WATER PR24 REFERENCES

Provisional Determinations Volume 5: Appendices A–F and Glossary

09 October 2025

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The Competition and Markets Authority has excluded from this published version of the provisional determination information which the group considers should be excluded having regard to section 206 of the Water Industry Act 1991.

Any omissions are indicated by [✄]. Any non-sensitive replacement content is indicated in square brackets.

CONTENTS

Appendix A: Conduct of our PR24 redetermination process

A.1 The CMA received five References from Ofwat on 18 March 2025.

A.2 Our administrative timetable was published on our case page.[1] We must issue the final report before 17 March 2026.[2] The timing of our final report will depend, for example, on the responses we receive to the provisional determinations and any further work required.

A.3 Our provisional determinations have been informed by extensive evidence from the Main Parties and third parties.

Evidence from Main Parties

A.4 We received and published a number of submissions from the Main Parties, including the Disputing Companies' statements of case, Ofwat's response to these statements of case, replies from the Disputing Companies to these documents, and further submissions from the Disputing Companies and from Ofwat.[3]

A.5 The Main Parties made initial presentations to the CMA and the Disputing Companies produced virtual site visit videos. The Disputing Companies (and their representatives) and Ofwat provided various technical teach-ins for CMA staff on analytical approaches and financial models. Ofwat also provided the CMA with some teach-in sessions on the regulatory process and PR24 ahead of the References (recordings of which were shared with the Disputing Companies).

A.6 We received responses from the Main Parties to several requests for information. In the interests of maintaining openness and transparency, we asked the Main Parties to copy each other into submissions and responses to our information requests, except where relevant information was commercially confidential.

A.7 We have reviewed Ofwat's PR24 FD documents and supporting materials including provisional decisions, methodologies and consultation documents. We have also considered the Disputing Companies' responses to and submissions on these materials.

A.8 On 28 May 2025 we published for consultation the CMA PR24 Approach document, setting out our proposed approach to the determinations (see Chapter 3, paragraph 3.14) and to which the Main Parties responded.

[1] Having requested, and been granted by Ofwat, an extension of the statutory deadline to 12 months.
[2] Rules (CMA204), Rule 4.1.
[3] See the versions published by the CMA at Water PR24 price redeterminations (eg Disputing Companies' statements of case, Ofwat's responses to statements of case, and Disputing companies' replies to Ofwat's responses to statements of case).

A.9 We held hearings with the Main Parties throughout late June and early July 2025. These included joint hearings to discuss cross-cutting issues as well as individual hearings to discuss concerns specific to each Disputing Company.

A.10 We also received brief written submissions from the Main Parties following these hearings focused on any perceived points of inaccuracy or responses to new information.

Evidence from third parties

A.11 We received over 40 submissions from third parties including environmental, conservation, business and consumer organisations, local government, academics, advisers, other water companies and other regulated businesses. We have published non-sensitive versions of all third party submissions on our case page.

A.12 A further six third party submissions were received in response to the CMA PR24 Approach document, which we have also published on our webpage.

A.13 We have engaged extensively with CCW, including through its own dedicated third-party hearing. We have held calls with the DWI, and have received responses to Requests for Information from CCW, the DWI and EA. We also met with representatives of the Thames Investor Group.

A.14 Although all submissions were considered carefully, we have not listed every relevant submission in relation to every point throughout our report.

A.15 We would like to thank everyone who has provided us with evidence to consider for our redeterminations.

Engineering assistance

A.16 We have employed a firm of engineering consultants, Water Research Centre Group (**WRc**) to provide specialist engineering expertise in relation to the determinations. WRc has advised the CMA on various technical aspects of the water and sewerage sector. We have treated WRc's advice as further evidence to aid the Group's provisional decision-making.

Appendix B: Background on economic regulation of the UK water sector

B.1 This appendix provides a brief introduction to economic regulation of the UK water sector, providing an overview of the regulatory bodies overseeing the water sector and their roles, the regulated companies, economic regulation of the sector and the factors determining the customer bills.

Privatisation of water sector in England and Wales, and regulatory bodies

B.2 Following a brief period of government ownership, The Water Act 1989 privatised the 10 regionally operated water authorities in England and Wales.[4] As part of the process of privatisation and creation of 10 major water and sewerage companies (**WaSCs**), the following three new regulatory bodies were also created.

(a) The Drinking Water Inspectorate (the **DWI**), responsible for monitoring the quality of drinking water and ensuring that the water supply is safe to drink and meets the standards set in the relevant water quality regulations. The DWI is also responsible for agreeing and managing water company programmes to improve drinking water.[5]

(b) The Environment Agency (the **EA**) and its Welsh counterpart Natural Resources Wales, responsible for environmental regulation.[6] The EA is the principal adviser to the government on the environment, and the leading public body protecting and improving the environment of England.[7] The EA has a duty to maintain and improve water quality, and exercises this duty through monitoring the quality of rivers, lakes the sea and ground water. The EA also issues water abstraction licences for activities such as drinking water supply, artificial irrigation and hydro-electricity generation, as part of its role in conservation and ecology.

(c) Ofwat, responsible for the economic regulation of the sector and setting the price regime.

B.3 The Department for Environment, Food and Rural Affairs (**Defra**) is responsible for the policy, planning and regulatory framework for the water sector in England. It

[4] At the time of privatisation, there already existed a significant number of private water-only companies.
[5] What we do - Drinking Water Inspectorate.
[6] At the time of privatisation, the regulator was the National Rivers Authority. The National Rivers Authority was dissolved in 1996 and superseded by the EA and Natural Resources Wales.
[7] Natural Resources Wales undertakes the equivalent role in Wales.

also works with devolved administrations in Wales, Scotland and Northern Ireland.[8]

B.4 In Scotland and Northern Ireland, water services are publicly owned and are regulated by the Water Industry Commission for Scotland and The Northern Ireland Authority for Utility Regulation respectively.

B.5 Other relevant bodies include the Natural England, which is the Government's adviser on the natural environment.

Water companies in England and Wales

B.6 Over time, water companies have been consolidated following mergers with other water companies or WaSCs.[9] Currently Ofwat regulates 6 regional water only companies (**WoC**s) and 10 regional WaSCs in England.[10]

B.7 Following privatisation, water services in England and Wales have been largely funded by customer bills and private investment. Water infrastructure networks require substantial capital investment and maintenance, and the need for investment is sometimes large and unforeseeable. Expenditure is funded by raising debt and equity financing. Funds generated from customer bills typically cover costs of operation, contribution towards capital repayments and returns on the financing of previous expenditure.[11] This limits fluctuations in customer bills and allows long-lived water assets to be paid for over time by more of the users who ultimately benefit. In return, investors require a return on finance, which customers also pay for over time.[12]

B.8 Water companies are licenced to operate in certain geographic areas. The water companies are also monopoly suppliers for the wholesale (and associated retail) provision of household water and wastewater services.

Economic regulation

B.9 Ofwat is responsible for the economic regulation of the water industry. Within this responsibility, Ofwat also has roles to protect consumers' interests, encourage competition and investment within the industry (these duties are discussed further in chapter 3 (Approach and prioritisation), at paragraphs 3.4 to 3.12). These roles

[8] For example, in Wales the Welsh Government sets the legislative and regulatory framework for the water companies. The Welsh Government also publishes statutory guidance which sets out the strategic priorities that it expects Ofwat to pursue in its regulation of the water industry in Wales. See Our regulators | Dŵr Cymru Welsh Water.
[9] Ofwat (2015) Structure of the water industry in England: does it remain fit for purpose? Annex A, paragraphs 5–7.
[10] Twelve small water and sewerage undertakers are also listed at Licences and licensees - Ofwat (accessed 9 September 2025).
[11] National Audit Office (2025) Regulating for investment and outcomes in the water sector report, p7, Key finding 9.
[12] National Audit Office (2015) The economic regulation of the water sector, p12, paragraphs 1.3 and 1.5.

are primarily carried out through Ofwat's administration and enforcement of the water companies' licence regimes.

B.10 Every five years – known as a price control period, or asset management period (**AMP**) – Ofwat performs a price review of the upcoming AMP. These reviews are intended to protect customers' interests by ensuring the investments and expenditure that companies are asking for are efficient, permit water companies to make enough money to generate a reasonable return for investors and adhere to various statutory obligations designed to protect customers and the environment. These price controls do not specify the individual prices or tariffs that companies charge for water services, which are usually set annually. There are separate regulatory processes that apply to companies concerning how tariffs are structured and ultimately set, as they may vary between different customers groups.

B.11 Ofwat's price control framework for wholesale price controls is based around the regulatory capital value (**RCV**). The RCV comprises the value of investment by a water company in its licensed activities that is recognised as such by Ofwat. The RCV also reflects the accumulated allowed expenditure to be recovered from future customers. This investment, or accumulated allowed expenditure, is returned over time to investors through RCV run-off (or the rate at which the costs are recovered) that makes up a component of allowed revenues. The RCV is calculated as the opening value of investment at the start of the year, plus inflation, plus capital investment in the year less RCV run-off (the way investments are recovered over time through customer bills). This is also shown in Figure B.1 below.

