historic data were rejected — if we were not constructing a quasi-sample of the future — matters are less straightforward. For example, it might be suggested that instead of a quasi-sample, historic data should be used to attempt to discern a time series relationship for past returns that could be projected into the future. This might allow us to project, from our model from historic returns, how returns would rise or fall over the forthcoming price control period. However, a time series model of

---

[9] A market is defined as "weakly efficient" if past price and volume movements do not predict future movements, with the consequence that stock price movements are completely independent of each other, and hence processes such as price momentum (future price movements tending to be in the same direction as past price movements) or mean reversion (future price movements tending to be in the opposite direction to past price movements) do not exist. The corporate finance theory underlying the Capital Asset Pricing Model assumes that markets are what is called "weakly efficient". A consequence of markets achieving weak efficiency is that so-called "technical analysis", attempting to identify and then trade from patterns in pricing data, cannot be effective. Since highly elaborate arbitrage pricing systems, operating at very high frequency, devote considerable resources to trading from technical patterns and arbitrage opportunities, it seems likely that market inefficiencies exist at the timescales upon which they operate (often markedly less than a second). On the other hand, precisely because such systems exist, it is also likely that they arbitrage away weak market inefficiencies if given sufficient time to do so, so that markets eventually must become weakly efficient, at least to the scale at which remaining anomalies are so low as to be impossible to make money by trading against.
In addition to "weak efficiency", two other "efficient markets" concepts are semi-strong efficiency and strong efficiency. A "semi-strongly efficient" market is one in which, as well as being weakly efficient, prices reflect all publicly available information. The Grossman-Stiglitz theorem (from their 1980 paper, "On the Impossibility of Informationally Efficient Markets", American Economic Review, 70(3), pp393-408) demonstrates that markets cannot be continuously semi-strongly efficient if there is any cost to collating, analysing or interpreting data. The intuition is that if it is costly to use data but the results of that data are already reflected in the price, there is no incentive to use the data, so the data would never become reflected in prices. A "strongly efficient" market would be one in which, as well as being weakly efficient, prices reflect the implications of all data, whether publicly available or not.

this kind (unless it were simply based on a trend) would imply markets were not weakly efficient, which would undermine the use of CAPM to estimate the cost of capital.

Empirical studies suggest that major developed stock markets (such as the UK market) become weakly efficient in relatively short time periods (certainly less than one year – the timescales relevant for the DMS dataset).[10] That does not mean they are necessarily continuously weakly efficient (after all, high-frequency arbitrage trading systems exist to exploit market inefficiencies). However, it is only at the point at which (the timescale over which) markets become weakly efficient that the CAPM would apply. Thus, if we are seeking to use historic data to construct a sample of potential future outcomes, and if we were using timescales over which there was mean reversion, we should use longer timescales and then use arithmetic averages over those longer timescales.

There are some key limitations of the average historical returns approach that should be borne in mind:

- Firstly, it is possible that, even with over a century worth of returns data, the observed outcomes give a biased sample from the underlying distribution of returns, and therefore bias expected outcomes. This could be true if a particularly long time period within the sample is considered atypical (i.e. not likely to be repeated).
- Secondly, it is possible that the actual underlying probability distribution of returns is not stable over time, due to some structural change in the economy, though there is no consensus on whether this has indeed occurred.
- Thirdly, for the UK, there are challenges in identifying a consistently relevant inflation series with which to deflate returns.

2.4.2 Dividend Growth Model

The Dividend Growth Model (DGM) expresses the current value of a stock as the present value of expected future dividends (calculated using the required rate of return as the discount rate). Taking a broad market index (e.g. FTSE All Share) as the basis for the model allows for the estimation of the rate of return for the market as a whole, i.e. to determine the total market return.

If the future growth of dividends is assumed to be constant, the infinite summation of the valuation of a current stock price is given by:

$$P_0 = \frac{D_1}{r - g}$$

where P_0 is the current price of the stock, D_1 is the expected next period dividend, r is the required rate of return, and g is the expected constant long-term growth rate of earnings.

Solving for r gives an approximation of the TMR,

$$r = \frac{D_1}{P_0} + g$$

In other words, the TMR is the prospective dividend yield of a stock plus the constant long-term growth rate of dividends. Because the dividend yield is expressed through a one-period difference between price and expected dividend, it represents prospective rather than historical or realised dividend yield for the stock.

