RFR methodology for PR24

Response to Ofwat PR24 consultation

Prepared for
Water UK

2 September 2022

Final

www.oxera.com

Contents

Figures and tables

Oxera Consulting LLP is a limited liability partnership registered in England no. OC392464, registered office: Park Central, 40/41 Park End Street, Oxford OX1 1JD, UK; in Belgium, no. 0651 990 151, branch office: Avenue Louise 81, 1050 Brussels, Belgium; and in Italy, REA no. RM - 1530473, branch office: Via delle Quattro Fontane 15, 00184 Rome, Italy. Oxera Consulting (France) LLP, a French branch, registered office: 60 Avenue Charles de Gaulle, CS 60016, 92573 Neuilly-sur-Seine, France and registered in Nanterre, RCS no. 844 900 407 00025. Oxera Consulting (Netherlands) LLP, a Dutch branch, registered office: Strawinskylaan 3051, 1077 ZX Amsterdam, The Netherlands and registered in Amsterdam, KvK no. 72446218. Oxera Consulting GmbH is registered in Germany, no. HRB 148781 B (Local Court of Charlottenburg), registered office: Rahel-Hirsch-Straße 10, Berlin 10557, Germany.

Executive summary

Ofwat has proposed a methodology for estimating the risk-free rate (RFR) for PR24. In this report we show the limits and some fallacies of Ofwat's proposal. We present an alternative methodology that is rigorous and aligned with previous decisions made by the Competition and Markets Authority (CMA) in its redetermination for the PR19 price control.

First we review the methodology proposed by Ofwat for PR24. For the RFR estimate, the regulator is proposing to draw on gilt yields as its primary source of evidence and to place no weight on AAA-rated bonds. Ofwat is considering employing long-term SONIA swap rates and nominal gilt yields as potentially useful cross-checks. It does not consider the inclusion of an uplift to the gilt yields to account for the presence of a convenience premium.

We then present our case for an alternative approach to that proposed by Ofwat. We begin by examining which proxies should be used to estimate the relevant RFR. Our position is in line with what the CMA proposed in its redetermination for PR19: 'zero-beta' assets represent valid proxies for the RFR. Consequently, we propose that the estimate of the RFR should be based on both index-linked gilts (ILGs) and AAA-rated bonds, rather than solely on ILGs. This approach is also consistent with that proposed by the CAA for the regulation of Heathrow Airport, and is conceptually similar to the approach adopted by Bundesnetzagentur, the German federal network agency, to estimate RFR, which uses a designated bond index that includes some corporate bonds and bank bonds.

We provide evidence for the existence of a convenience premium in the returns of gilts, which indicates that using gilt yields to estimate the RFR is likely to result in an underestimation of the 'true' rate. We also discuss the existence of a small risk premium and a liquidity premium in AAA bonds. This indicates that using yields on AAA bonds to estimate the RFR is likely to result in an overestimation. We consider the exact quantification of the convenience premium, risk premium and liquidity premium as potentially subject to estimation error and therefore refrain from providing an exact estimate of each of these factors.

Instead, we take a more practical approach that is consistent with the CMA's approach for the PR19 redetermination, whereby the RFR is estimated as an average between the yield on AAA bonds and the yield on gilts. Our empirical analysis on the historical betas of government bonds and AAA bond indices shows that both are equally valuable inputs to estimating the 'true' RFR.

We discuss the use of SONIA swaps as a cross-check for the RFR estimate based on gilts. We first observe that, in a theoretical frictionless world, the yield curve obtained from bootstrapping the bond yields is identical to that obtained from bootstrapping the swap rates. This implies that swap rates do not contain any new information that is not already embedded in the yield curve derived from bonds. In other words, in a theoretical frictionless world, using SONIA swaps as a cross-check is a futile exercise.

In the real world (where frictions do exist), historically we observe a non-zero swap spread, which means that there is a difference between swap and gilt rates. The spread tends to be positive on shorter maturities and negative on longer ones. This spread is caused by frictions, such as the convenience premium and excess demand, and its persistence over time is due to limits to arbitrage. These limits prevent profit-seeking arbitrageurs from using trading strategies that would otherwise eliminate the spread and produce the 'frictionless' outcome in which there is only one yield curve. Thus, in practice, the yield curve derived from swaps is a 'noisy' proxy for one obtained from gilts. Using SONIA swap rates as a cross-check not only does not provide any additional information, but rather adds unnecessary noise to the estimate of the yield curve obtained from bonds.

Finally, we provide our estimates for the RFR for PR24, at between -1.22% and -0.96% (CPIH-real), with a midpoint of -1.09% as of July 2022. Specifically, we set the bottom of the range as the **six-month trailing average of the UK 20-year ILG,** and the top of the range **as the six-month trailing average of the iBoxx £ non-gilt AAA 10+ and 10-15 indices**, as of July 2022. As stated by the CMA, this approach is a more pragmatic and simpler way of estimating the RFR, which avoids quantifying the convenience premium in a bottom-up approach and adjustments to AAA bond yields in a top-down approach.[1] This updated approach also implicitly allows for the convenience premium by setting an RFR above the ILG yields.

Our updated RFR estimates are based on our estimate of the RPI-CPIH wedge, of 56bp. We show that Ofwat's proposed methodology for estimating the wedge, 'the official forecasts', significantly underestimates the RPI-CPIH wedge by omitting the CPI-CPIH wedge and overlooking the ongoing uncertainties surrounding the transition from RPI to CPIH planned for 2030. We present a more robust and **market-based estimate of the wedge based on RPI swap rates, CPI swap rates and the historical CPI-CPIH wedge.**

[1] Competition and Markets Authority (2021), Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations: Final report, 17 March, para. 9.160. https://www.gov.uk/cma-cases/ofwat-price-determinations#final-report.

1 Introduction

In this report, we provide a methodology for estimating the risk-free rate (RFR) for the purpose of regulation in PR24 for the water sector. Our approach is intended as a response to Ofwat's proposals, as well as an opportunity to lay out a sound methodology that provides clarity on how to implement the capital asset pricing model (CAPM) in this context.

The most important issue in this regard is to decide which proxies should be used for estimating the RFR. The main candidates proposed by Ofwat are RPI-linked gilts, nominal gilts, SONIA swaps, and an index of AAA-rated bonds. The challenge in choosing the proxies for the estimation comes primarily from the fact that while, in the theoretical framework of the CAPM, there is only one RFR (the 'true' RFR), in practice the RFR could be proxied using the rates of several different assets. In order to choose which rates to use, objective criteria are needed.

The key requirement for a RFR proxy is to be a zero-beta asset. Hence our attention is focused on identifying which assets have zero-beta. Our search for such assets leads us to rely on the yields of gilts and AAA bonds as the main sources for estimating the RFR. This choice is in line with what the CMA has proposed in its redetermination for PR19, and with the CAA's June 2022 proposal for the regulation of Heathrow.[2] In this context, we also discuss why the argument on the nature of the marginal investor as 'net borrower' or 'net lender' is not helpful for identifying the best RFR proxies to use.

Ofwat proposes to use SONIA swaps as a possible cross-check on the rates provided by gilts. We first investigate this choice from a theoretical point of view and explain why looking at swap rates is a redundant exercise when the yield curve based on bond rates is available. We then discuss this problem in a more realistic setting in which there are limits to arbitrage and explain that SONIA swap rates only add 'noise' to the estimation of the yields based on government bonds. Hence, we conclude that SONIA swaps should not be used as a cross-check for the gilt rates.

Our methodology leads us to set the bottom of the range as the six-month trailing average of the UK 20-year index-linked gilt (ILG), and the top of the range as the six-month trailing average of the iBoxx £ non-gilt AAA 10+ and 10-15 indices, as of July 2022.

Ofwat has also discussed how to forecast inflation, in light of the planned RPI to CPIH transition scheduled for 2030. We show that Ofwat's proposed methodology for estimating the wedge, 'the official forecasts', significantly underestimates the RPI-CPIH wedge, which could in turn lead to an underestimated CPIH-real RFR. We provide a market-based estimate of the wedge, also taking into account the wedge between CPI and CPIH.

The report is structured as follows.

- Section 2 reviews Ofwat's position on key issues relating to the RFR estimation, including the convenience premium, RFR proxies, SONIA cross-checks, and inflation adjustments.

[2] CAA (2022), 'Economic regulation of Heathrow Airport: H7 Final' (henceforth 'CAA Final Proposals), https://www.caa.co.uk/commercial-industry/airports/economic-regulation/h7/consultations/final-and-initial-proposals-for-h7-price-control/..

- Section 3 discusses the possible proxies for the estimation of the RFR, showing that the yields on gilts should be used in conjunction with the yields on AAA bonds. Both types of assets satisfy the requirement of being ‘zero beta’ and are therefore eligible proxies for the RFR. We also discuss why SONIA swaps do not provide a good cross-check for the RFR.
- Section 4 highlights our concerns with the ‘officials forecast’ approach used by Ofwat to estimate the RPI-CPIH wedge, and proposes a market-based alternative estimate of the wedge based on RPI swap rates, CPI swap rates and the historical CPI-CPIH wedge.
- Section 5 presents Oxera’s updated methodology for RFR estimation, which arrives at a CPIH-real RFR of -1.09% (as of July 2022).