Figure B.1: RCV calculation

Source: CMA.

B.12 These cost recovery charges make up part of the allowed revenue that Ofwat determines in its price control. In setting the revenue that each company can recover in AMP8, Ofwat determined:

(a) its assessment of efficient expenditure;

(b) its assessment of this expenditure to be recovered within the period;

(c) its assessment of this expenditure to be added to the RCV and recovered in the future;

(d) what it considered to be a reasonable level of return on the RCV, based on the cost of capital; and

(e) a tax allowance.

B.13 The above steps make up Ofwat's general methodology for setting price controls.

B.14 Under this approach, Ofwat assessed what each company's expenditure requirements would be if it were an efficient company. These expenditure requirements then formed part of its calculations of the wholesale price control, while factoring in elements of cost recovery and a reasonable level of return.

B.15 Ofwat used comparative analysis of all the water companies to inform its assessment of the efficient expenditure requirements of each individual company (along with target performance and incentive rates); by looking at all the water companies and making allowances for differences between them, it sought to estimate what revenues an efficient company performing its functions would require, given the geographic area in which it operated. For example, it used econometric models to estimate an efficient benchmark based on costs and characteristics of different companies' actual operations. Ofwat has used actual data where available, and/or forecast data.[13]

B.16 However, there are limits in relying purely on comparative regulation. Differences between companies may mean that Ofwat is not able to fully determine and measure efficiencies between companies. This could be for a variety of reasons, including factors that contribute to efficiencies, limited number of comparators, and possible information asymmetries between Ofwat and the companies. There are various ways in which Ofwat sought to address some of these challenges, and which are discussed in our main report.

B.17 For PR24, Ofwat emphasised the need for companies to submit stretching business plans in terms of efficiency,[14] and introduced a quality and ambition assessment (**QAA**) to the initial business plans submitted by the companies during the PR24 process. Ofwat said that the goal of the QAA was to encourage companies to provide business plans that included ambitious levels of service at efficient costs and delivered more for customers and the environment for AMP8 and beyond. Where Ofwat thought the plan was insufficiently ambitious or complete, in its PR24 DD it applied penalties in the form of a reduction in returns

[13] When Ofwat issued its PR24 FD, certain actual company data for 2024-25 was not yet available, so Ofwat used forecast data. The actual 2024-25 data was published by companies in July 2025, following which Ofwat will – through its 'blind year reconciliation' process, which it performs at the end of each AMP – adjust companies' PR24 price controls to account for the difference between companies' actual 2024-25 performance and the forecast performance included in Ofwat's PR24 FD. This may result in Ofwat making adjustments to both the revenue allowances companies can recover from customers and the RCV for each company. See further Blind Year Reconciliation for 2024-25 - Ofwat (accessed 4 September 2025).

[14] Ofwat (2022) Our final methodology for PR24, p77 and Figure 11.2.

allowed. Where the companies subsequently improved their business plans, these penalties were removed.[15]

B.18 The level of detail at which company operations are examined, the number of overlapping regulatory requirements and the overall process of determining price controls have become increasingly complex over successive price control periods. This has been indicated in various recent sector reviews.[16]

Water and wastewater bills

B.19 A combined household water and wastewater bill is made up of:

(a) current costs;

(b) RCV run-off (similar to depreciation and related to expenditure recovered over time - the return on capital investment in assets);

(c) return on capital (financing debt and providing a return to shareholders); and

(d) a small remaining percentage relates to tax, the cost of retail activities and other less material items.

B.20 Household water and wastewater bills vary significantly between the different service areas. This is due to a variety of reasons including:

(a) the state of existing infrastructure;

(b) the availability of raw water and how it is abstracted, stored and transported;

(c) the scale of treatment required;

(d) population density; and

(e) the pace of investment programmes.

B.21 Ofwat sets price controls for the total revenue a water company can earn for each of the following.

(a) A water network, ie the infrastructure and services used to supply clean water to customers.[17]

[15] Ofwat (2024) PR24 draft determinations: Quality and ambition assessment summary, eg pp1, 5 and 7.
[16] See eg Independent Water Commission (2025) Final Report, pp8–9, Recommendations 12 and 15.
[17] This includes water mains (large pipes, usually laid under public land or highways and maintained by a water company); and communication pipes that connect water mains to private properties. Responsibility for pipes and pumping stations - Ofwat (accessed 4 September 2025).

(b) A wastewater network, ie the infrastructure and services used to convey wastewater and stormwater from properties to sewage treatment works.[18]

(c) Wastewater treatment works.

(d) Bioresources.[19]

(e) Retail, ie customer-facing services such as meter reading or call centres.[20]

[18] This includes sewer networks which transport wastewater to treatment facilities, and pumping stations to move wastewater through the network.
[19] This refers to the semi-solid by-product of wastewater treatment, also known as sewage sludge. Ofwat (2022) Creating tomorrow, together: our final methodology for PR24, p41, paragraph 3.7.1.
[20] Defra (2013) Water Bill: water glossary.

Appendix C: Estimating water sector productivity changes

C.1 Ofwat uses total factor productivity (**TFP**) estimates from the KLEMS database when setting the frontier shift. To aid our provisional decision, we estimated productivity changes in the water sector and compared these with the KLEMS TFP estimates.

C.2 The KLEMS TFP estimates are derived from national accounts using an approach known as 'growth accounting'. It is not possible to apply directly this methodology to the water sector since the UK national accounts do not report data at that level of disaggregation.[21] However, it is possible to use the econometric models of base costs (both under our approach and under Ofwat's) to derive estimates of productivity changes that are conceptually equivalent to the KLEMS TFP estimates, and consistent with the concept of the frontier shift in Ofwat's models.

C.3 The first section of this technical appendix outlines the theoretical basis for the proposed approach; the second discusses its implementation; and the third presents the results.

Methodology

C.4 The TFP benchmarks available in the KLEMS database are estimated using the following equation:[22]

$$a_{jt} = y_{jt} - v_{jt}^{L} l_{jt} - v_{jt}^{K} k_{jt} \tag{1}$$

where:

a_{jt} is the log of productivity for industry j in year t

y_{jt} is the log of output for industry j in year t

l_{jt} and k_{jt} are the logs of labour and capital used in industry j in year t

v_{jt}^{L} and v_{jt}^{K} are the expenditure shares of labour and capital in nominal output, which are defined as follows:

$$v_{jt}^{L} = \frac{W_{jt} L_{jt}}{P_{jt} Y_{jt}} \quad v_{jt}^{K} = \frac{R K_{jt}}{P_{jt} Y_{jt}} \tag{2}$$

where W_{jt} is the wage rate and R_{jt} is the cost of capital.

[21] Economic Insight reports results for 'Water supply; sewerage, waste management and remediation activities' because this is the closest industry classification to the regulated water sector within the EU KLEMs data set. Economic Insight (2024) The importance of a balanced approach to frontier shift, chapter 3.
[22] O'Mahony, M., & Timmer, M. P. (2009), 'Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database', *The Economic Journal*. The model used in KLEMS has more inputs, but for simplicity we limit the exposition to a simple model with labour and capital.

C.5 The expenditure shares satisfy $v_{jt}^{L} + v_{jt}^{K} = 1$.

C.6 The KLEMS model can be motivated by a Cobb-Douglas production function with constant returns to scale.[23]

$$Y_{jt} = A_{jt} L_{jt}^{\alpha} K_{jt}^{\beta} \quad s.t. \quad \alpha + \beta = 1 \tag{3}$$

C.7 If firms minimize costs and face competitive input markets, this Cobb-Douglas production function is equivalent to the following cost function:[24]

$$C_{jt} = \left(\frac{Y_{jt}}{A_{jt}}\right)^{\frac{1}{\alpha+\beta}} W_{jt}^{\frac{\alpha}{\alpha+\beta}} R_{jt}^{\frac{\beta}{\alpha+\beta}} \left[\left(\frac{\alpha}{\beta}\right)^{\frac{\beta}{\alpha+\beta}} + \left(\frac{\beta}{\alpha}\right)^{\frac{\alpha}{\alpha+\beta}}\right] \tag{4}$$

C.8 It follows that productivity in the water sector can be estimated as the (transformed) residuals in the following regression:

$$c_{jt} = \kappa + \delta y_{jt} + \boldsymbol{\gamma}'\boldsymbol{x_t} + \tilde{a}_{jt} \tag{5}$$

where:

c_{jt} is log expenditure

y_{jt} is a measure of log output (or a cost driver – see below)

$\mathbf{x_t}$ is a vector of relevant log input prices

$\kappa, \delta, \boldsymbol{\gamma}$ are parameters (or parameter vectors)

C.9 The residuals of this regression map onto the structural productivity parameters as follows:

$$\tilde{a}_{jt} = \frac{1}{\alpha + \beta}(a_{jt} - \bar{a}) \tag{6}$$

[23] To see this, note that the firm's profit-maximization problem (assuming competitive output and input markets) is:

$$\max_{L_{jt},K_{jt}} P_{jt} A_{jt} L_{jt}^{\alpha} K_{jt}^{1-\alpha} - W_{jt} L_{jt} - r_{jt} K_{jt}$$

The two first order conditions are:

$$\alpha P_{jt} A_{jt} L_{jt}^{\alpha-1} K_{jt}^{1-\alpha} - W_{jt} = 0$$

$$(1-\alpha) P_{jt} A_{jt} L_{jt}^{\alpha} K_{jt}^{-\alpha} - r_{jt} = 0$$

Substituting the expression for Y_{jt} in equation (3) above in both first order conditions, this simplifies to:

$$\alpha = \frac{W_{jt} L_{jt}}{P_{jt} Y_{jt}}$$

$$1 - \alpha = \frac{R_{jt} K_{jt}}{P_{jt} Y_{jt}}$$

Substituting these quantities in the production function in log form gives:

$$y_{jt} = \frac{W_{jt} L_{jt}}{P_{jt} Y_{jt}} l_{jt} + \frac{R_{jt} K_{jt}}{P_{jt} Y_{jt}} + a_{jt}$$

Which is the KLEMS model.