A major caveat to be taken into account for the DGM is its assumption of constant long-term growth. In practice it is often not possible to predict the next period dividend even for a relatively steady stock. Multi-stage variations of this model therefore allow for differentiation of growth between dividend periods (for

---

10 See: Malkiel, B. (2003) "The efficient market hypothesis and its critics", *Journal of Economic Perspectives*, 17(1), pp59-82. Available at: https://eml.berkeley.edu/~craine/EconH195/Fall_14/webpage/Malkiel_Efficient%20Mkts.pdf

example, short and long-term). However, these often require further assumptions to be made about when and by how much a dividend will vary over time.[11]

In both one-stage and multi-stage models, some serious restrictions apply to the assumed (short-/long-term) growth rate g — in particular it may not equal the rate of return r (or prices would be infinite), nor can it exceed it (or current prices would be negative). Thus, the model often fails when it is applied to high-growth stocks, because differences in valuation become disproportionately sensitive as g approaches r, because g cannot equal r, and the price value will be negative if g exceeds r. However, the model would not be vulnerable to this critique for "market-wide" DGM because that will include both high-growth stocks, plateauing stocks and stocks in long-term decline.

Within this general framework, there are several decisions and assumptions a modeller has to make. In particular, those assumptions are associated with:

- whether the model should use nominal or real values; and
- whether the relevant model outputs are spot estimates or rolling averages.

Regarding the first point — our models operate in real terms. Consistent with a Fama and French (2002) paper,[12] we argue that estimations based on real returns are more accurate than those based on nominal returns.

Regarding the second point — based on academic research[13] as well as statistical tests we conducted, we argue that rolling 5-year averages are more accurate predictions than spot returns.[14]

We develop three DGM model variants, namely:

- Multi-stage DGM model based on GDP growth.
- Variant of the multi-stage DGM model based on GDP growth with expected inflation.

---

11 To illustrate, a multi-stage DGM model where we assume a different short-term growth rate in the first three years and another long-term growth rate in the following years, would rely on the following formula:

$$P_0 = \frac{D_0 \cdot (1+g_{ST})}{(1+r)} + \frac{D_0 \cdot (1+g_{ST})^2}{(1+r)^2} + \frac{D_0 \cdot (1+g_{ST})^3}{(1+r)^3} + \frac{D_0 \cdot (1+g_{ST})^4 \cdot (1+g_{LT})}{(1+r)^4} + \frac{D_0 \cdot (1+g_{ST})^4 \cdot (1+g_{LT})^2}{(1+r)^5} + \cdots$$

where D_0 is the amount of dividends paid in period 0, g_{ST} is the short-term growth rate, and g_{LT} is the long-term growth rate. This is equivalent to:

$$P_0 = \frac{D_1}{(1+r)} + \frac{D_2}{(1+r)^2} + \frac{D_3}{(1+r)^3} + \frac{D_3 \cdot (1+g_{LT})}{(1+r)^4} + \frac{D_3 \cdot (1+g_{LT})^2}{(1+r)^5} + \cdots =$$

$$= \frac{D_1}{(1+r)} + \frac{D_2}{(1+r)^2} + \frac{D_3}{(1+r)^3} + \frac{1}{(1+r)^3} \cdot \left(\frac{D_3 \cdot (1+g_{LT})}{(1+r)} + \frac{D_3 \cdot (1+g_{LT})^2}{(1+r)^2} + \cdots \right) =$$

$$= \frac{D_1}{(1+r)} + \frac{D_2}{(1+r)^2} + \frac{D_3}{(1+r)^3} + \frac{1}{(1+r)^3} \cdot \frac{D_4}{r - g_{LT}}$$

12 "One can estimate expected returns in real or nominal terms. Since portfolio theory says the goal of investment is consumption, real returns seem more relevant, and only results for real returns are shown." See: Fama, E. and K. French (2002), "The equity risk premium".

13 For example, as mentioned by PwC "[…] using data for the US market, Damodaran found the technique with the best predictive power of actual returns over the following 5-years was recent averages of implied outputs such as DDM". See PwC (2017), "Refining the balance of incentives for PR19". Available at: https://www.ofwat.gov.uk/wp-content/uploads/2017/07/PwC-Balance-of-incentives-June2017.pdf

14 Specifically, we compared sum of the squared errors and aggregate absolute errors for real versus nominal models and for five year average versus spot models (for comparable time windows), over the period 2000 to 2017. Real models always outperformed nominal models. Five year averages outperformed spot estimates in respect of sum of squared errors, and in respect of absolute errors in all but one case.

- Multi-stage DGM model based on dividend growth.

We describe each in turn.

Multi-stage DGM model based on GDP growth

The key features of this model are:

- multi-stage – the model assumes a different short-term dividend growth rate (i.e. a growth rate applicable for the first five years) and a different long-term growth rate (which is applicable for all subsequent periods of time);
- capital growth modelled with historic GDP and IMF forecasts of future GDP;
- real – the model inherently operates in real terms (i.e. all nominal inputs are translated into real July 2018 terms);
- accounts for buybacks by directly adding them to the amount of dividends.