2 Ofwat’s proposed RFR methodology for PR24

In this section, we summarise Ofwat’s proposed methodology for PR24 and its reasoning behind the proposals. This includes the regulator’s views on various key issues in RFR estimation. We discuss these issues in more detail in later sections of this report.

2.1 Risk-free rate proxy

Ofwat proposes to draw on gilt yields as its primary source of evidence for the RFR, justifying its choice on the basis that ILGs have the desirable property for an RFR proxy in that they offer inflation protection, high liquidity and negligible default risk. Ofwat proposes to place no weight on AAA-rated corporate bonds to inform its RFR estimate.[3]

Ofwat acknowledges that the CMA’s PR19 redetermination used an index of AAA-rated corporate debt to inform the upper end of its RFR range because the CMA’s view is that the yield is a more relevant borrowing rate for market participants than ILGs. Nevertheless, Ofwat proposes to disregard an index of AAA-rated bonds on the basis that, as noted by the CMA in its RIIO-2 redetermination, such an index is difficult to use and defend owing to the limited number of index constituents. Furthermore, Ofwat considers the likely presence of liquidity, inflation and default risk components in the AAA-rated synthetic index yield as an additional challenge to estimating an RFR that should not be affected by such risks.[4]

Ofwat also acknowledges that many stakeholders, in responding to the consultation, argued against the use of ILG yields as an unadjusted proxy for the RFR, noting variously that: using gilt yields violates the CAPM requirement that the RFR should be a borrowing and a lending rate for market participants; and that RPI-linked yields are artificially depressed by a ‘convenience premium’ reflecting the liquidity and safety of the asset.[5]

Ofwat responds to these critiques by arguing that all proxies for the RFR are affected by potential distortions that drive a yield different to that which would apply for the hypothetical ‘true’ RFR. Calibrating the adjustment to account for these distortions is typically subject to uncertainty and forecast risk. Ofwat argues that there is therefore a risk that any adjustment may make the estimation worse rather than better.[6]

Ofwat is considering employing long-term SONIA swap rates and nominal gilt yields as potentially useful cross-checks. It acknowledges that, during the consultation, several respondents disagreed with the use of SONIA swap rates to inform the RFR because there was insufficient liquidity at longer horizons and other potential distortions reduced its validity as a risk-free proxy.[7]

Ofwat responds to these critiques by arguing that it does not consider these concerns sufficiently serious to disqualify SONIA swap rates as a useful datapoint. First, it notes that the Bank of England assesses the SONIA swap market as deep, liquid and transparent for durations of up to 50 years. Second, it notes that the Bank of England has recently started to publish Overnight Index Swap (OIS) spot curves up to 25 years (an increase from the previous

[3] Ofwat (2022), ‘Creating tomorrow, together: Consulting on our methodology for PR24’, Appendix 11, pp. 5–6. (Henceforth ‘PR24 consultation’)
[4] Ibid., Appendix 11, p. 6.
[5] Ibid., Appendix 11, p. 4.
[6] Ibid., Appendix 11, p. 5.
[7] Ibid., Appendix 11, p. 5.

five years), after evidence emerged of improving liquidity at longer tenors following the transition from LIBOR to SONIA. [8]

2.2 Convenience premium

Ofwat recognises that it has been argued that ILGs have special characteristics as an RFR proxy (safety and liquidity) which make them desirable to investors, increasing demand for ILGs and therefore potentially reducing their yield below that of a zero-beta asset.[9]

Nevertheless, Ofwat is not convinced that it would be appropriate to uplift ILG yields for a ‘convenience premium’. First, it argues that as the zero-beta asset is a hypothetical asset without an observable traded yield, the direction of any correcting adjustment would be ambiguous. Second, it argues that even if there is a ‘convenience premium’, the process for adjusting RPI-linked gilt yields to correct for it is difficult, mainly due to the lack of recent, high-quality UK estimates that could be used to supply a point estimate for the adjustment. Where estimates have been made in the literature, these tend to relate to overseas studies and lie in a wide range.[10]

2.3 Inflation adjustment

In its December 2021 discussion paper Ofwat asked how best to convert RPI-linked yields to their CPIH-linked equivalents when deriving an RFR point estimate. This question was posed in response to the UK Statistics Authority’s transition from RPI to CPIH expected in February 2030, which will result in RPI being effectively aligned to CPIH in data and methods.[11]

Some responses to Ofwat suggested that a time-varying RPI-CPIH wedge could be derived based on evidence from zero-coupon RPI and CPI inflation swap rates. Other responses argued that the impact of the 2030 RPI reforms was uncertain, with several responses citing market evidence on yields which seemed to contradict the premise that markets are pricing a zero RPI-CPIH wedge post-2030. These responses argued for the retention of a long-run RPI-CPIH wedge of approximately 1.0%. Some suggested it might be appropriate to use the estimate by the Office of Budget Responsibility (OBR) at the relevant future point(s) in time to cover the period up to 31 January 2030 and to assume a zero wedge based on full convergence for the last two months of PR24. Others suggested a cross-check starting from nominal gilt yields of similar duration and deflated using a long-term fixed CPIH assumption.[12]

Ofwat is currently considering an approach to convert RPI-linked yields to a CPIH basis based on the ‘official forecasts’. Under this approach Ofwat would base the RPI-CPIH wedge on the OBR’s RPI and CPI forecasts before 2030, and then assume that the RPI will be fully aligned with the OBR’s long-term CPI forecast (i.e. assume an RPI-CPI wedge of zero) after 2030. The annualised geometric average wedge over the period would then be adopted.[13]

[8] PR24 consultation, Appendix 11, pp. 5–6.
[9] PR24 consultation, Appendix 11, p. 7.
[10] PR24 consultation, Appendix 11, p. 7.
[11] PR24 consultation, Appendix 11, p. 8.
[12] PR24 consultation, Appendix 11, pp. 8–9.
[13] PR24 consultation, Appendix 11, p. 9.

3 Risk-free rate proxies

In this section, we discuss the proxies that are appropriate for estimating the relevant RFR. Our position is broadly in line with that of the CMA in its redetermination for PR19, namely that the estimate of the RFR should be based on both the ILGs and the AAA-rated bonds. Our position is also in line with that of the CAA in its latest proposals for the regulation of Heathrow Airport, in which the ILG rates are augmented by a convenience premium that reflects the yield spreads of the AAA-rate bonds.[14]

We agree with the CMA that the RFR is the representation of the return required on a 'zero beta' asset within the CAPM. It is a measure of the rate of return that an investor can expect to earn without taking any systematic risk. To provide a correct application of the CAPM, Ofwat should look for assets that satisfy the zero-beta condition.

The CMA observes that ILGs closely match the key requirement of the RFR. The UK government enjoys a strong credit rating of AA/Aa3, and as a sovereign nation has monetary and fiscal levers to support debt repayment that are not available to commercial lenders.[15]

In considering whether highly rated, non-government bonds may improve the RFR estimation in the context of price controls, the CMA assessed the IHS iBoxx UK non-gilt AAA 10+ index and the IHS iBoxx UK non-gilt AAA 10-15 index.[16] The CMA concluded that the constituents of these indices are not 'risk-free' in the same way as government bonds denominated in the home country's currency are. This is because investors of these non-government bonds still bear liquidity risks, as well as the additional default risks associated with the issuer. That said, the CMA recognised that the default risks of these high-quality bonds are exceptionally low, and evidence from actual performance suggests that the expected loss is significantly lower than the debt premium.[17] As a result, the CMA concluded that the yields on AAA-rated non-government bonds are suitable inputs to the RFR estimation.[18]

In line with the decision of the CMA, the CAA Final Proposals conclude that it is appropriate to place a 50% weight on AAA-rated non-government bonds.[19] More specifically, the CAA states that:

> We remain of the view that ILGs may exhibit a "convenience yield" or other specific factors that mean that the yields on ILGs may underestimate the "true" risk free rate. Stakeholders' submissions to date have not included new evidence that has altered this view. We therefore consider that there is still a case for **placing weight on an alternative risk free rate benchmark that does not exhibit a convenience yield.** [emphasis added]

The CAA proposes to estimate the convenience premium embedded in gilts by comparing the returns on these gilts to the closest nominal gilt in maturity for each of the iBoxx non-Gilts AAA-rated 10+ years and 10-15 years indices. This approach is equivalent to using the AAA-rated bonds directly in the weighting formula for the RFR.

[14] CAA Final Proposals, section 3, para. 9.250.
[15] CMA redetermination, para. 9.103.
[16] CMA redetermination, para. 9.145.
[17] CMA redetermination, para. 9.146.
[18] CMA redetermination, para. 9.162.
[19] CAA Final Proposals, section 3, paras 9.247–9.250.

Specifically, the CAA proposes:[20]

> to estimate the risk free rate by placing equal weight on the following reference points:
> - the one-month trailing average yield on ILGs to 31st March 2022; and
> - the one-month trailing average yield on ILGs over the same period plus a convenience yield of 32bps, in line with the approach set out above.