[24] Bounthavong, M (2019), 'Cobb-Douglas production function and costs minimization problem' for a detailed derivation. The assumption of constant returns to scale is not necessary to support this equivalence.

where $\bar{a}$ is the average productivity over the firms and years (this is subsumed into the constant).

C.10 Therefore, we can recover the change in productivity for each company in each year using the following correspondence:

$$\Delta a_{jt} = \frac{1}{\delta}(\tilde{a}_{jt} - \tilde{a}_{j,t-1}) \qquad (7)$$

where all the quantities on the right-hand side have been estimated.

C.11 These productivity improvements for water companies can be approximated using our base costs econometric models and the Ofwat models, and they can be meaningfully compared to the TFP estimates from the KLEMS database. Furthermore, productivity improvements can be seen as comparable to a frontier shift applied.

Estimating productivity changes using our econometric and Ofwat's cost models

C.12 Building on the theoretical framework described above, we estimate Equation (5) using our base cost econometric models and Ofwat's cost models.

C.13 For our models, we use the models described in chapter 4 (Base costs), at paragraphs 4.46 to 4.55.

C.14 For Ofwat's models we use the same dependent and independent variables and include random effects in the estimations, in line with Ofwat's approach. The only change we make to the models is the addition of the input price variables that Ofwat has identified as relevant for RPEs.[25] This is required to make the resulting estimates of productivity comparable conceptually to the TFP estimates derived by KLEMS (equation (1) at paragraph C.4 above). These are:

- Regional median hourly earnings for the manufacturing SIC code, based on ONS ASHE data: see chapter 4 (Base costs), paragraph 4.51(a);[26] and
- the energy price index: see chapter 4 (Base costs), paragraphs 4.51(b).

C.15 Under Ofwat's approach, each cost model comprises multiple sub-models, estimated using different regression specifications. For illustration, we focus on the wholesale water model, which includes a total of 24 regressions divided across three sub-models: *water resources plus* (6 regressions), *treated water distribution*

[25] Ofwat (2025) PR24 final determinations: Expenditure allowances, section 4.1. These are price indices rather than input prices, but this does not affect the coefficient on the output or the residuals.
[26] Southern SoC, supporting document 'SOC-2-0069_Southern_Water_Error_4-Regional_Wages-Within_model_adjustment.xlsx'.

(6 regressions), and *wholesale water* (12 regressions).[27] Ofwat aggregates results from these regressions using a two-step process. First, within each sub-model, the results from individual regressions are combined using regression-specific weights. Second, the weighted sub-model results are aggregated using a triangulation approach: the combined *water resources plus* and *treated water distribution* sub-models are assigned a total weight of 50%, and the *wholesale water* sub-model receives the remaining 50%.

C.16 Where models include aggregation, we apply the same aggregation process in our analysis of productivity changes. The process of aggregation across models of cost involves the aggregation of cost functions after a log transformation. In such cases the theoretical approach outlined above does not directly apply due to the fact there is not separability of the productivity term. As such for consistency in our analysis we use an approximation of (7) whereby we estimate the change in productivity as:

$$\Delta\alpha_{jt} \approx ln\left(\frac{\hat{Y}_{j,t}}{Y_{j,t}}\right) - ln\left(\frac{\hat{Y}_{j,t-1}}{Y_{j,t-1}}\right) \qquad (8)$$

Where $Y_{j,t}$ represents the observed historical costs for company j in period t and $\hat{Y}_{j,t}$ is the resulting predicted costs.

C.17 Note equation (8) does not include the scaling factor $\frac{1}{\delta}$ that appears in equation (7) as there is no way to combine coefficients across models that have been aggregated by an arithmetic average. In effect this assumes constant returns to scale.

Results

C.18 In this section, we present the productivity changes estimated using our models and Ofwat's models. For each activity (wholesale water and wastewater), we show the estimated productivity change for each company in each year, together with the mean and median across companies (in each year). Productivity changes reported in this analysis are expressed in approximate percentage terms, as they are calculated from changes in the residuals of a log-linear cost model. For example, a value of 0.02 indicates that productivity has increased by approximately 2% relative to the previous year.

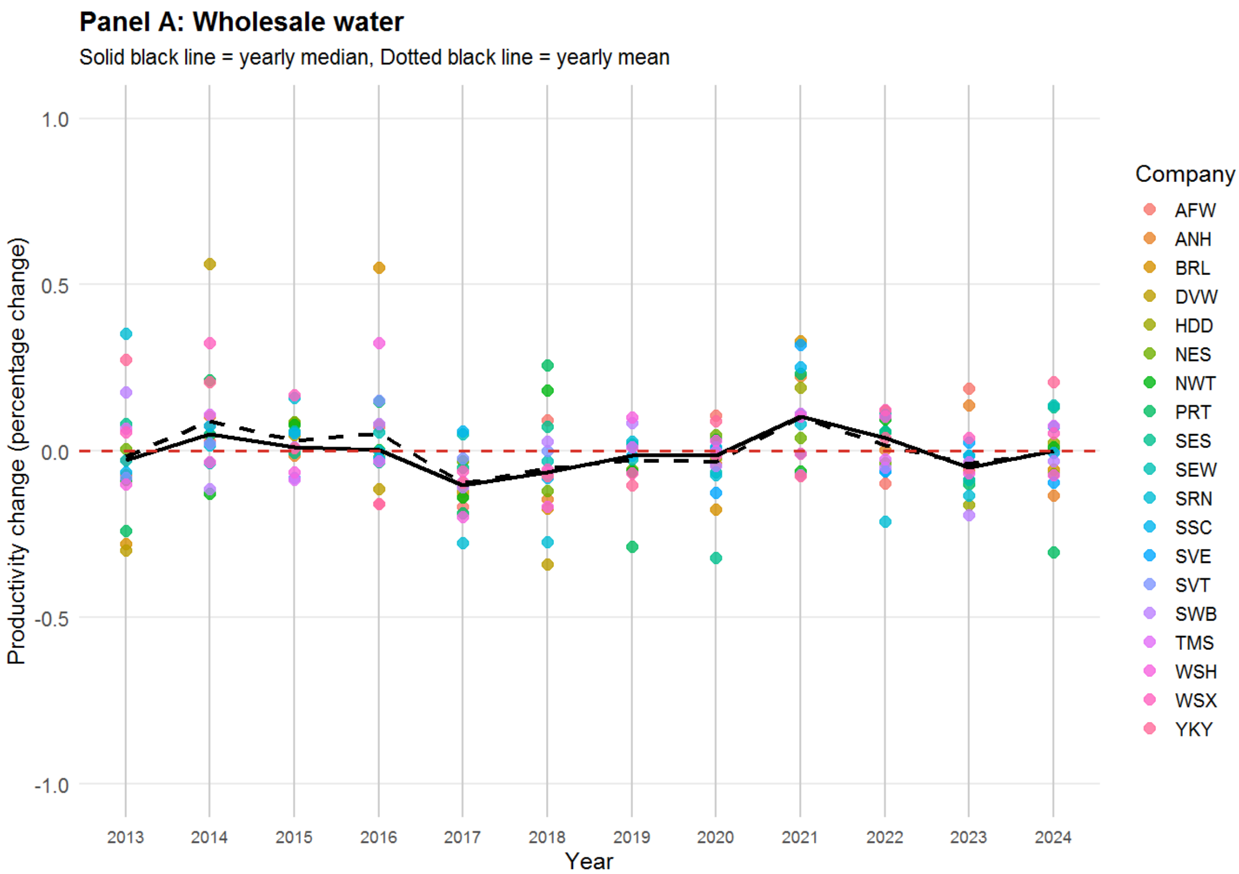
C.19 As explained above, these estimates of productivity changes are effectively transformed regression residuals, and therefore they incorporate the effect of unobserved cost drivers as well as genuine changes in productivity. For this reason, it is important to not over-interpret results for individual companies and