Variant of the multi-stage DGM model based on GDP growth with expected inflation

This model is a variant of our multi-stage DGM model described above, and thus has the same basic features. The difference is in how the expected dividend growth is modelled. In particular, the dividend growth rates are based on real GDP growth rates, which are first translated into nominal terms using CPI and then deflated back to real terms with expected, rather than actual, inflation.

We estimated the inflation expectations based on HM Treasury UK economy forecast reports. This was done by calculating a weighted average between the expected CPI inflation in the current calendar year and the next calendar year, where the weights were determined by the months of the year in which the expectations were provided.[15]

It should be noted that because the inflation expectations in HMT reports are per calendar year rather than for the next 12 months, HMT-inferred estimates are likely to obscure some of the volatility in the inflation expectations, i.e. the estimates tend to be closer to long-term mean than actual expectations over the next 12 months (and actual inflation figures). As such, the rolling five year average of real returns is likely to be close to what we would get by simply deflating the rolling five year average of nominal returns by the average inflation expectation (as compared to deflating each month of nominal returns with the relevant inflation expectations for that month).

Multi-stage DGM model based on dividend growth

The key features of this model are:

- multi-stage – similarly to the other DGM models, the model assumes a different short-term dividend growth rate for the first five years and a different long-term growth rate;
- capital growth modelled on the actual annual growth in dividends and buybacks;
- real – the model inherently operates in real terms (i.e. all nominal inputs are translated into real July 2018 terms);
- accounts for buybacks by directly adding them to the amount of dividends.

Using DGM results to estimate returns on capital

By definition, the average return on a stock is the average dividend yield plus the average rate of capital gain. For a firm with a ratio of dividends to prices that is stable over time, in the long-run the compound rate of

---

[15] For example, as of March 2017 the expected CPI was 2.9 per cent for 2017, and 2.6 per cent for 2018, from which we get an estimated inflation of 2.85 per cent ($= 10/12 \cdot 2.9\% + 2/12 \cdot 2.6\%$, where the $10/12$ weight represents the number of months left in 2017, and $2/12$ represents the number of months in 2018 until March 2018).

dividend growth will tend to approach the compound rate of capital gain, since the present value of capital is, at any point in time, the discounted present value of the future stream of dividends. If we have an estimate of the future growth rate of dividends, we can therefore use that to estimate the future growth in capital.

The dividend-price ratio may not be stable for various reasons. For example, firms might move, over time, away from dividends towards share repurchases as a way to deliver payoffs to shareholders.

Furthermore, because it is compound dividend and capital growth, not simple annual returns, that converge over the long run in the model, the use of the model to calculate annual simple returns will intrinsically produce a downwards bias if and insofar as annual returns on capital are more volatile than dividend yields. This means that the annual average return for dividends produced by the model will be an under-statement of the annual average return of the capital value series that the dividends are proxying for.

Fama and French (2002) note this issue and recommend an adjustment of half the difference between the historic variances of the growth rates of the dividends and capital series.[16] However, our analysis of the data found that the variance of the growth rate of dividends and buybacks is currently higher than the variance of the growth rate of capital values, and hence the circumstances do not currently exist for the downward bias discussed above. We therefore do not make use of a volatility adjustment in our analysis below.

Summary of DGM models

Table 2.2 summarises the assumptions we made in each of the three DGM models.

Table 2.2: Summary of approach taken to DGM models

	Multi-stage DGM based on GDP growth	Multi-stage DGM based on GDP growth with HMT-inferred inflation	Multi stage DGM based on dividend growth
Dividends and buybacks	Dividends and buybacks yields and price index for the FTSE All Share, used to calculate annual dividend and buyback per share (Reuters). Data cover the period From Jan 2000 to Jul 2018.	As in 'Multi-stage DGM based on GDP growth' model.	As in 'Multi-stage DGM based on GDP growth' model.
Basis for growth rates	UK GDP (IMF)	As in 'Multi-stage DGM based on GDP growth' model.	Annual growth in dividend and buyback outturns per share (Reuters).
Short-term growth	Short-term growth rate is defined as average of real GDP growth in a given month for the next 5 years (e.g. for July 2013, it is the average of the GDP growth rate in July 2013, July 2014, July 2015, July 2016 and July 2017)	As in 'Multi-stage DGM based on GDP growth' model.	Short-term growth rate is defined as average of real dividends and buybacks growth in a given month for the next 5 years (e.g. for July 2013, it is the average of the dividend and buyback growth rate in July 2013, July 2014, July 2015, July 2016 and July 2017).

[16] Fama, E. and K. French (2002), "The equity risk premium".