The CMA acknowledges that the debate on the suitability of ILGs and AAA bonds has revolved around whether other market participants aside from the government can borrow at rates as low as those accessible to the government itself.[21] Part of this discussion revolves around the non-trivial issue of whether the marginal investor of the water companies is a 'net lender' or a 'net borrower'.

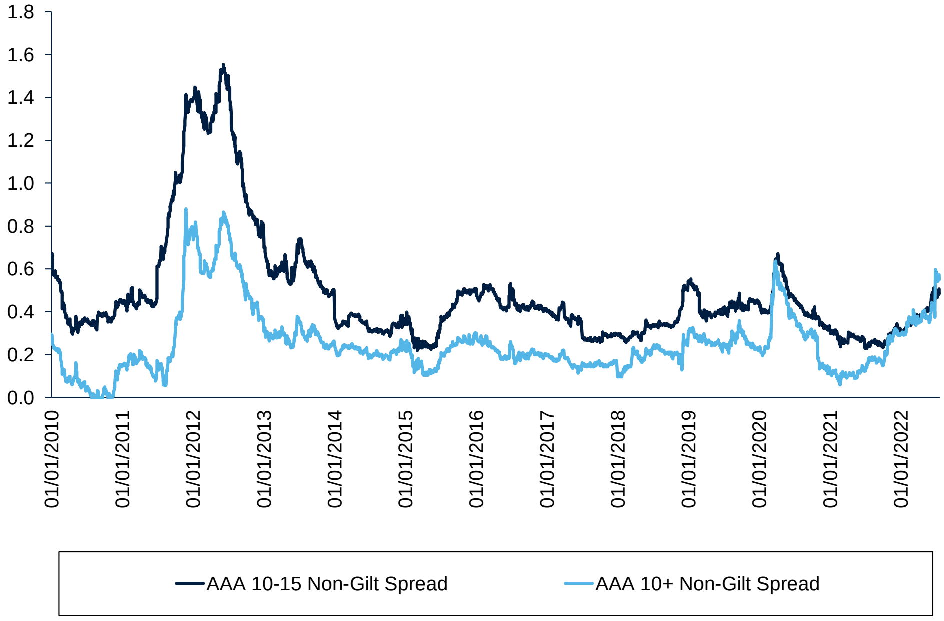
We consider that providing a definitive answer to the debate on the nature of the marginal investor as net borrower or lender is unnecessary for the practical point of assessing whether AAA bonds should be used as inputs in the estimation of the RFR. It suffices to say that as long as a representative investor can obtain a zero-beta risk exposure by investing in AAA bonds, the rate of AAA bonds is a valid proxy for the RFR. Assessing whether the marginal investor (or for that matter, any investor) can borrow at the same rate as the government is more of a test of the empirical validity of the CAPM than useful evidence on what represents a reliable proxy for the RFR. In practice, there are several rates that can be regarded as eligible RFRs, in the sense that they have zero beta. It is the case that only some borrowers (specifically the government) will be able to borrow at the lowest rates within the eligible range of RFRs. However, the perspective of the consumption CAPM is not that of the borrower but that of the investor (a representative investor). As long as a representative investor can invest in a given zero-beta asset, the return of that asset is a valid proxy for the RFR.

In contrast to AAA-rated non-government bonds, government bonds have special properties (noted in detail below) that create additional demand for these instruments. In other words, market participants have reasons to hold government bonds and these reasons go beyond the rate of return expected on these instruments. Bond yields and bond prices are inversely related, so when this additional demand pushes the price higher, the bond yield falls below a normal market-clearing price based solely on risk-free cash flows. These effects are collectively known as the 'convenience premium' and push the rate of return on government bonds below a 'true' RFR based on a zero-beta asset.

Figure 3.1 presents nominal spreads of the iBoxx £ AAA non-gilt 10+ and 10-15 indices. These yield spreads have consistently been positive over the past ten years.

[20] CAA Final Proposals, section 3, para.9.250.
[21] CMA redetermination, paras 9.91–9.93.

Figure 3.1 Nominal spreads of AAA bond indices



Note: The spreads are calculated by deducting yields on maturity-matching nominal gilts.

Source: Oxera analysis of IHS Markit and Bank of England data.

Thus, when using ILGs as a proxy for the RFR, a convenience premium must be added to the yield implied in the prices of ILGs in order to obtain a correct estimate for the RFR.

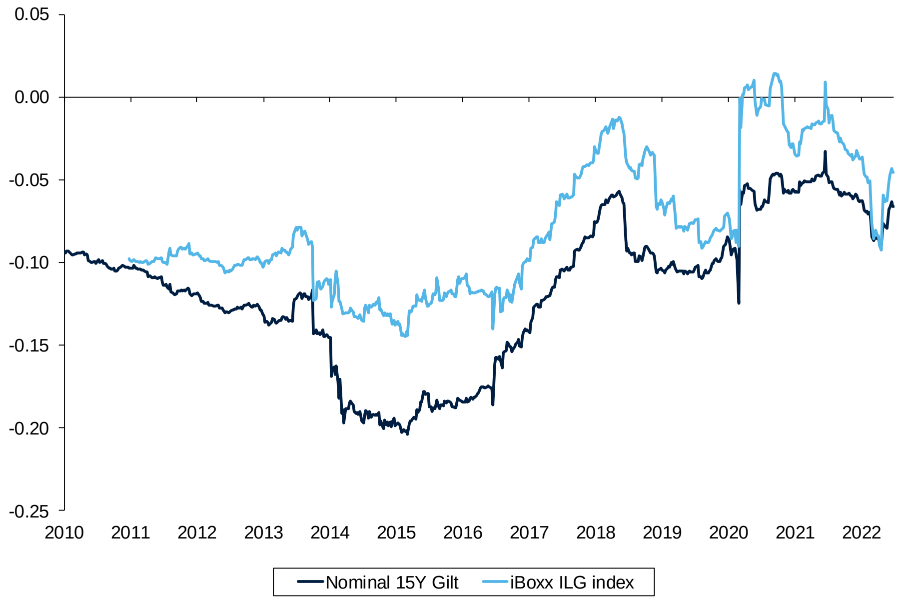
At the other end of the spectrum, the CMA acknowledges that illiquidity premiums, some default risk, and the unavailability of a 'perfect match' average-maturity benchmark all suggest that the yield on AAA non-government indices is likely to be an imperfect proxy for the RFR, and slightly above its 'true' level.[22]

To test whether the gilts and iBoxx AAA indices qualify for the zero-beta asset requirement, we implement five-year rolling regressions, regressing the weekly return of bond indices (for nominal gilt and ILG bond indices and the iBoxx AAA indices) against the weekly return of the equity market index (specifically, the FTSE All-share index). We find that government and AAA bond returns have consistently exhibited non-positive betas since 2010.

Furthermore, the estimated betas of both government bonds and AAA bonds follow similar trends. This is shown in Figure 3.2 and Figure 3.3. These empirical results show that government bonds and AAA bonds are equally valuable inputs for the estimation of a 'true' RFR for the CAPM.

[22] CMA redetermination, para. 9.151.

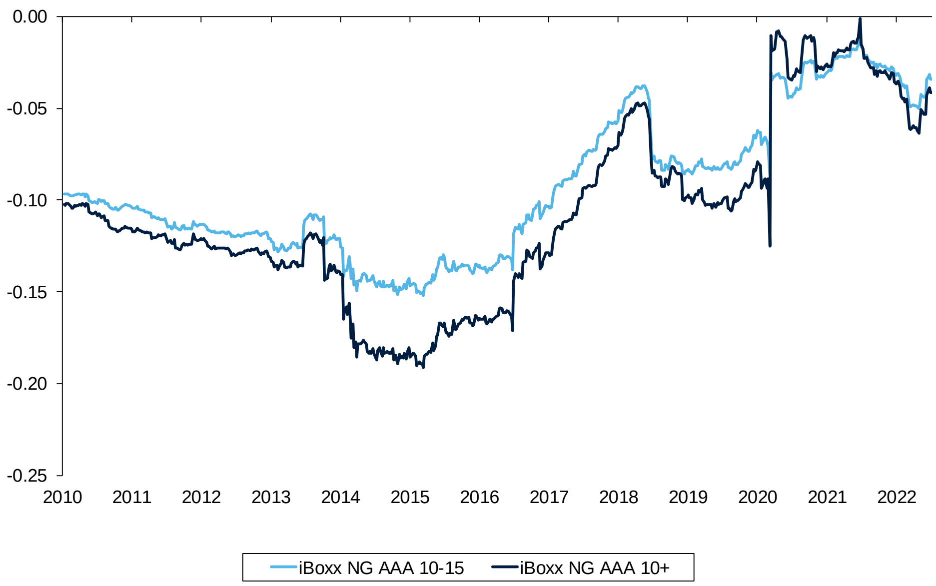
Figure 3.2 Coefficients for five-year rolling regression of returns of UK gilts against returns on FTSE All-share index



Note: These coefficients are calculated by regressing the weekly return on bond indices against the weekly return on the FTSE All-share index.

Source: Oxera analysis using data from Thomas Reuters Datastream and Markit iBoxx.

Figure 3.3 Coefficients for five-year rolling regression of returns of iBoxx £ non-gilt indices against returns on FTSE All-share index



Note: These coefficients are calculated by regressing the weekly return on bond indices against the weekly return on the FTSE All-share index.