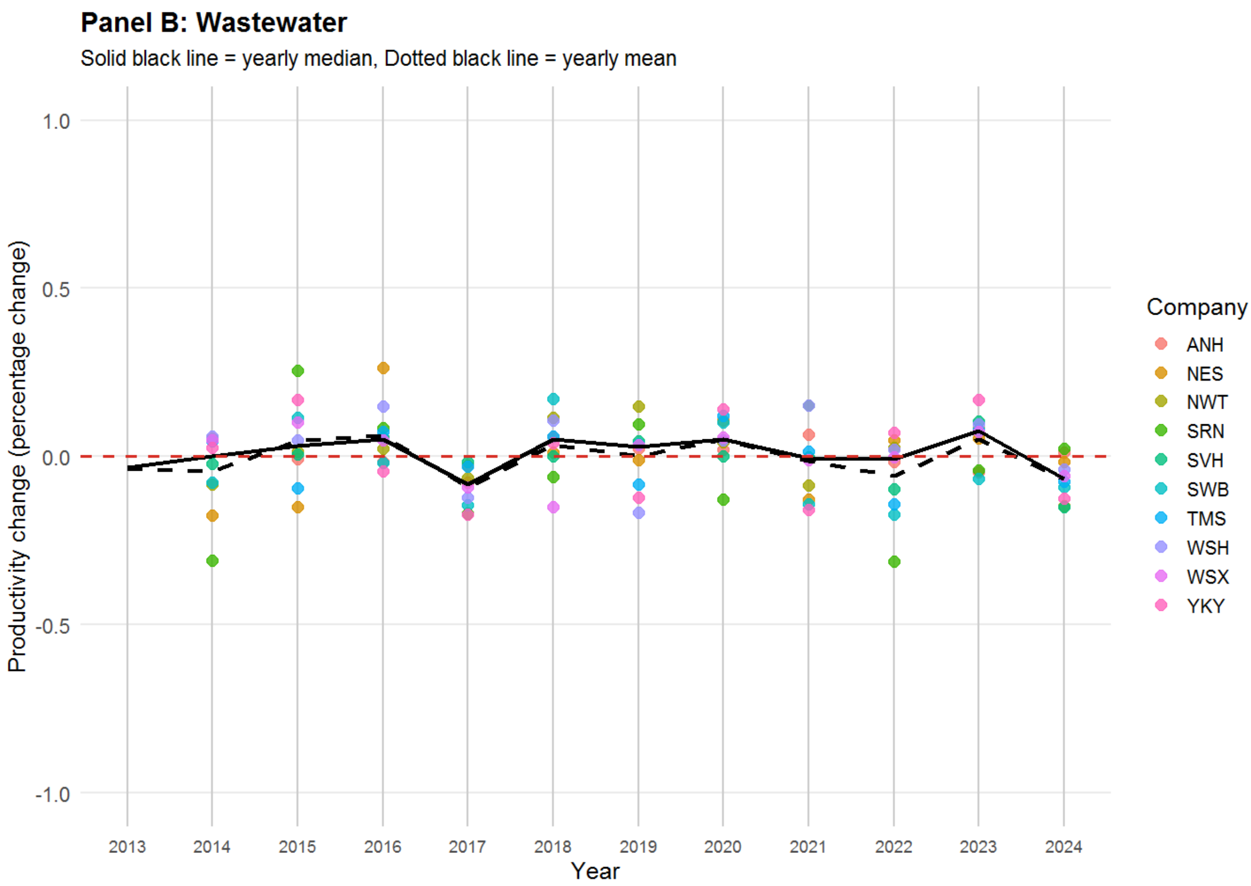
[27] Ofwat (2024) PR24 draft determinations: Expenditure allowances – Base cost modelling decision appendix sets out a detailed explanation of all Ofwat's cost models, including the exact model specifications and definitions of all variables used.

individual years, and focus on broad patterns instead. If the water industry as a whole had seen significant productivity increases over the past 12 years, we should see a large share of productivity increases for individual company and years in these charts.

C.20 Figure C.1 below shows estimated productivity changes for our models in wholesale water (Panel A) and wastewater (Panel B), and Figure C.2 below shows equivalent results under Ofwat's models. For presentational purposes, in the figures company dots are excluded if they lie below -1 or above 1. Overall, the charts show that average and median productivity changes vary from positive to negative over years and are generally not very large.

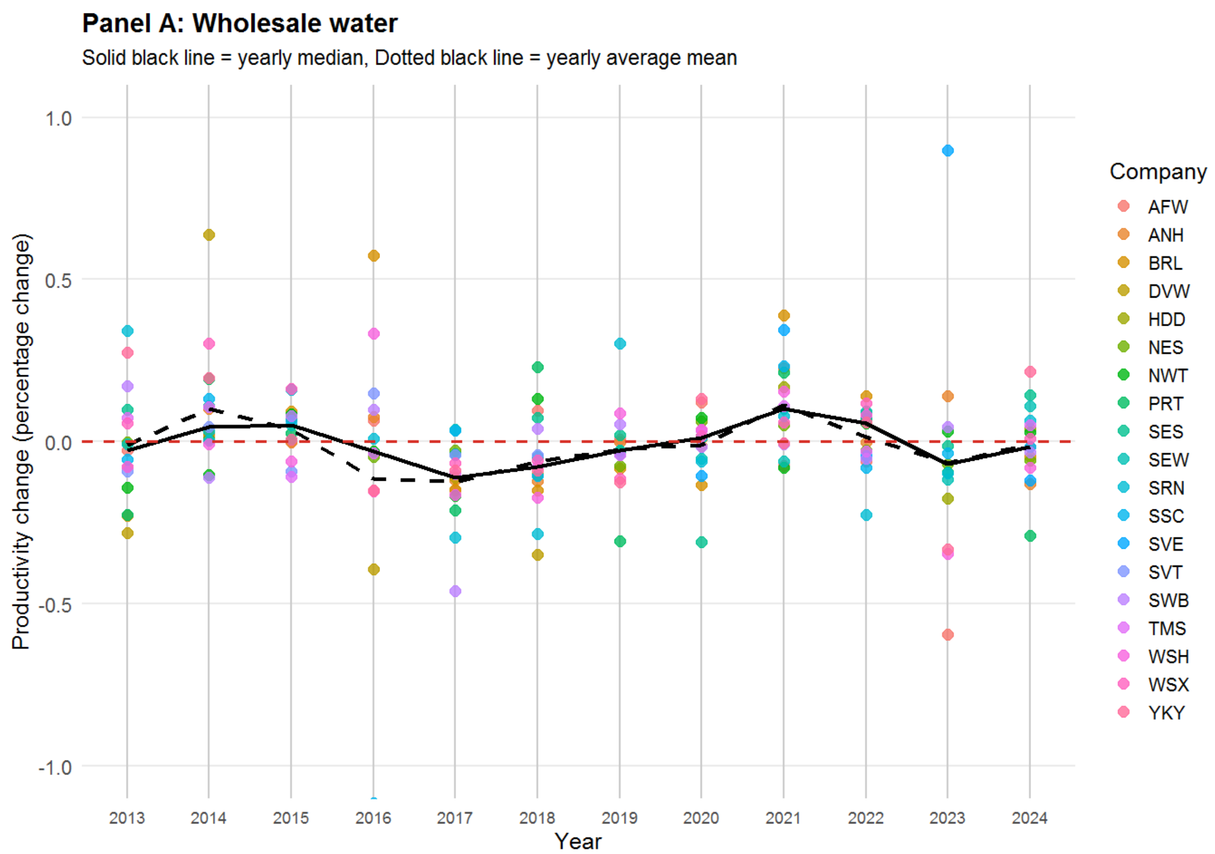
Figure C.1: CMA models - estimated productivity changes by UK water company and year