	Multi-stage DGM based on GDP growth	Multi-stage DGM based on GDP growth with HMT-inferred inflation	Multi stage DGM based on dividend growth
Long-term growth	Long-term growth rate is the long-term GDP growth as expected in a given year, drawn from OBR and HM Treasury figures, with some interpolation from Europe Economics analysis.	As in 'Multi-stage DGM based on GDP growth' model.	Dividends and buybacks are assumed to grow at 3.0% in the long-term, which is the average dividend and buyback growth inferred from FTSE All Share and FTSE All Share Total Return since 1991.
Inflation	CPI (ONS)	Inferred from HM Treasury UK economy forecast reports. This was done by calculating a weighted average between the expected CPI inflation in the current calendar year and the next calendar year, where the weights were determined by the months of the year in which the expectations were provided.	As in 'Multi-stage DGM based on GDP growth' model.

Source: Europe Economics.

The key difference between the models is associated with the assumed short-term and long-term growth rates (including how inflation is factored into those assumptions). To illustrate the implications of this difference, in Table 2.3 below we provide the averages of short-term and long-terms growth rates from each of our models for the period October 2016 to March 2018.

Table 2.3: DGM growth assumptions — averages between October 2016 and March 2018

	Multi-stage DGM based on GDP growth	Multi-stage DGM based on GDP growth with HMT-inferred inflation	Multi stage DGM based on dividend growth
Average real short-term growth rate	1.6%	2.3%	-1.9%
Average real long-term growth rate	1.8%	1.8%	3.0%

Source: Europe Economics.

2.5 Estimation of the TMR

Below we present our estimates for the TMR based on the approaches described above.

2.5.1 Average historical returns

We present in Table 2.4 below the average historical real TMR (real returns on equities) for different geographies and averaging methods (geometric and arithmetic). These results are based on long-run historical returns data from 1900 to 2017.

Table 2.4: Real TMR estimates by geography and by averaging method, based on data 1900 to 2017

	Geometric mean	Arithmetic mean
UK	5.5	7.3
Europe	4.3	6.2
World	5.2	6.6

Source: Dimson, Marsh and Staunton (2018), "Credit Suisse Global Investment Returns Yearbook 2018".

For 1900-2017, the average historical real TMR in the UK was 7.3 per cent based on the arithmetic average. The UK figures are based on three different inflation indices: the index of retail prices prior to 1962; the RPI from 1962 to 1988; and the CPI since 1988.

To overcome the issue of inconsistent inflation treatment over time, we have used imputed historic CPI data from the Bank of England,[17] along with data on nominal equity returns from DMS (2018), to estimate a historic real series which is consistently deflated by CPI. The arithmetic return of this consistently CPI-deflated series is 7.0 per cent. This is similar to the 7.3 per cent obtained when deflated using the three different inflation indices (reflecting the limits of inflation data availability at the time).

2.5.2 Dividend Growth Model (DGM)

We report below our results for the three variants of the DGM model:

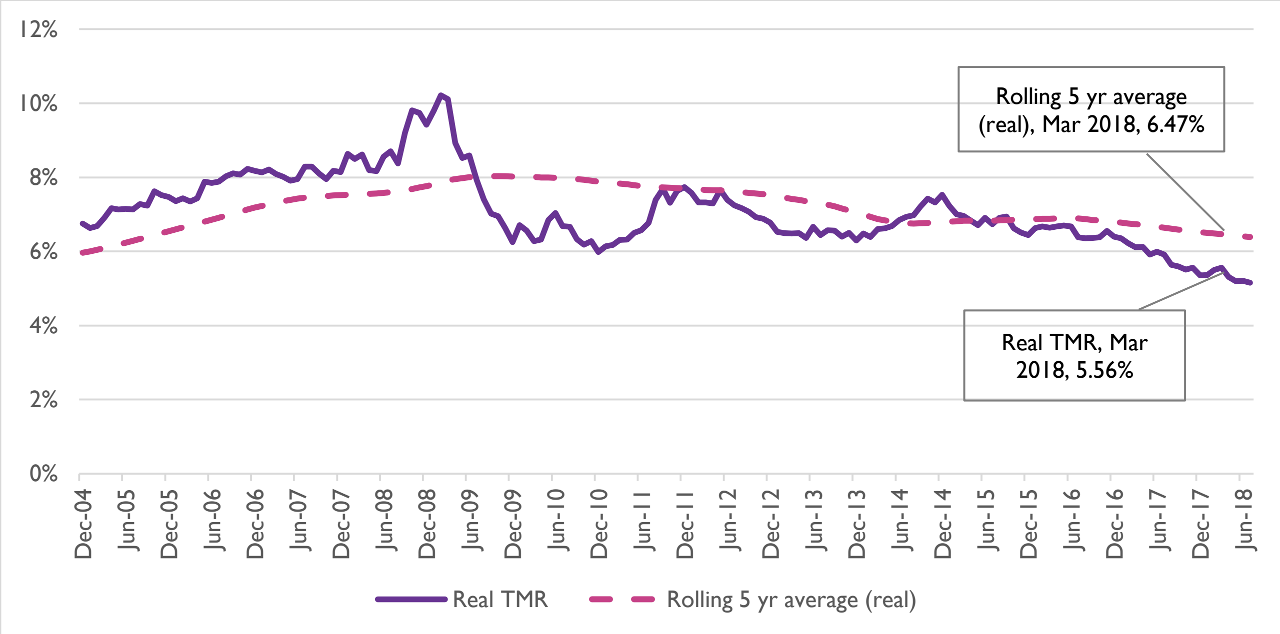
- Multi-stage DGM based on GDP growth
- Variant of the multi-stage DGM model based on GDP growth with expected inflation
- Multi-stage DGM based on dividend growth