Source: Oxera analysis using data from Thomas Reuters Datastream and Markit iBoxx.

In the next sections, we discuss the factors that affect the estimate of the RFR respectively using ILGs and AAA corporate bonds as starting points for the estimation. These factors include the convenience premium embedded in ILGs, and the risk premium and liquidity premium associated with AAA corporate bonds.

3.1 Convenience premium

As acknowledged by Ofwat in its PR24 consultation documents, a large body of academic literature supports the existence of a convenience premium.[23] Below, we examine the academic literature that discusses and/or empirically examines the convenience premium, including some of those cited by Ofwat.

3.2 Evidence on the convenience premium and its size

A substantial amount of evidence from the academic literature explicitly supports the use of an RFR for the CAPM that is higher than the yield on government bonds. For example, Krishnamurthy and Vissing-Jorgensen (2012) conclude that:[24]

> Treasury interest rates are not an appropriate benchmark for 'riskless' rates. **Cost of capital computations using the capital asset pricing model should use a higher riskless rate than the Treasury rate**; a company with a beta of zero cannot raise funds at the Treasury rate. [Emphasis added]

Berk and DeMarzo (2014) also explain that:[25]

> practitioners sometimes use [risk-free] rates from the **highest quality corporate bonds** in place of Treasury rates. [Emphasis added]

According to Feldhütter and Lando (2008), the magnitude of the convenience premium varies over time and can range from 30 to 90bp.[26] They explain the convenience premium as follows:[27]

> **The premium is a convenience yield on holding Treasury securities arising from**, among other things, (a) repo specialness due to the ability to borrow money at less than the GC repo rates, (b) that Treasuries are an important instrument for hedging interest rate risk, (c) that Treasury securities must be purchased by financial institutions to fulfil regulatory requirements, (d) that the amount of capital required to be held by a bank is significantly smaller to support an investment in Treasury securities relative to other securities with negligible default risk, and to a lesser extent (e) the ability to absorb a larger number of transactions without dramatically affecting the price. [Emphasis added]

Similarly, Krishnamurthy and Vissing-Jorgensen (2012) estimate the average of the liquidity component of the convenience premium to be 46bp from 1926 to 2008.[28] Ofwat has also helpfully noted that Van Binsburgen et al. (2020) estimate a convenience premium of around 40bp on US government bonds over 2004–18.[29]

A Bank of England study finds that some investor groups in UK government bonds display the behavioural properties that theory associates with preferred habitat investors.[30] It concludes that these groups of investors, which comprises institutional investors such as life insurers and pension funds, are less sensitive to price movements than other investor groups. This empirical

---

[23] PR24 consultation, Appendix 11, p. 7.
[24] Krishnamurthy, A. and Vissing-Jorgensen, A. (2012), 'The Aggregate Demand for Treasury Debt', *Journal of Political Economy*, **120**:2, pp. 233–67.
[25] Berk, J. and DeMarzo, P. (2014), *Corporate Finance*, third ed., Pearson, p. 404.
[26] Feldhütter, P. and Lando, D. (2008), 'Decomposing swap spreads', *Journal of Financial Economics*, **88**:2, pp. 375–405.
[27] Ibid., p. 378.
[28] Krishnamurthy and Vissing-Jorgensen (2012), op. cit.
[29] Van Binsbergen, J. H., Diamond, W. F. and Grotteria, M. (2022), 'Risk-free interest rates' *Journal of Financial Economics*, 143:1, pp. 1–29.
[30] Giese, J., Joyce, M., Meaning, J. and Worlidge, J. (2021), 'Preferred habitat investors in the UK government bond market', Bank of England Research Paper Series, 10 September.

finding is consistent with the academic theories underlying the convenience premium, where investors have reasons to hold government bonds and these reasons go beyond the rate of return expected on these instruments. It also further supports the existence of a convenience premium in the UK.

Koijen and Yogo (2020) develop a pricing model to study sources of variation in exchange rates, long-term yields, and stock prices across 36 countries from 2002 to 2017.[31] Their model finds that, in the absence of special-status demand for US assets by foreign investors and foreign exchange reserves, the US long-term yield would be 215bp higher. In other words, the authors find evidence consistent with a significant convenience premium for US Treasuries between 2002 and 2017.

Longstaff (2004) also examines the 'flight to liquidity' premium in Treasury bond prices by comparing them with prices of bonds issued by the Resolution Funding Corporation (REFCORP), a US government agency, which are guaranteed by the US Treasury.[32] Using yield data from April 1991 to March 2001, Longstaff finds a premium in Treasury bonds relating to:

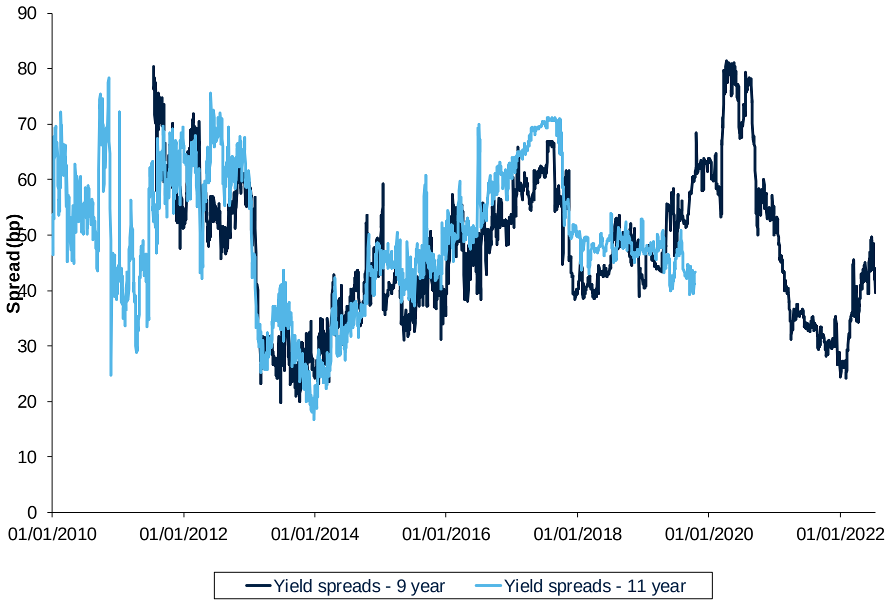
- changes in consumer confidence;
- the amount of Treasury debt available to investors;
- the flows into equity and money market mutual funds.

Longstaff concludes that these features of Treasury bonds directly affect their value.

Using a methodology that is broadly consistent with that set out in Longstaff (2004), we also estimate the size of this premium since 2010. Figure 3.4 below shows that the long-term convenience premiums implied by the spreads of 9- and 11-year REFCORP bonds from 2010 to date are on average 47bp and 50bp respectively.[33] It can be seen that the 11-year spreads reduced significantly in early 2020 when the COVID-19 pandemic began, but at the start of January 2022 this reversed and the spreads are currently trending upwards. These estimates are consistent with the upward adjustment of 50–100bp that we recommended in our May 2020 report,[34] which is added to the yield of 20-year ILGs to estimate the 'true' RFR for the CAPM.

[31] Koijen, R.S. and Yogo, M. (2020), 'Exchange rates and asset prices in a global demand system', No. w27342, National Bureau of Economic Research.
[32] Longstaff, F.A. (2002), 'The flight-to-liquidity premium in US Treasury bond prices', No. w9312, National Bureau of Economic Research.
[33] Due to data limitations, it is not possible to reconstruct times series of spreads for maturities longer than 11 years. For illustration, as of 1 January 2010, only six out of 41 outstanding REFCORP bond strips had maturities greater than or equal to 20 years. As of 19 October 2010, all outstanding REFCORP bond strips had maturities less than 20 years.
[34] See Oxera (2020), 'Review of the CMA PR19 provisional findings', 26 October, p. 14; and Oxera (2020), 'Are sovereign yields the risk-free rate for the CAPM?', 20 May, p. 2.

Figure 3.4 Evolution of yield spreads of 9- and 11-year zero-coupon REFCORP bonds strips since 2010



Note: Assumes a cut-off date of 1 July 2022. The yield spreads at a given point in time are calculated by averaging the daily spreads across all outstanding REFCORP bond strips that have maturities equal to the target maturities at that time (i.e. 9- and 11-year). The spreads are calculated based on the USD US Treasury bonds/notes (FMC 82) zero coupon yield curve, which has maturities available at yearly intervals between one and ten years, and also at 15 years, 20 years and 30 years. The gaps between these maturities are linearly interpolated.

The nine-year spreads series are not available until 20 July 2011, as before that date no REFCORP bond strips have maturities shorter than or equal to nine years. The 11-year spreads series are not available after 17 October 2019, as after that date no REFCORP bond strips have maturities longer than or equal to 11 years. Due to data limitations, it is not possible to reconstruct times series of spreads for maturities longer than 11 years. For illustration, as of 1 January 2010, only six out of 34 outstanding REFCORP bond strips had maturities greater than or equal to 20 years. As of 19 October 2010, all outstanding REFCORP bond strips had maturities less than 20 years.