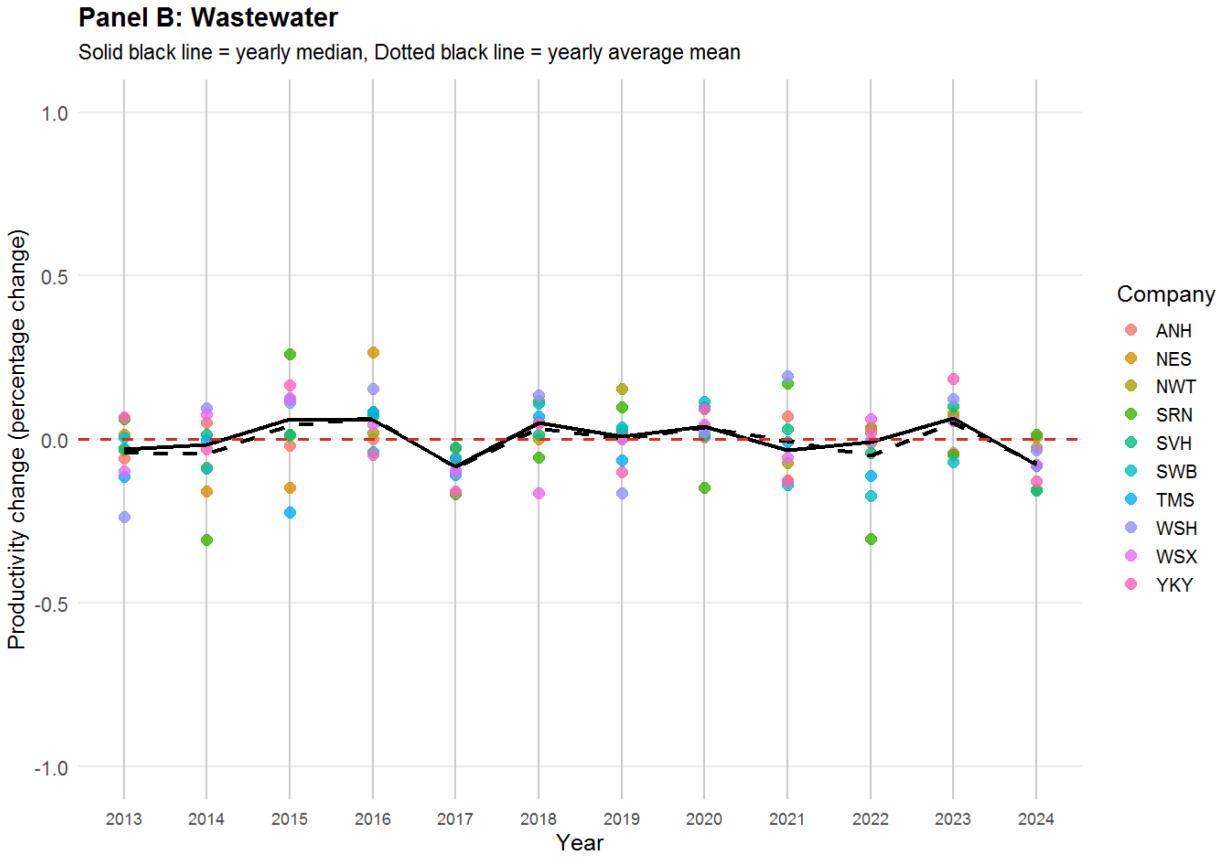




Source: CMA analysis of Ofwat (2025) [PR24 Final Determination models data](#).

Figure C.2: Ofwat models - estimated productivity changes by UK water company and year





Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data.

C.21 Table C.1 shows the mean and median productivity changes across all company-year observations under our and Ofwat's approaches. Overall, this analysis suggests that productivity changes in the water sector have not been significant.

Table C.1: Mean and median productivity change estimates over all companies and years in the CMA and Ofwat models

	CMA		*Ofwat*	
	Mean	Median	Mean	Median
Wholesale water	0.31%	-0.66%	-1.23%	-0.23%
Wastewater	-0.51%	0.92%	-0.53%	0.42%

Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data

Appendix D: Base cost modelling

D.1 This appendix provides additional technical details relating to the modelling (see chapter 4 (Base costs) paragraphs 4.4 to 4.73), covering:

(a) a discussion of the LASSO modelling methodology and selection of the penalty parameter; and

(b) additional results regarding efficiency scores, coefficients, and allowances.

The penalty parameter

D.2 LASSO is a regression technique that simultaneously estimates model coefficients and performs variable selection. It does this by applying a penalty to the size of the coefficients, which encourages the model to shrink some of them (in some cases to zero). In effect, this means that LASSO automatically excludes variables that do not contribute meaningfully to explaining variation in the outcome.

D.3 The equation below shows a mathematical description of the LASSO estimator, where β (beta) is the vector of coefficients, X is a matrix of cost drivers where each row corresponds to the cost drivers for a given company-financial year pair, Y is a vector of costs for each company-financial year pair, and λ (lambda) is the penalty level. p and N are the number of parameters and observations in the model, respectively. Finally, $\|\,.\,\|_p$ indicates the ℓ^p-norm. The difference from the standard ordinary least squares equation is the addition of the penalty term $\lambda\|\beta\|_1$ which applies a penalty to the sum of the absolute value of the coefficients.

$$\min_{\beta \in \mathbb{R}^p} \frac{1}{N} \|Y - X\beta\|_2^2 + \lambda\|\beta\|_1$$

D.4 The most common approach to determining the appropriate level of penalisation uses a technique called cross-validation.[28] This essentially measures the performance of the model across different candidate values of the penalty parameter, to identify the value likely to generate the most precise predictions. The data is divided into ten parts, or 'folds'.[29] The model is trained on nine of these folds and tested on the remaining one. This process is repeated ten times, each

[28] Unlike some modelling approaches that rely on a simple training-test split, we do not partition the data in this way. This is a deliberate choice driven by the limited size of the dataset available for wastewater and wholesale water modelling. A training-test split would reduce the effective sample size for model estimation and risk undermining the reliability of the results. Instead, we rely on cross-validation to assess model performance and generalisability. Cross-validation allows us to use all available data for both training and validation, rotating through different subsets to ensure that the model is not overly tailored to any particular portion of the data.

[29] The use of ten folds is widely accepted as a robust default in applied econometrics and machine learning. See for example Refaeilzadeh, P., Tang, L., Liu, H. (2009). Cross-Validation. In: LIU, L., ÖZSU, M.T. (eds) Encyclopedia of Database Systems. Springer, Boston, MA. It is also the default choice in the statistical software we use to estimate our model. See Friedman, J., Hastie, T., & Tibshirani, R. (2024). glmnet: Lasso and elastic-net regularized generalized linear models (Version 4.1-8) [R package documentation]. Comprehensive R Archive Network (CRAN). https://cran.r-project.org/web/packages/glmnet/refman/glmnet.html#cv.glmnet.

time using a different fold for testing. In each iteration, the model's performance is measured using the mean squared error (**MSE**) in the testing fold, which quantifies the average difference between the model's predictions and the actual observed values. The MSE is then averaged over the results of the ten iterations to obtain an average indicator of model performance for each candidate value of the penalty parameter. We use a dense grid of 1,000 candidate values of the penalty parameter, which ensures that the model is not sensitive to arbitrary choices in the regularisation path and allows for a more precise identification of the optimal lambda.

D.5 The folds used in the cross-validation procedure are selected at random, which implies that the results of the procedure are themselves random. We have followed the commonly accepted procedure to address this issue, which is to repeat the cross-validation procedure a large number of times and average the results over iterations.[30]

D.6 This procedure identifies two values of lambda that are of particular interest. The first, known as 'lambda.min', is the value that produces the lowest average prediction error. The second, known as 'lambda.1se', is the largest value of lambda that results in a prediction error within one standard error of the minimum (the error produced by the lambda.min). The standard error reflects the uncertainty in the estimate of the prediction error. The approach commonly recommended in the literature is to use the lambda.1se, as this mitigates the risk of overfitting, and we have followed this practice.[31] The concern that is addressed through this practice is that a model that fits the data in the estimation sample particularly well is unlikely to be the best model for the purpose of predicting outcomes on a different sample.

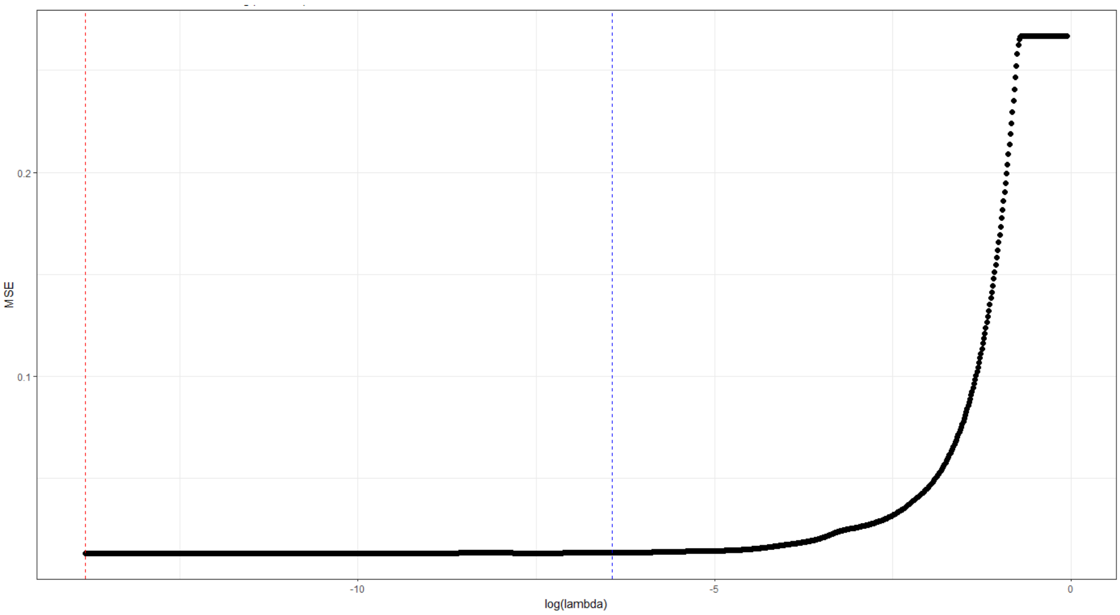
D.7 Figure D.1, Figure D.2 and Figure D.3 below plot the mean cross-validated error (measured by MSE) against the logarithm of lambda in the wastewater, treated water distribution and water resources plus models. At low values of lambda (towards the left of the plot), the model includes more variables, and the error is relatively low and stable. As lambda increases (moving right), the penalty becomes stronger, more coefficients are shrunk to zero, and the model becomes simpler. However, if lambda is set too high, important variables are excluded and the error rises sharply, indicating underfitting. Two vertical dotted lines are drawn on the figures to guide model selection. The dotted red line marks lambda.min, the value of lambda that minimises the cross-validated error. The dotted blue line marks lambda.1se, the largest value of lambda for which the cross-validated error