Multi-stage DGM based on GDP growth

In this version of our model, capital growth expectations are based on GDP growth rates. This model produces a real TMR point estimate of 5.56 per cent (as of July 2018), and a 5-year average of 6.47 per cent (see Figure 2.1 below). This is equivalent to a TMR range of 7.67 to 8.60 per cent in nominal terms (assuming 2 per cent CPI inflation).

[17] Bank of England "A millennium of macroeconomic data". Available at: https://www.bankofengland.co.uk/statistics/research-datasets

Figure 2.1: Multi-stage DGM based on GDP growth (up to July 2018)



Source: Europe Economics' analysis. Underlying data sources described in Table 2.2 above.

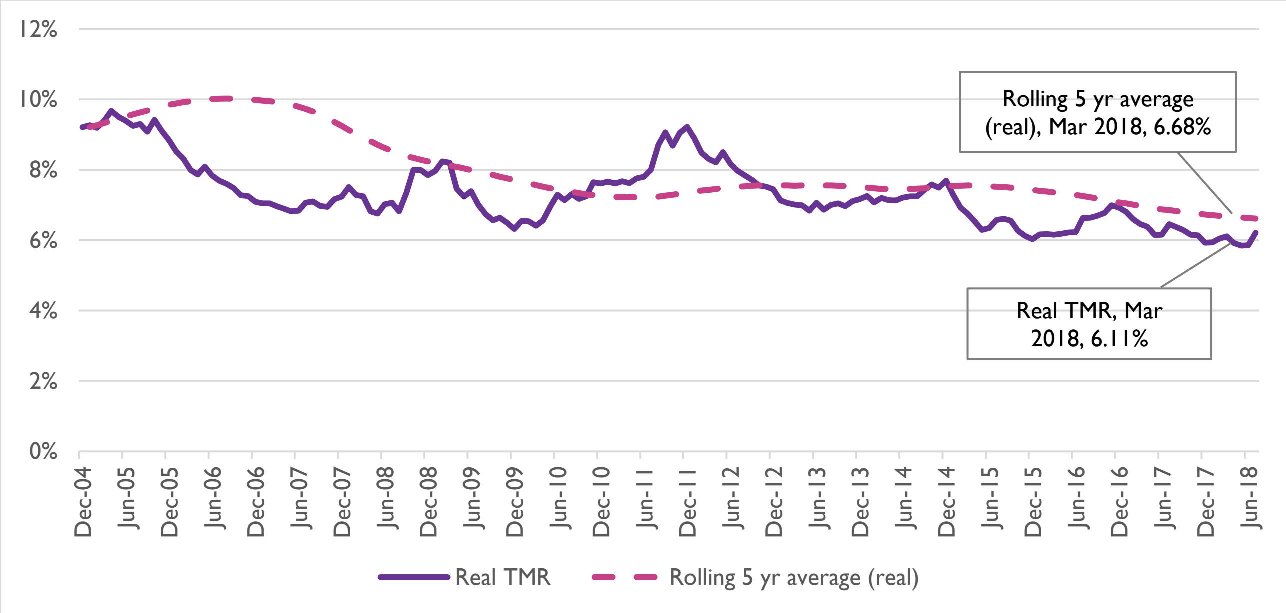
Variant of the multi-stage DGM model based on GDP growth with expected inflation

As a cross-check, we estimated the above DGM model using expected inflation rather than actual inflation (as described in Section 2.4.2). This variant of the model produced a 5.49 per cent real TMR point estimate as of July 2018, and 6.44 per cent 5-year average (which is equivalent to 7.60 to 8.57 per cent in nominal terms). This is very similar to the range produced by the multi-stage DGM model based on GDP growth rates discussed above.

Multi-stage DGM based on dividend growth

This variant of the model based on dividend growth rates produced a 6.11 per cent real TMR point estimate as of July 2018, and 6.68 per cent 5-year average (which is equivalent to 8.23 to 8.81 per cent in nominal terms).

Figure 2.2: Multi-stage DGM based on dividend growth (up to July 2018)



Source: Europe Economics' analysis. Underlying data sources described in Table 2.2 above.