Source: Oxera analysis using Bloomberg data.

The CAA, in its latest proposal for the regulation of Heathrow, reiterates that it remains of the view that ILGs exhibit a 'convenience premium' or other specific factors that mean that the yields on ILGs may underestimate the 'true' RFR. The CAA estimates the convenience premium as follows:

- identify the nominal gilt closest in maturity for each of the iBoxx non-gilt AAA-rated 10+ years and 10–15 year indices;
- deduct the yield on each gilt from the corresponding iBoxx index over the relevant averaging period; and
- average the difference in yields over this period.

The CAA's estimate of the convenience premium using this methodology is 32bp. The CAA observes that this approach addresses two issues:

- higher short-term inflation is likely to affect nominal gilts and AAA-rated corporate bonds to a similar extent, and so should not materially influence the estimate of the convenience premium or the RFR;

- by estimating the convenience premium by comparing the yield on two sets of fixed-rate instruments, the inflation risk premium is stripped out from the estimated convenience premium.

The allowance for convenience is also not a novel concept in the context of international energy regulation. For example, the German federal network agency, Bundesnetzagentur (BNetzA), has implicitly allowed for an adjustment for convenience premium since 2005. [35] Specifically, BNetzA, in its cost of capital determination for regulated energy networks, uses 'yields on debt securities outstanding issued by residents'[36] as a proxy for the RFR. The official regulatory consultation published in 2021 explained that this designated index includes some corporate bonds and bank bonds.[37]

3.3 Risk premium

Elton et al. (2001) consider actual default rates and bankruptcy recovery rates on corporate debt and show that a risk-neutral investor will require (at most) a 5bp default premium to invest in a ten-year AA-rated corporate bond. [38]

Berk and DeMarzo (2014) report data from Moody's that indicates an annual default rate of 0.0% for AAA corporate bonds over 1983–2011 based on a ten-year holding period.[39] The authors also report an average loss rate for unsecured debt of about 60%. This data is consistent with the expected loss component of the AAA corporate yield being close to zero over a ten-year horizon.

Feldhütter and Schaefer (2018) provide estimates of default probabilities using a structural model (Black–Cox) and a new approach for calibrating the model to historical default rates that leads to more precise estimates of investment-grade default probabilities. The authors present estimates of default probabilities and premiums up to a 20-year investment horizon.

The authors report actual cumulative default probabilities of 0.87% and 1.71% for AAA-rated corporate bonds over 10- and 20-year horizons.[40] The default probabilities implied by the Black–Cox model are reported as 0.54% and 1.18% for these horizons. The annualised default probabilities are obtained by dividing these figures by the investment horizon. Multiplying by an average loss rate of 60% gives the annualised default premiums reported in Table 3.1.

Table 3.1 Estimates of default premiums

Horizon	10-year	20-year
Actual	0.03%	0.04%
Black–Cox model	0.05%	0.05%

Source: Oxera analysis based on Feldhütter and Schaefer (2018), Table 8.

[35] Bundesnetzagentur (2021), 'Verordnung über die Entgelte für den Zugang zu Elektrizitätsversorgungsnetzen (Stromnetzentgeltverordnung - StromNEV)" , para. 7, https://www.gesetze-im-internet.de/stromnev/BJNR222500005.html.
[36] Official English translation by Bundesbank. 'Umlaufsrenditen inländischer Inhaberschuldverschreibungen / Insgesamt / Monatswerte' (in German).
[37] Bundesnetzagentur (2021), op. cit., para. 7 Abs. 6 StromNEV/GasNEV, https://www.bundesnetzagentur.de/DE/Beschlusskammern/BK04/BK4_74_EK_Zins/BK4_Beschl_EK_Zins.html, p. 5.
[38] Elton, E., Gruber, M., Agrawal, D. and Mann, C. (2001), 'Explaining the Rate Spread on Corporate Bonds', *The Journal of Finance*, **56:**1, February, Table 6.
[39] Berk, J. and DeMarzo, P. (2014), *Corporate Finance: Third Edition*, Pearson, Table 12.2.
[40] Feldhütter, P. and Schaefer, S. (2018), 'The Myth of the Credit Spread Puzzle', *The Review of Financial Studies*, **31**:8, August, pp. 2897–2942, Table 8.

In addition, Feldhütter and Schaefer (2018) account for the systematic risk premium in AAA corporate yields. Although it is rare for a bond to default when rated AAA, some bonds that default will have originally been rated AAA when they were issued. As the investment horizon increases, the cumulative default probability and the risk premium increase. The uncertainty of the estimate also increases, particularly given that defaults of bonds originally rated AAA at issue are rare.

Table 3.2 summarises the estimated spreads between AAA corporate yields and the underlying RFR, taking into account both default risk and the systematic risk premium. Both the actual and modelled spreads increase with the investment horizon. The divergence between actual and modelled spreads also increases with the investment horizon.

Table 3.2 Estimated spreads of AAA corporate bond yields to risk-free rate

Horizon	7–13-year	13–20-year
Actual	0.06%	0.22%
Black–Cox model	0.01%	0.02%

Source: Oxera analysis based on Feldhütter and Schaefer (2018), Table 9.

The evidence presented in this section illustrates the following points with respect to estimates of the premium for expected loss on AAA corporate bonds.

- The estimates are based on long time series that average out any volatility in the premium for expected loss over short time horizons.
- There is a wide range of uncertainty around the estimates across the different estimation approaches.

This means that there is a risk of inconsistency when making such adjustments to any particular AAA-rated corporate bond or index. To the extent that such adjustments are appropriate in any specific circumstance, at a ten-year horizon a downward adjustment of approximately 5bp to the yields on AAA corporate bonds could be considered to control for expected loss. At a 20-year investment horizon, a larger downward adjustment of 5–20bp could be considered.

3.4 Liquidity premium

When using the yield on AAA corporate bonds to inform the estimate of the RFR for the CAPM, liquidity risks may need to be accounted for. This can be done by deducting a liquidity premium from the yield on AAA bonds. Below, we discuss the empirical evidence from the academic literature, as well as findings from our own empirical analysis.

Van Loon et al. (2015) decompose the credit spreads of the constituents of the iBoxx GBP Investment Grade Index from 2003 to 2014, and find that the median liquidity premium on AAA bonds fluctuated between c. –8bp and +48bp.[41] Excluding the periods of the global financial crisis (2007–08) and the height of the European debt crisis (2011–12), the median liquidity premium largely fluctuates between 0bp and +20bp. While this analysis relies on pre-

[41] Inferred from Figure 20 in Van Loon, P.R., Cairns, A.J., McNeil, A.J. and Veys, A. (2015), 'Modelling the liquidity premium on corporate bonds', *Annals of Actuarial Science*, **9**:2, pp. 264–89.

2014 data, it serves as a cross-check on our empirical analysis, which we present below.

While there are many proxy measures of liquidity, our empirical analysis focuses primarily on the bid–ask spread of the constituents of the iBoxx £ Corp AAA 15+ index. [42]

The bid–ask spreads are expressed in percentage terms, calculated as:

$$\frac{(Ask\ price - bid\ price)}{Mid\ price}.$$ [43]

We calculate the six-month trailing averages of the percentage bid–ask spread preceding 1 July 2022 for each of the constituent of iBoxx £ non-gilts AAA 10-15 and iBoxx £ non-gilts AAA 10+ respectively.[44]

We obtain liquidity premia of 3.3bp and 5.5bp that are calculated by dividing the percentage bid–ask spreads over an assumed holding period of 20 years.

3.5 SONIA cross-checks

In this section, we consider Ofwat's proposal to use the SONIA swap rate as a proxy for the RFR in the CAPM, in the context of the PR24 consultations.

In its Final Determinations for RIIO-T2 and RIIO-GD2, Ofgem commented on the benchmarks that can be used to estimate the RFR in the CAPM. It considered the 20-year SONIA swap rate to be a potential measure of the nominal RFR. Ofwat agrees with Ofgem's use of SONIA swaps as an RFR proxy, and in its RFR estimation is minded to adopt SONIA swap rates as a cross-check on the ILG yields.[45]

3.5.1 The yield curve in a frictionless world and associated arbitrage

To shed some clarity on whether it is useful to use SONIA swaps as cross-checks, it is helpful to review how the yield curve is derived. The yield curve can be equivalently obtained by bootstrapping the bond yields or the swap rates over the different maturities. Smith (2014) illustrates how to infer the forward curve starting from swaps,[46] while Hull (2003) illustrates how to infer it from Treasury bonds. [47]

In a theoretical frictionless world, the two methods lead to the same exact yield curve. In other words, the term structure of SONIA swap rates and gilt yields should be perfectly aligned. If this were not the case, any misalignments would be eliminated by profit-seeking arbitrageurs. It then follows that, in a frictionless world, SONIA swap rates do not provide additional information that is not already contained in the yield curve obtained from gilts. This implies that carrying out a cross-check based on SONIA swaps is futile.