[30] This method is known as repeated cross validation. See Kim, J.-H. (2009). Estimating classification error rate: Repeated cross-validation, repeated hold-out and bootstrap. Computational Statistics & Data Analysis, 53(11), 3735–3745.

[31] Hastie, T., Tibshirani, R. and Friedman, J. (2009), The Elements of Statistical Learning, Springer Series in Statistics, Springer, New York.

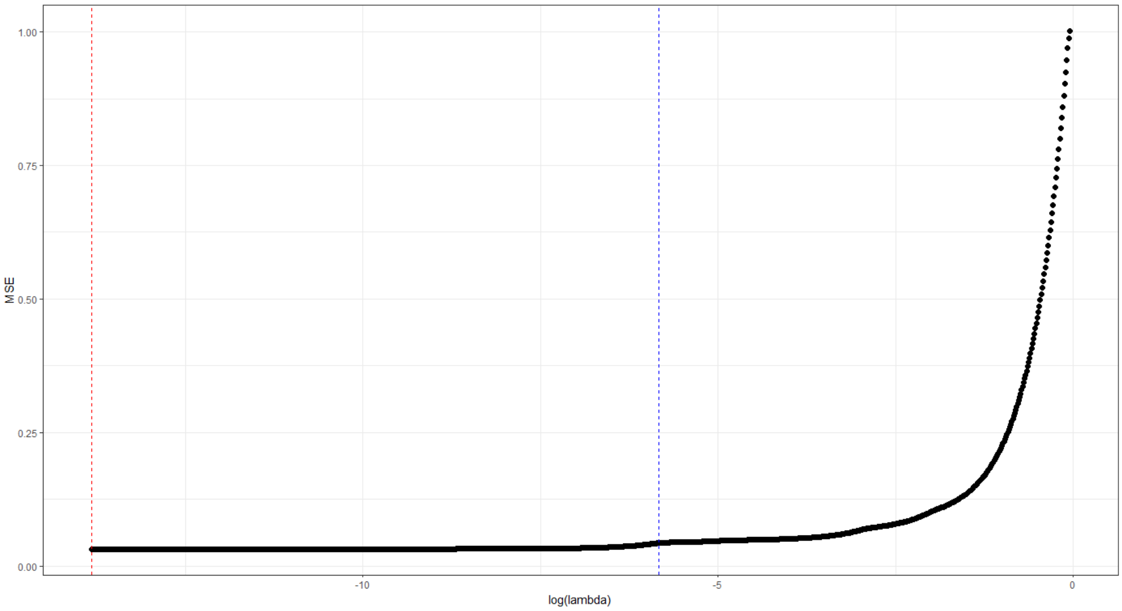
remains within one standard error of the minimum. As noted in paragraph D.6 above, we select lambda.1se.

Figure D.1: Mean cross-validation errors in the wastewater model



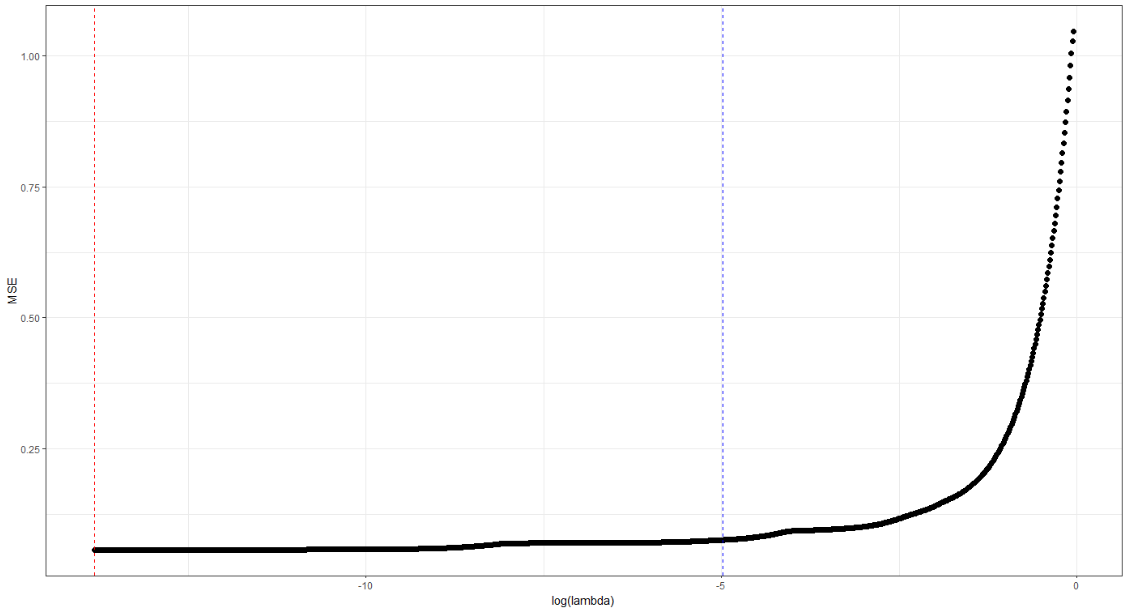
Source: CMA analysis of Ofwat (2025) [PR24 Final Determination models data]

Figure D.2: Mean cross-validation errors in the treated water distribution model



Source: CMA analysis of Ofwat (2025) [PR24 Final Determination models data]

Figure D.3: Mean cross-validation errors in the water resources plus model



Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data

D.8 Once the final lambda is selected, the model undergoes a post-LASSO procedure. This involves fitting a standard linear regression model estimated by ordinary least squares (**OLS**) using only the variables that were retained by LASSO. The benefit of this step is that it removes the bias introduced by the penalisation, while preserving the variable selection. In other words, it allows for unbiased estimation of the coefficients for the selected variables, improving the interpretability and reliability of the model.[32]

D.9 To evaluate the performance of the final model, the root mean squared error (**RMSE**) is calculated. RMSE is simply the square root of the mean squared error, and it has the advantage of being expressed in the same units as the original data. A lower RMSE indicates better predictive accuracy, and in this context, it provides a useful benchmark for assessing the quality of the approaches used to generate cost allowances. Overall, the use of RMSE makes it easier to compare the performance of our approach to Ofwat's PR24 FD approach. In contrast, other measures, such as R-square, can only be constructed for each component model and therefore cannot be used to compare predictions made from the triangulation approach used by Ofwat.

[32] Belloni, A., & Chernozhukov, V. (2013). Least squares after model selection in high-dimensional sparse models. Bernoulli, 19(2).

Additional results

Estimated efficiency scores

D.10 As part of our assessment of base cost allowances, we have examined the efficiency scores implied by our modelling approach relative to those used by Ofwat. These scores reflect the ratio of actual to predicted expenditure, and are used to determine the extent of catch-up efficiency applied to each company. A score above one indicates that a company is spending more than predicted and is therefore deemed inefficient, while a score below one suggests relative efficiency.

D.11 Table D.1 below compares the efficiency scores and upper quartile benchmarks used by Ofwat and those implied by our modelling.