Summary of our DGM models

Table 2.5 summarises the results produced by the three DGM models discussed above. The table provides five-year averages and spot figures (in real and nominal terms). For the reasons provided earlier in footnotes 13 and 14, we place most weight on the real rolling 5-year averages.

Table 2.5: Summary of our DGM models

	Multi-stage DGM based on GDP growth	Multi-stage DGM based on GDP growth and HMT-inferred inflation	Multi stage DGM based on dividend growth
Real rolling 5yr average	6.47%	6.44%	6.68%
Nominal rolling 5yr average	9.07%	9.50%	9.28%
Real spot return (March 2018)	5.56%	5.49%	6.11%
Nominal spot return (March 2018)	8.13%	8.52%	8.70%

Source: Europe Economics.

2.5.3 Reconciling evidence from different approaches

The evidence on the TMR is as follows:

- Regulatory precedents suggest an RPI-deflated TMR in the region of 5 to 6.5 per cent, which we estimate would be equivalent to a real TMR of 6.0 and 7.5 per cent (assuming a long-run RPI-CPI wedge of 1%), or 6.3 to 7.9 per cent (assuming a long-run RPI-CPI wedge of 1.3%).[18]
- Average historical returns, using a consistent CPI inflation series, imply a real TMR of 7.0 per cent (and using real DMS data directly, a real TMR of 7.3 per cent).

[18] As explained in the appendix, the Office for Budget Responsibility (OBR) estimated a long-run wedge of 1.0 per cent in 2015, while the Bank of England estimated a wedge of 1.3 per cent in 2014.

- Dividend growth models imply real returns of 6.4 to 6.7 per cent.

Given that the data available for estimating the TMR typically support a fairly wide range of values, we consider that real TMR estimates are most appropriately given to the nearest quarter.

Drawing the above data sources together, we recommend a real TMR range of **6.25 to 7 per cent**, equivalent to 8.4 to 9.1 per cent in nominal terms. The RPI-deflated range is 5.2 to 6.0 if the OBR's long-run estimate for the RPI-CPI wedge of 1.0 per cent is used, or 4.9 to 5.7 per cent if the Bank of England's wedge estimate of 1.3 per cent is used.

2.6 Relationship between real risk-free rate and real TMR

We have investigated the relationship between the real risk-free rate and the real TMR over time. To do this, we have used monthly estimates of the real TMR from our DGM variants and compared these with monthly real yields on 5, 10 and 20-year gilts.

Table 2.6 below presents estimated coefficients for two DGM variants, each of which is explained in detail in Section 2.4.2, and three different estimates of the real risk-free rate (5, 10 and 20-year real yields on zero coupon government bonds). These results are for CPI deflated gilts and CPI deflated TMRs, where the CPI deflated TMRs are the same as those generated by the models reported in Section 2.5.2. We have used monthly data from January 2004 to July 2018, such that we are solely looking at the period since the Bank of England introduced CPI targeting.[19]

Table 2.6: Estimated coefficients for real TMR and real risk-free rate relationship (all CPI deflated)

	Real risk-free rate (5-year gilt)	Real risk-free rate (10-year gilt)	Real risk-free rate (20-year gilt)
Real TMR (DGM based on GDP growth)	0.33*	0.42*	0.55*
Real TMR (DGM based on dividend growth)	0.33*	0.43*	0.57*

Source: Bank of England data, Europe Economics' analysis. Asterisk (*) denotes statistical significance at 95% confidence level.

The above table shows that there is a statistically significant relationship between the real TMR and the real risk-free rate, with the coefficient ranging in value from around +0.3 to +0.6.

For completeness, we have also calculated equivalent results using RPI-deflated data, though given the problems with RPI discussed in the appendix we do not consider that much weight should be placed on the RPI-deflated results. Table 2.7 shows the results for RPI-linked gilts and RPI deflated TMRs, where the RPI deflated TMRs are generated using the same DGM models but using RPI inflation inputs instead of CPI inflation inputs.[20]

[19] This is because we are using the Bank of England CPI target as the best proxy for investors' inflation expectations over the lifetime of the gilts.

[20] In the case of RPI deflated series, we have investigated monthly data from January 2000 to July 2018, using TMR data generated by our DGM models back to January 2000.

Table 2.7: Estimated coefficients for RPI-deflated TMR and nominal risk-free rate deflated by RPI

	Real risk-free rate (5-year gilt)	Real risk-free rate (10-year gilt)	Real risk-free rate (20-year gilt)
Real TMR (DGM based on GDP growth)	0.05	0.07	0.05
Real TMR (DGM based on dividend growth)	0.35*	0.53*	0.72*

Source: Bank of England data, Europe Economics' analysis. Asterisk (*) denotes statistical significance at 95% confidence level.