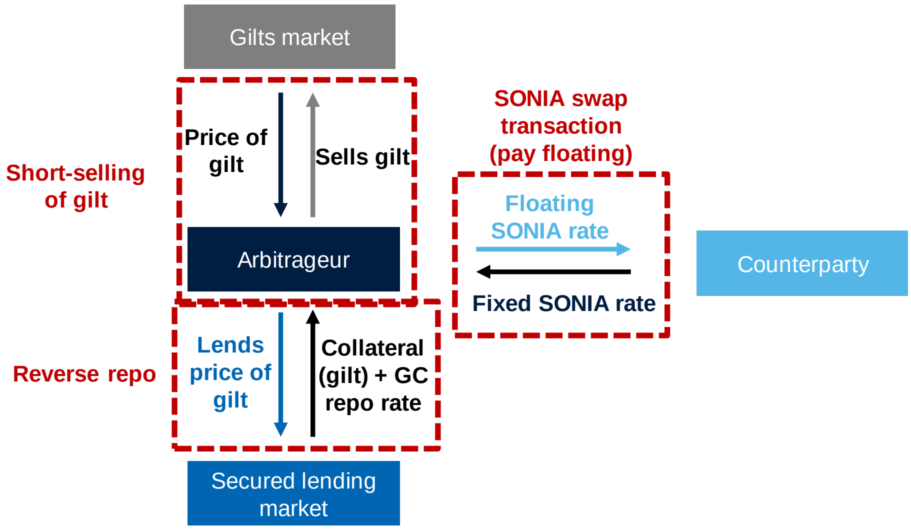
What follows is a description of how an arbitrage strategy would eliminate any difference between the yield curve obtained from gilts and that obtained from SONIA swaps.

[42] Oxera (2020), 'Adjusting AAA corporate bond yields for expected loss', 20 July, p. 2.
[43] The percentage bid–ask price may also be calculated using the ask price or the bid price as the denominator. In our analysis, we use the mid-price as the denominator following the definition set out in International Monetary Fund (2006), 'Financial Soundness Indicators Compilation Guide', para. 8.44.
[44] The iBoxx £ non-gilts AAA 10-15 and the iBoxx £ non-gilts 10+ indices had 5 and 14 constituents respectively, as at 22 July 2022.
[45] PR24 consultation, Appendix 11, p. 2.
[46] Smith, D.J. (2014), *Bond math: the theory behind the formulas, + website*, John Wiley & Sons, p. 181.
[47] Hull, J.C. (2003), *Options, futures and other derivatives*, Pearson Education India, section 4.5.

Consider first the case of a positive difference between the rate on the fixed leg of the SONIA swap and the corresponding yield on gilts. This case is known as 'positive swap spread'. In this case, investors can arbitrage this spread by going long on the SONIA swap and short on the gilt, and then lending to a third party the amount obtained from the short sale of the gilt.

More precisely, the long position on the swap implies that the investor pays the floating SONIA rate and receives the fixed rate. The short position on the gilt implies that the investor pays the fixed rate of the gilt. The arbitrage strategy is completed by lending the short-selling proceeds to a borrower in a reverse repurchase agreement (reverse repo) earning the general collateral (GC) repo rate, which is used to cover the payments of the floating rate of the SONIA swap.[48] This strategy is depicted in Figure 3.5 below.

Figure 3.5 Illustration of arbitrage strategy if SONIA swap spreads are positive



Source: Oxera.

The total cash flows that the investor receives are equal to the difference between the fixed leg of the swap rate and the gilt yield (swap spread), plus the difference between the GC repo rate (interest on the reverse repo) and the floating SONIA rate (if positive). Absent market frictions, investors can adopt this arbitrage strategy and generate positive profits until the swap spread is zero and the GC repo rate equals the SONIA rate.

Duarte, Longstaff and Yu (2007) provide an explanation of this strategy:

> The swap spread arbitrage strategy has two legs. First, an arbitrageur enters into a par swap and **receives a fixed coupon rate CMS [constant maturity Swap]** and pays the floating Libor rate Lt. Second, the arbitrageur **shorts a par Treasury bond** with the same maturity as the swap and invests the proceeds in a margin account earning the repo rate. The cash flows from the second leg consist of **paying the fixed coupon rate of the Treasury bond CMT [constant maturity Treasury]** and **receiving the repo rate** from the margin account rt. Combining the cash flows from the two legs shows that the arbitrageur receives a fixed annuity of SS = CMS − CMT and pays the floating spread St = Lt − rt. The cash flows from the reverse strategy are just the

[48] In a reverse repo transaction, the borrower and lender agree to a short-term agreement, whereby the lender agrees purchase securities in order to sell them back to the borrower at a slightly higher price. In the present case, investors are lenders in the reverse repo transaction, lending to the borrowers by purchasing gilts from them. When the reverse repo agreement unwinds, investors receive the initial purchase price plus an interest.

opposite of these cash flows. There are no initial or terminal principal cash flows in this strategy.[49] [emphasis added]

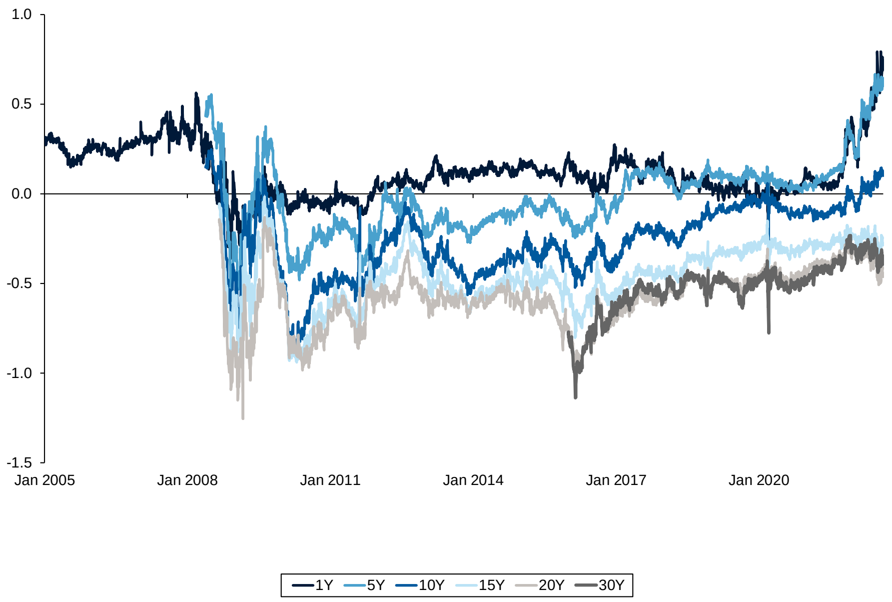
Conversely, if the swap rates are lower than the gilt yields (i.e. there is a negative swap spread), the arbitrage portfolio can be reversed such that investors short the swap spread instead of going long on it. The arbitrage trades will repeat until the swap spreads are pushed to zero.

3.5.2 Limits to arbitrage

The above discussion explains why the SONIA swap spread would be zero in a frictionless world. In practice, the swap spread is typically different from zero. Figure 3.6 presents the historical spreads of 1-, 5-, 10-, 15-, 20- and 30-year SONIA swap rates.

While the shorter maturities tend to have positive (or less negative) spreads especially since the start of the COVID pandemic, the longer maturities (10Y+) have had consistent negative spreads since the 2007–2008 financial crisis. Similar patterns are also observed in the USD market, as shown by Boyarchenko et al. (2018). These discrepancies in spreads are driven by various factors, which we discuss below in more detail.

Figure 3.6 Historical data on SONIA swap spreads



Source: Oxera analysis based on Bloomberg and Bank of England data.

Two main points need to be explained:

- why the swap spreads are generally positive at shorter maturities and negative at longer maturities;
- why these non-zero swap spreads are not arbitraged out (i.e. why they persist over time).

The starting point is to look at the persistence of positive spreads for shorter maturity swaps. As noted above, gilts carry a convenience premium at shorter

[49] Duarte, J., Longstaff, F.A. and Yu, F. (2007), 'Risk and Return in Fixed-Income Arbitrage: Nickels in Front of a Steamroller?', *The Review of Financial Studies*, 20:3, pp. 769–811, https://doi.org/10.1093/rfs/hhl026.

maturities due to their greater liquidity as well as other factors. Insofar as swap rates do not carry such premium, a positive swap spread will occur.

In theory, an arbitrage strategy like that discussed in the previous section and illustrated in Figure 3.5should lead to the elimination of the spread. In practice, for the strategy to be profitable, the difference between the GC repo rate and the SONIA floating rate must be sufficiently non-negative. Historically, GC rates have often been significantly below SONIA rates.

A similar pattern is observed in the USD market, in reference to which Agustin et.al. (2021) explain that, due to higher risk, uncollateralised interest rates (the equivalent of SONIA rates) are generally greater than collateralised rates (GC repo rates).[50] This fact is also noted by Boyarchenko et al. (2018), which observe that LIBOR generally exceeds the interest rate earned in the reverse repo transaction, making the overall trade uneconomical.

Overall, this evidence supports the claim that the reverse repo arbitrage illustrated in Figure 3.5 is typically not profitable, which is why we observe persistent positive swap spreads on shorter maturities.

We now discuss possible reasons why we observe negative swap spreads at longer maturities. The academic literature has attributed the existence of a negative spread primarily to 'excess' demand for hedging relative to supply (i.e. there is a convenience premium for swap rates). Since limits to arbitrage prevent the market from correcting these supply–demand imbalances, negative swap rates persist.

More precisely, Klinger and Sundaresan (2019) develop a model in which underfunded pension plans' demand for duration hedging creates demand for the fixed rate leg in swaps with long maturities. The authors explain that:[51]

> Pension funds have long-term liabilities in the form of unfunded pension claims and invest in a portfolio of assets, such as stocks, as well as in other long-term assets, like government bonds. They can balance their asset-liability duration by investing in long-term bonds or by receiving fixed in an IRS [interest-rate swap] with long maturity. Our theory predicts that, **if pension funds are underfunded, they prefer to hedge their duration risk with IRS rather than buying Treasuries**, which may be not feasible given their funding status. The preference for IRS to hedge duration risk arises because the swap requires only modest investment to cover margins, whereas buying a government bond to match duration requires outright investment. **This demand, when coupled with dealer balance sheet constraints [as set out in Boyarchenko et al. (2018), which we discuss below], results in negative swap spreads**. [Emphasis added]

Empirically, Klinger and Sundaresan (2019) also find that the aggregate funding status of defined-benefit pension plans is a significant explanatory variable of 30-year swap spreads in the USA. For the euro market, where the supply of interest rate swaps is lower than in the USA, Domanski et al. (2017) explain that the impact of demand-driven pressure on the swap spreads can be extremely significant:[52]

> [W]hen [the] long-term interest rate fell sharply in December 2008, Dutch pension funds' coverage ratios fell to about 95 percent, and their attempts to

[50] Augustin, P., Chernov, M., Schmid, L. and Song, D. (2021), 'Benchmark interest rates when the government is risky', *Journal of Financial Economics*, 140:1, pp. 74–100.
[51] Klingler, S. and Sundaresan, S.M. (2019), 'An explanation of negative swap spreads: Demand for duration from underfunded pension plans', *The Journal of Finance,* 74:2, pp. 675–710.
[52] Domanski, D., Shin, H.S. and Sushko, V. (2017), 'The hunt for duration: not waving but drowning?', *IMF Economic Review*, pp. 113–53.

> close their interest rate gaps via the use of swaps were associated with a **31 percent cumulative decline** in the 50-year swap rate in just two days (3-4 December). [Emphasis added]

This 'excess demand' cannot be met with additional supply due to limits to arbitrage. Boyarchenko et al. (2018) focus on limits to arbitrage resulting from the more stringent regulatory requirements for swap dealers. Specifically, they argue that higher capital requirements reduce incentives for market participants to enter into the relevant arbitrage trades.[53] The authors conclude that, given the balance sheet costs for the dealers, spreads must reach more negative levels to generate an adequate risk-adjusted return on equity for dealers. The authors' conclusions are supported by the observations of Chowdhury and Wurm (2017) on the UK swap market:[54]

> More puzzling, perhaps, the strong inversion of swap spreads across maturities and persistent, negative long-term swap spreads suggest the presence of unexploited arbitrage opportunities. Increased regulation motivating end-of-quarter bond sell-offs by banks and large-scale QE-induced tightness of the repo market, resulting in **costlier and thus unprofitable hedges**, are the most likely explanations for reduced **dealer appetite** to participate in such agreements. [Emphasis added]

Jermann (2020) develops a theoretical framework explaining long-term negative swap spreads under limited arbitrage. Consistent with explanations focusing on capital market inefficiencies, this theory assumes frictions limiting the size of dealers' fixed-income portfolios and derives negative swap spreads even in the absence of demand-side effects.[55]

3.5.3 Concluding remarks on SONIA swap rates as viable cross-checks

In conclusion, SONIA swap rates should theoretically be equal to the RFR in a theoretical frictionless world. This implies that, in a frictionless, world swap rates do not provide additional information with respect to a yield curve built on government bond yields (i.e. there should only be one yield curve).

In practice, a variety of distortions and market frictions lead to significant and persisting swap spreads. In particular, we observe persistent negative spreads for long-maturity SONIA swaps. Thus, in the real world, as opposed to a theoretical frictionless world, swap rates provide a noisy proxy for the yield curve based on government bond yields. The 'noise' is due to the fact that a variety of frictions distort swap rates, resulting in multiple non-perfectly overlapping yield curves.

Using SONIA swap rates as a cross-check for RFR only adds more noise and distortions to RFR estimation. Therefore, we do not consider the 20-year SONIA swap rate to be the appropriate proxy for the RFR in the context of the PR24 price control.

[53] Boyarchenko, N., Gupta, P., Steele, N. and Yen, J. (2018), 'Negative swap spreads', *Federal Reserve Bank of New York Economic Policy Review*.
[54] Chowdhury, S. and Wurm, M.A. (2017), 'Modelling and Forecasting Interest Rate Swap Spreads', *Moody's Analytics risk perspectives,* https://www.moodysanalytics.com/risk-perspectives-magazine/managing-disruption/principles-and-practices/modeling-and-forecasting-interest-rate-swap-spreads (accessed 30 June 2021).
[55] Jermann, U. (2020), 'Negative Swap Spreads and Limited Arbitrage', *Review of Finance*, pp. 212–38.

4 Estimation of the RPI-CPIH wedge

In November 2020, the Chancellor announced that the UK Statistics Authority could introduce its RPI to CPIH transition unilaterally from 2030. These planned reforms will align the Retail Price Index (RPI) with the Consumer Price Index including owner occupier housing costs (CPIH).[56]

Against this background, Ofwat is considering a number of methodologies for estimating the RPI/CPIH wedge in order to convert RPI-linked ILG yields into CPIH-real RFR estimates.

Ofwat's preferred method is the 'official forecasts' approach:[57]

> under this option we would base the RPI-CPIH wedge on the OBR's RPI and CPI forecasts before 2030, and then assume that the RPI will be fully aligned with the OBR's long-term CPI forecast (ie, we assume an RPI-CPI wedge of zero) after 2030. The annualised average wedge over the period would then be the geometric average of this series.

By construction, the official forecasts approach implicitly assumes that the RPI inflation rate implied by the ILGs will equal the CPIH inflation rate with 100% probability from 2030 onwards. This assumption is controversial. There is material uncertainty surrounding the RPI-CPIH transition.

Notably, the right to undertake a judicial review of the RPI-CPIH transition has been granted to some pension funds.[58] The court case, to be heard in summer 2022, challenges both the RPI reform and the Chancellor's decision not to compensate ILG holders. If compensations were to be paid to ILG holders in light of the judicial review, ILG prices would increase, resulting in lower yields. This would consequently increase the break-even RPI inflation implied by the nominal gilt yields and ILG yields, leading to a wider RPI-CPIH wedge. It is also not possible to rule out entirely a scenario whereby the RPI-CPIH transition gets delayed or even cancelled in light of the judicial review.

The uncertainties set out above will inevitably affect market expectations surrounding the break-even inflations implied in the ILGs. As a result, Ofwat's approach based on official forecasts is unlikely to provide a robust estimate of the RPI-CPIH wedge.

4.1 Alternative methodologies

In its consultation, Ofwat considers two alternative methodologies for estimating the RPI-CPI(H) wedge. The first, the 'Do minimum' approach, entails using a wedge of around 1%:[59]

> 'Do minimum' approach: This would involve adjusting RPI-linked gilt yields for the OBR's long-term RPI-CPI 'wedge' of around 1.0%, as we did for PR19 final determinations.

Ofwat argues that this methodology incorrectly assumes that the market is currently pricing gilts that mature after 2030 with no regard to the RPI-CPIH transition.

[56] UK Statistics Authority (2020), 'Response to the joint consultation on reforming the methodology of the Retail Prices Index', https://uksa.statisticsauthority.gov.uk/news/response-to-the-joint-consultation-on-reforming-the-methodology-of-the-retail-prices-index/
[57] PR24 consultation, p. 9.
[58] See Linklaters (2022), 'The High Court considers RPI replacement challenge', 22 June, https://www.linklaters.com/en/knowledge/publications/alerts-newsletters-and-guides/2022/june/22/the-high-court-considers-rpi-replacement-challenge#_ftn1.
[59] PR24 consultation, Appendix 11 [?], p. 9.

The second methodology considered by Ofwat is to estimate the wedge based on zero-coupon RPI and CPI swaps:[60]

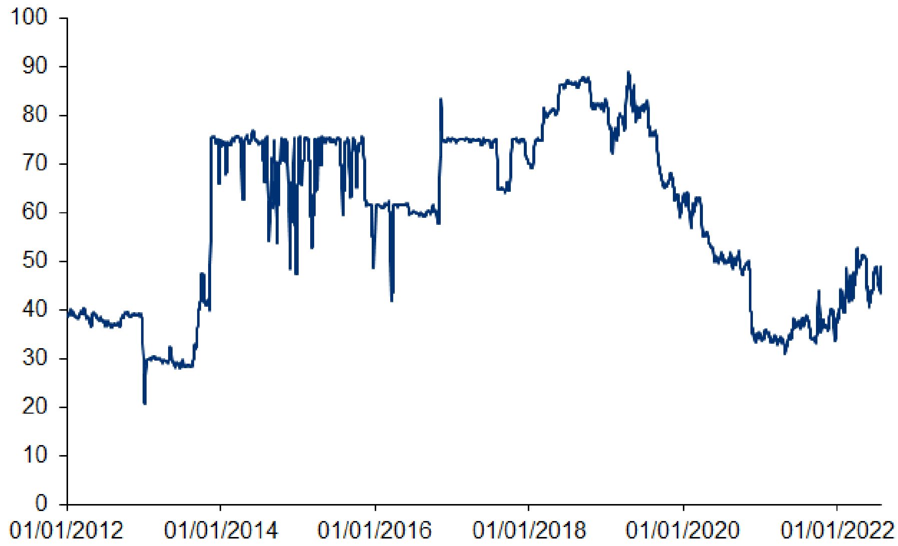
> 'Inflation swaps' approach: an alternative option would be to infer the market-implied long-term expectation of the RPI-CPIH wedge based on rates of zero-coupon RPI swaps and zero-coupon CPI swaps at our chosen CAPM investment horizon.