The DGM based on dividend growth using the RPI deflated series produces statistically significant positive coefficients ranging in value from around +0.4 to +0.7. By contrast, the estimated coefficients using the RPI deflated series and the DGM based on GDP growth are not significantly different from zero.[21]

PwC also studied this relationship on behalf of Ofwat.[22] That analysis found a negative correlation between the real risk-free rate and the real ERP, with a coefficient of -0.62 (on the basis of analysis of monthly data from 2000 to 2017). The ERP data was based on outputs from PwC's own DGM, but it is unclear what maturity gilts were used as the measure of the risk-free rate.

PwC's estimated coefficient between the risk-free rate and the ERP of -0.62 corresponds to a coefficient of +0.38 between the risk-free rate and the TMR. PwC's figure is therefore at the lower end of the range of statistically significant coefficients we estimate using our preferred measure of inflation (i.e. +0.3 to +0.6).

---

21 These results raise the question of why using RPI rather than CPI has a more substantial impact on the results when using the DGM based on GDP growth than when using the DGM based on dividend growth. It may be because, in the DGM model based on dividend growth, switching inflation measure affects both the TMR estimates (due to changes in the deflated historical growth of dividends) and the deflated gilt yields, meaning the relationship between the two is less substantially altered. By contrast, in the DGM model based on GDP growth, switching inflation measure has little effect on the TMR (since the same GDP growth assumption is used), meaning that when gilt yield data deflated using RPI rather than CPI are used the relationship alters substantially.

22 PwC (2017), "Updated analysis on cost of equity for PR19". Available at: https://www.ofwat.gov.uk/wp-content/uploads/2017/12/PwC-Updated-analysis-on-cost-of-equity-for-PR19-Dec-2017.pdf

3 Conclusions

In this report we have considered the total market return to be applied by Ofcom in setting the cost of capital to BT's regulated services.

We have concluded as follows.

- There are a variety of bases upon which one can estimate total market returns. Particular care needs to be taken in using past regulatory precedents for RPI-deflated TMRs — given that the RPI-CPI wedge has grown over time, we should expect RPI-deflated TMRs to have fallen over time even if real TMRs were stable.
- If we focus the analysis on real returns, TMRs appear to have fallen a little in recent years, but by less than the impression given by RPI-deflated estimates.
- We propose a TMR range of 6.25 to 7 per cent real, equivalent to 8.4 to 9.1 per cent in nominal terms or around 5.0 to 6.0 per cent on an RPI-deflated basis.
- Our analysis (using CPI-based data) suggests that there is a statistically significant relationship between the TMR and the risk-free rate, with the coefficient ranging in value from around +0.3 to +0.6 depending on the term to maturity of the gilts used in the calculations.

Appendix: Treatment of Inflation

Historically the RPI has been used as the primary measure of inflation. However, the RPI was declassified in as a national statistic in 2013. In the Johnson Review (2015) of consumer price statistics, it was noted that CPI had become the headline measure of inflation in the economy.[23]

The RPI and CPI differ in a number of dimensions:

- Coverage: while the basket of goods and services covered by the RPI and CPI is generally quite similar, a key difference is that RPI includes owner occupiers' housing costs in the form of council tax, mortgage interest payments, house depreciation, buildings insurance, ground rent and other house purchase costs. The CPI excludes these costs.
- Weights: the weights attached to different goods and services within the basket (to reflect their relative importance) is based on the results of the Living Costs and Food Survey in the case of RPI, but on the Household Final Monetary Consumption Expenditure in the case of CPI.
- Reference populations: the RPI reference population includes all private households in the UK, except for pensioner households where at least three quarters of the households' income comes from state pensions and benefits, and high-income households (where household income is in the top 4 per cent of the income distribution based on the LCF). The CPI, on the other hand, relates to domestic expenditure by all private UK households, residents of university and retirement and nursing home establishments.
- Aggregation formulae: the RPI is constructed using arithmetic means (Carli and Dutot formula), while the CPI mostly uses geometric means (Jevons formula). The mathematical properties of the Carli and Dutot formula imply that inflation rates calculated using this formula cannot be lower than the ones constructed using the Jevons formula (holding the basket of goods and services constant). Thus even if the CPI and RPI baskets were more aligned (e.g. due to the inclusion of housing costs in CPI), we would still expect a difference between RPI and CPI due to the aggregation formulae applied.