Ofwat prefers the official forecasts approach to the inflation swap approach, as it argues that the latter is subject to distortions from inflation risk premia and/or low liquidity.

Instead, we argue that there is merit in using the method based on the comparison between RPI and CPI swaps: to the extent that the two types of inflation swaps are affected by inflation risk premia and liquidity risk premia in similar ways, the levels of distortion can be reduced when estimating the RPI-CPI wedge from the difference between zero-coupon RPI swaps and zero-coupon CPI swaps.

Oxera's analysis using data from Bloomberg, shown in Figure 4.1, finds that the latest six-month average spread of RPI-CPI swap is around 46bp (as of July 2022).

Figure 4.1 Weekly average of 20-year RPI-CPI spread



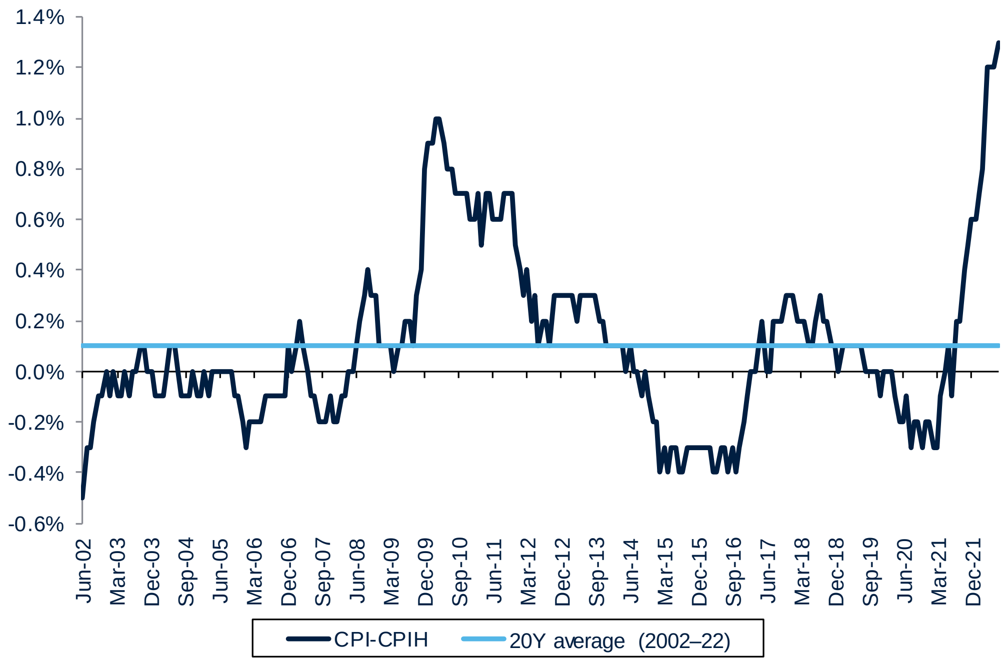
Note: Seven-day moving average.

Source: Oxera analysis using Bloomberg data.

To obtain the final estimate of the RPI-CPIH wedge, the RPI-CPI wedge set out above needs to be adjusted for a CPI-CPIH wedge. The 20-year long-run average CPI–CPIH wedge from June 2002 to June 2022 is approximately 10bp (see Figure 4.2).

[60] PR24 consultation, Appendix 11, p. 9.

Figure 4.2 Historical CPI-CPIH wedge, 2002 to 2022



Source: Oxera analysis using data from ONS.

The positive wedge between CPI and CPIH must be added to the RPI–CPI wedge implied by swap rates to obtain the RPI–CPIH wedge. This results in an RPI-CPIH wedge of **56bp** based on current market data (see Table 4.1).

Table 4.1 RPI-CPIH wedge projections over 20 years, as of July 2022

Component	Formula	bp
Six-month average of the RPI–CPI wedge implied by 20-year RPI and CPI swap rates	[A]	46
20-year average CPI–CPIH wedge	[B]	10
Estimate of the RPI–CPIH wedge for 20-year gilts	[C] = [A]+[B]	56

Source: Oxera analysis.

Table 4.2 provides a comparison of different CPIH-real estimates of the RFR based on different estimation methods for the RPI-CPIH wedge. The first estimate uses 'official forecasts', while the second uses an estimate of the RPI-CPIH wedge based on market data.

Table 4.2 CPIH-real gilt yields as of July 2022

	Formula	Ofwat's official forecasts approach	Oxera's estimate
20-year ILG yields, RPI-real, 6m average	[A]	-1.77%	-1.77%
20y RPI-CPIH Wedge	[B]	0.43%[1]	0.56%[2]
20y CPIH-real yield	[C] = (1+[A])*(1+[B])-1	-1.35%	-1.22%

Note: [1] See Appendix 1. [2] Oxera calculation in Figure 4.1.

Source: Oxera analysis of Bank of England, OBR and Bloomberg data.

5 Estimation of the real risk-free rate

In this section, we set out our latest RFR estimate using our updated methodology, based on an average of yields over the last six months.

The choice of six months as an averaging period is consistent with the CMA's decision for the PR19 appeals.[61] The CMA noted that 'a 6-month period would provide a suitable balance of ensuring the use of up-to-date data while avoiding the issues of short-term mark volatility.' As the CMA has already weighed the benefits of adopting shorter or longer averaging periods, we also adopt six months to achieve a consistent approach over time.

Our RFR estimate is the average of the CPIH-real iBoxx yields and the 20y CPIH-real ILG yields.

CPIH-real iBoxx yields are obtained by deflating the nominal yields of iBoxx £ Non-Gilt AAA indices using a CPIH inflation forecast, which is estimated by taking the breakeven RPI inflation implied by 20y nominal gilts and 20y ILGs, and subtracting the RPI-CPIH wedge of 56bp estimated by Oxera (see Table 4.1).

The RPI-real yields of ILGs are adjusted from RPI-real to CPIH-real by adding the 56bp RPI-CPIH wedge.

Table 5.1 below sets out Oxera's estimate of RFR as at July 2022.

Table 5.1 Oxera's estimate of RFR as of July 2022

	Formula	Six-month average
20y breakeven RPI inflation	[A]	3.90%
20y RPI-CPIH wedge	[B]	0.56%[1]
20y CPIH inflation	[C] = (1+[A])/(1+[B])-1	3.33%
iBoxx £ non-gilt AAA 10-15, nominal	[D]	2.49%
iBoxx £ non-gilt AAA 10+, nominal	[E]	2.27%
Average of AAA indices, CPIH-real	[F] = (1+AVG([D],[E]))/(1+[C])-1	-0.96%[2]
20y ILG, CPIH-real	[G]	-1.22%[3]
Oxera's RFR estimate	[H] = AVG([F],[G])	-1.09%

Note: [1] See Table 4.1. [2] The calculations set out in the table arrive at an estimate of -0.92%, which is an approximation. In practice, we deflate the nominal daily yields of iBoxx indices using the daily 20y CPIH inflation, which are derived based on the daily values of 20y breakeven RPI inflation. This arrives at the more precise estimate of -0.96% set out in the table. [3] See Table 4.2.

Source: Oxera analysis using data from Bloomberg and Bank of England.

[61] CMA redetermination, para. 9.208.

A1 RPI-CPI wedge estimated under the official forecasts approach

Table A1.1 sets out the RPI-CPI wedge estimated under the official forecasts approach, which amounts to **43bp** as of July 2022. The RPI and CPI inflation forecasts are based on the OBR's forecasts from 2022 to 2026, assumed to be the long-term Bank of England target from 2027 to 2029 and assumed to be 2% (the long-term CPI target) from 2030 onwards.

Table A1.1 RPI-CPIH wedge under the official forecast approach, as of July 2022

	RPI inflation	CPI inflation	RPI-CPI wedge (bp)
2022	9.8%	7.4%	240
2023	5.5%	4.0%	150
2024	2.3%	1.5%	80
2025	2.5%	1.9%	60
2026	2.7%	2.0%	70
2027	3.0%	2.0%	100
2028	3.0%	2.0%	100
2029	3.0%	2.0%	100
2030 – 2042	2.0%	2.0%	0
Geometric average			43

Source: Oxera analysis using data from Bank of England and the OBR.

www.oxera.com