As a result of these factors there is a wedge between the RPI and CPI indices. One component of the wedge that has received particular attention is the formula effect. ONS data show the formula effect to have accounted for 0.7 percentage points of the difference between the RPI and CPI rates in 2017.[24] Moreover, in 2015, the Johnson review stated that the Carli formula should not be used to calculate changes in consumer prices as it is "statistically flawed and can result in an upward bias in recorded inflation".[25] The formula effect received particular attention in 2010 when a change in the measurement and coverage of clothing items doubled the formula effect.[26]

Figure 0.1 below shows a breakdown of components contributing to the wedge between RPI and CPI. It can be seen that the wedge between RPI and CPI has varied considerably between January 2005 and June 2015, with the RPI typically higher than the CPI. It can be seen that in the last few years the wedge has increased,

[23] Johnson, P. (2015), "UK Consumer Price Statistics: A Review". Available at: https://www.statisticsauthority.gov.uk/archive/reports---correspondence/current-reviews/uk-consumer-price-statistics---a-review.pdf

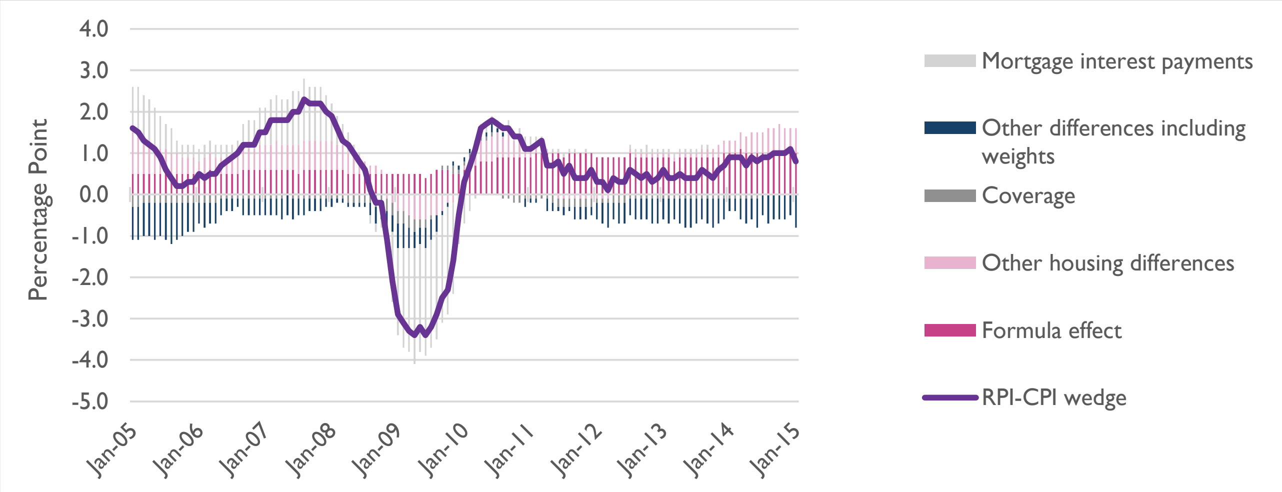
[24] ONS (2018), "Shortcomings of the Retail Prices Index as a measure of inflation". Available at: https://www.ons.gov.uk/economy/inflationandpriceindices/articles/shortcomingsoftheretailpricesindexasameasureofinflation/2018-03-08

[25] Johnson, P. (2015) "UK consumer price statistics: a review" p.13 Available at: https://www.statisticsauthority.gov.uk/archive/reports---correspondence/current-reviews/uk-consumer-price-statistics---a-review.pdf

[26] ONS (2018), "Shortcomings of the Retail Prices Index as a measure of inflation".

from around 0.4 percentage points in 2012 to around 0.9 percentage points in 2014. Forecasts of the long-run wedge between the RPI and CPI are higher than this. The Office for Budget Responsibility (OBR) estimated a long-run wedge of 1.0 per cent in 2015,[27] while the Bank of England estimated a wedge of 1.3 per cent.[28]

Figure 0.1: Components of the difference between RPI and CPI, Jan 2005 – Jan 2015



Source: OBR data.[29]

Given this long-run wedge, the choice of price index will have a significant effect on the estimated market parameters. With the CPI now the headline measure of inflation and the RPI declassified as a national statistic since 2013, our preferred measure of inflation in this report is the CPI. With respect to the TMR we therefore choose to publish three statistics:

- The real TMR.
- The nominal TMR – this is the real TMR inflated by CPI using the Fisher formula.
- The nominal TMR deflated by RPI – this is the nominal TMR deflated by RPI using the Fisher formula.

We favour use of the above labels, as they recognise that in principle there is only one 'real' and one 'nominal' value for the TMR. Since the CPI is currently considered the headline measure of inflation, we use the CPI to adjust between 'real' and 'nominal' values.

27 Office for Budget Responsibility (2015), "Economic and Fiscal Outlook: March 2015". Available at: http://obr.uk/docs/dlm_uploads/March2015EFO_18-03-webv1.pdf

28 Bank of England (2014), "Inflation Report: February 2014". Available at: https://www.bankofengland.co.uk/-/media/boe/files/inflation-report/2014/february-2014.pdf?la=en&hash=0273B58E1361D57BD0E7EFFC0F638B775CB06394

29 Data available at: http://obr.uk/box/revised-assumption-for-the-long-run-wedge-between-rpi-and-cpi-inflation/