Table D.1: Comparison of efficiency scores in wastewater and wholesale water models

	Wholesale Water				*Wastewater*			
	Ofwat		*CMA*		*Ofwat*		*CMA*	
Company	*Efficiency score*	*Upper quartile*	*Efficiency score*	*Upper quartile*	*Efficiency score*	*Upper quartile*	*Efficiency score*	*Upper quartile*
Affinity Water	0.97	0.99	1.01	0.94				
Anglian	0.97	0.99	0.95	0.94	1.04	0.99	0.99	0.96
Bristol Water	1.10	0.99	0.91	0.94				
Hafren Dyfrdwy	1.03	0.99	0.94	0.94	1.00	0.99	0.92	0.96
Northumbrian	1.11	0.99	1.08	0.94	1.05	0.99	1.00	0.96
United Utilities	1.01	0.99	1.01	0.94	1.01	0.99	0.97	0.96
Portsmouth Water	0.81	0.99	0.89	0.94				
SES Water	1.33	0.99	1.26	0.94				
South East	1.04	0.99	0.94	0.94				
Southern	1.56	0.99	1.39	0.94	1.21	0.99	1.13	0.96
South Staffs Water	0.76	0.99	0.87	0.94				
Severn Trent Water	1.04	0.99	1.03	0.94	1.00	0.99	0.92	0.96
South West Water	1.09	0.99	1.00	0.94	1.21	0.99	1.08	0.96
Thames Water	0.99	0.99	1.04	0.94	1.02	0.99	1.01	0.96
Dŵr Cymru	1.10	0.99	1.08	0.94	0.95	0.99	0.92	0.96
Wessex	1.30	0.99	1.03	0.94	0.94	0.99	0.96	0.96
Yorkshire Water	1.12	0.99	0.98	0.94	0.99	0.99	0.98	0.96

Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data

D.12 The correlation between Ofwat's efficiency scores and ours is 0.86 in wholesale water, and 0.91 in wastewater, meaning that our model yields a broadly similar outlook on the relative performance of companies. The majority of companies who are above the upper quartile in Ofwat's model are also above the upper quartile in our model. However, there are some differences for some individual companies.

D.13 The upper quartile benchmarks used in our modelling are lower than Ofwat's (0.944 and 0.960 compared to 0.987 and 0.994 in wholesale water and wastewater, respectively), implying a more stringent efficiency standard. This has implications for the catch-up challenge faced by companies: under our approach, more companies are required to improve efficiency, but the benchmark is derived from a model with stronger predictive performance, as evidenced by lower RMSE values (see chapter 4 (Base costs), paragraph 4.57.

Estimated coefficients

D.14 Table D.2 and Table D.3 below show the results for wholesale water. For wholesale water models, we developed separate specifications for treated water distribution (**TWD**) and for water resources plus (**WRP**). The length of mains and the number of booster stations per length are positively associated with cost. The average pumping head (**APH**) is also estimated to be an important driver of cost, consistent with its role in energy demand. Wage levels and energy use are also included as input cost controls and have the expected signs.

Table D.2: Coefficients in the treated water distribution model

	Estimate	*Standard Error*	*Significance*
(Intercept)	-0.29076	0.943416	
LAD from MSOA - Weighted average density (log)	-2.27995	0.232098	***
LAD from MSOA - Squared weighted average density (log)	0.157994	0.018392	***
MSOA - Squared weighted average density (log)	0.030612	0.008619	***
Properties per length - Squared weighted average density (log)	0.040286	0.019108	*
Length of mains (log)	0.864898	0.05412	***
Booster pumping stations per length of mains (log)	0.306473	0.06851	***
Average pumping head TWD (log)	0.33811	0.047622	***
Wages interacted with the length of mains	0.037398	0.02305	
Energy index interacted with the length of mains	0.016933	0.005838	**

Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data.
**** indicates significance at 0.1% level, ** at 1% level, * at 5% level, . at 10% level*
Estimate refers to the coefficient in the model, the standard error is a measure of precision of the estimate, significance refers to statistical significance, which highlights the likelihood that an estimate is different from zero; for example, a significance level of 5% would provide evidence that the estimate is different from zero.

Table D.3: Coefficients in the water resources plus model

	Estimate	*Standard Error*	*Significance*
(Intercept)	-15.5371	4.683425	**
Connected properties (log)	0.897081	0.042861	***
Water treated at complexity levels 3 to 6 (%)	0.008842	0.001478	***
LAD from MSOA - Weighted average density (log)	-0.50015	0.08126	***
MSOA - Squared weighted average density (log)	0.087825	0.011063	***
Properties per length - Weighted average density (log)	3.308733	2.23475	
Properties per length - Squared weighted average density (log)	-0.56294	0.271194	*
Average volume per WTW (log)	-0.08277	0.050339	
Energy index interacted with the length of mains (log *log)	0.012557	0.007604	

Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data.
**** indicates significance at 0.1% level, ** at 1% level, * at 5% level, . at 10% level*
Estimate refers to the coefficient in the model, the standard error is a measure of precision of the estimate, significance refers to statistical significance, which highlights the likelihood that an estimate is different from zero; for example, a significance level of 5% would provide evidence that the estimate is different from zero.

D.15 The WRP model highlights the importance of the number of properties served and the proportion of water treated to higher standards. These variables are strongly associated with cost, suggesting that both scale and quality requirements influence expenditure. Spatial population metrics again appear, with similar patterns to those in the TWD model. Network length and its squared term are included to capture potential economies or diseconomies of scale (in a potentially non-linear way). The average volume per WTW and energy use is also included, with signs of the expected direction.

D.16 Table D.4 below shows the results for our top-down model of wastewater. In the wastewater model, the strongest predictor is the logarithm of load, which refers to the volume of wastewater treated. Its coefficient is positive and highly significant, indicating that costs increase with greater treatment volumes, as expected. Variables such as pumping capacity per unit of network length and the proportion of ammonia concentrations below regulatory thresholds reflect technical and environmental dimensions of service provision.

D.17 The model also includes measures of population density. Two of these weighted average density variables have a positive coefficient, while another is negative, consistent with the view that the impact of density on costs is unclear. Rainfall intensity in urban areas, scaled by network length, emerges as another significant factor, likely capturing the impact of stormwater management on operational costs. Finally, energy consumption per unit of service is positively associated with costs, reinforcing the role of energy as a key input in wastewater operations.

D.18 Overall, all included variables are of the sign we would expect, suggesting the model has a strong economic and engineering rationale.

Table D.4: Coefficients in the wastewater model

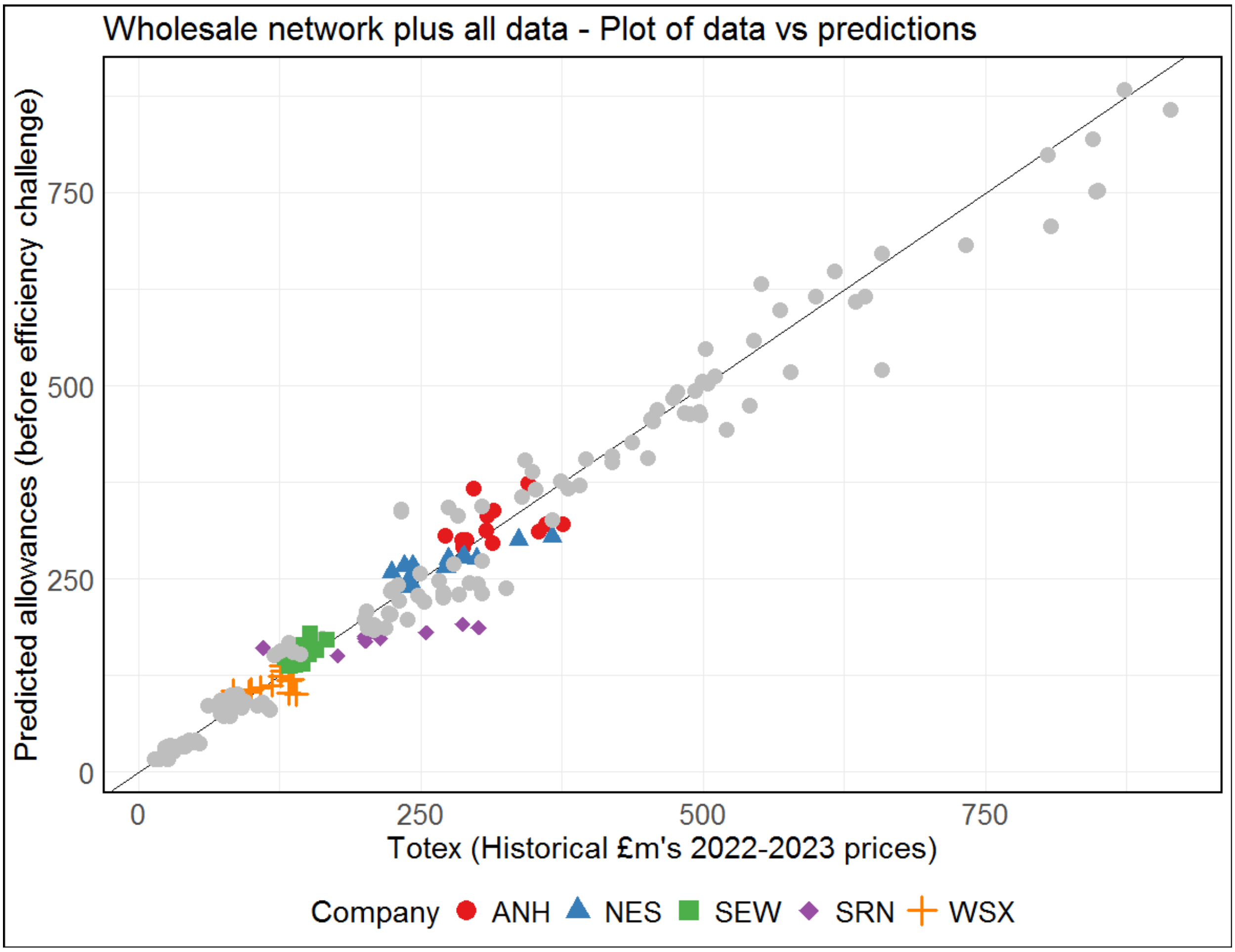
	Estimate	*Standard Error*	*Significance*
(Intercept)	-3.89374	1.214897	**
Load (log)	0.675462	0.041488	***
Properties per sewer length - weighted average density (log)	0.598887	0.289174	*
Pumping capacity per sewer length (log)	0.114878	0.114484	
Load treated with ammonia consent ≤ 3mg/l	0.003696	0.001345	**
LAD from MSOA - weighted average density (log)	0.192871	0.085529	*
MSOA - weighted average density (log)	-0.28086	0.15	.
Weighted average treatment size (log)	-0.12243	0.040352	**
Load treated in size bands 1 to 3 (%)	0.011417	0.00921	
Urban rainfall per sewer length (log)	0.088456	0.030213	**
Energy index interacted with pumping capacity (log * log)	0.015644	0.003602	***

Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data
**** indicates significance at 0.1% level, ** at 1% level, * at 5% level, . at 10% level*
Estimate refers to the coefficient in the model, the standard error is a measure of precision of the estimate, significance refers to statistical significance, which highlights the likelihood that an estimate is different from zero; for example, a significance level of 5% would provide evidence that the estimate is different from zero.

D.19 To assess the performance of the CMA's modelling approach, Figure D.4 and Figure D.5 below compare predicted allowances to actual historical expenditure for wholesale water and wastewater. The figures present scatter plots for each business area, with each point representing a company-year observation. The x-axis shows actual historical expenditure (£m's Totex, in 2022/23 prices), while the y-axis shows the corresponding predicted allowance before the application of the efficiency challenge.

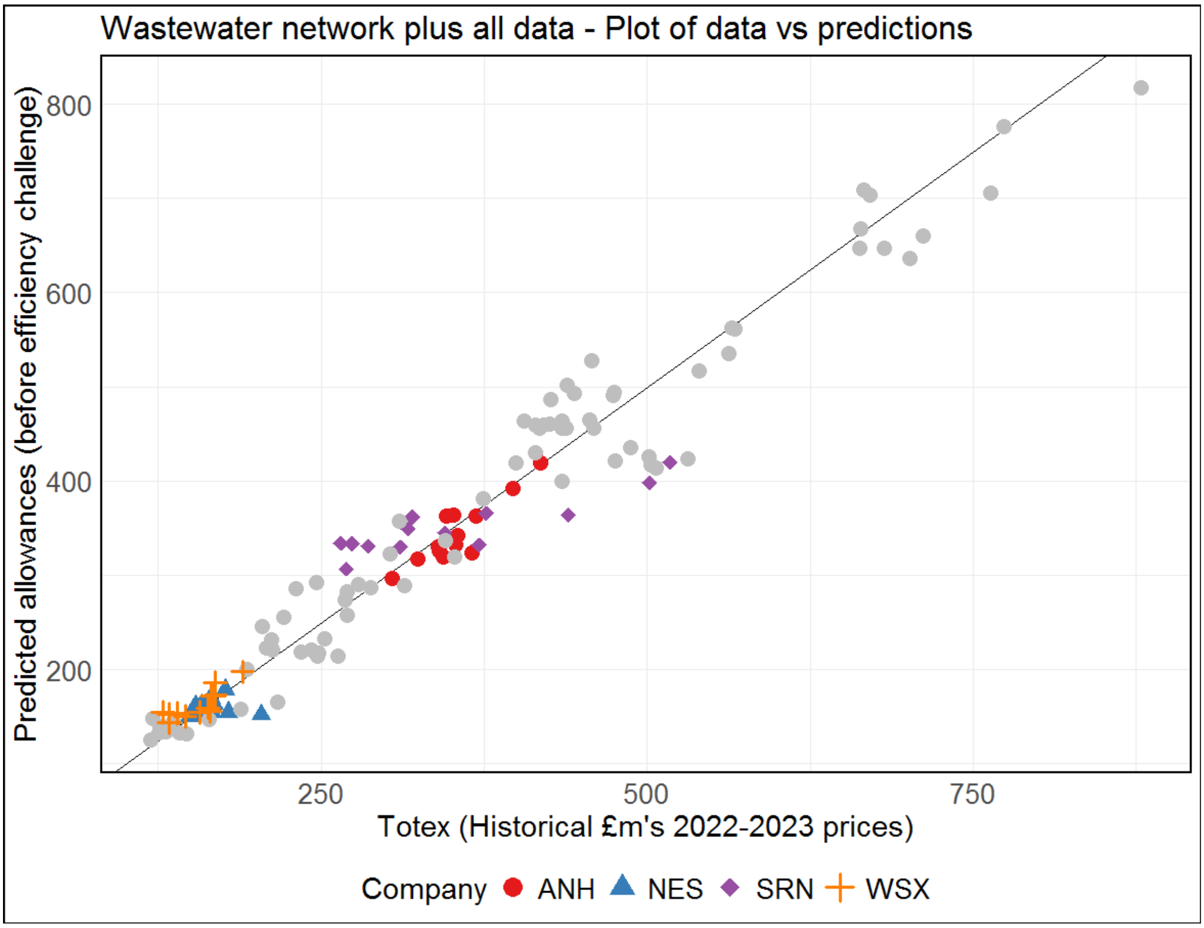
D.20 Each Disputing Company is represented by a distinct marker and colour: red circles for Anglian (ANH), blue triangles for Northumbrian (NES), green squares for South East (SEW), purple diamonds for Southern (SRN), and orange crosses for Wessex (WSX). Grey represents non-disputing companies.

Figure D.4: Comparison of predicted allowances under the CMA's approach to historical spend in wholesale water



Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data

Figure D.5: Comparison of predicted allowances under the CMA's approach to historical spend in wastewater



Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data

D.21 Points lying close to this line indicate that the model's predictions are well calibrated for those observations, while points above or below the line suggest over- or under-prediction, respectively.

D.22 The wholesale water plot shows that, for most companies and years, predicted allowances are closely aligned with historical expenditure, with only modest deviations from the diagonal. This suggests that the model captures the main cost drivers and provides a reasonable basis for setting allowances. The wastewater plot displays a similar pattern, with the majority of points clustered near the line of perfect fit, though some variation remains, reflecting a mix of company-specific inefficiency and the inherent uncertainty in cost modelling.

Allowances

D.23 Table D.5 below shows the resulting allowances for wholesale water and wastewater services under our provisional approach. The table includes a comparison to Ofwat's Final Determinations, which include RPEs and, where applicable, allowances made for Water Treatment Works (**WTW**s) Cost Adjustment Claims (**CAC**s). Our figures incorporate the upper-quartile (**UQ**) efficiency challenge approach discussed in chapter 4 (Base costs), paragraphs 4.63 to 4.72. All figures are in 2022/23 prices.

Table D.5: Provisional allowances under our approach (£ m, 2022/23 prices)

	Wholesale water			*Wastewater*			*Total*
Company	*Ofwat PR24 FD including RPEs and WTWs CACs*	*CMA provisional allowance*	*Percentage change*	*Ofwat PR24 FD including RPEs*	*CMA provisional allowance*	*Percentage change*	*Percentage change*
Affinity Water	1,289	1,138	-11.8%				-11.8%
Anglian	**1,816**	**1,722**	**-5.2%**	**1,945**	**1,933**	**-0.6%**	**-2.8%**
Bristol Water	411	463	12.4%				12.4%
Hafren Dyfrdwy	134	138	2.6%	26	27	0.3%	2.2%
Northumbrian	**1,467**	**1,403**	**-4.3%**	**856**	**828**	**-3.3%**	**-4.0%**
United Utilities	2,558	2,410	-5.8%	2,452	2,384	-2.8%	-4.3%
Portsmouth Water	197	163	-17.0%				-17.0%
SES Water	200	193	-3.8%				-3.8%
South East	**844**	**867**	**2.7%**				**2.7%**
Southern	**867**	**888**	**2.4%**	**1,896**	**1,926**	**1.6%**	**1.8%**
South Staffs Water	569	451	-20.8%				-20.8%
Severn Trent Water	2,993	2,823	-5.7%	2,523	2,531	0.3%	-2.9%
South West Water	867	866	-0.2%	726	766	5.6%	2.4%
Thames Water	4,864	4,328	-11.0%	3,963	3,751	-5.4%	-8.5%
Dŵr Cymru	1,317	1,260	-4.3%	1,218	1,160	-4.8%	-4.5%
Wessex	**528**	**634**	**19.9%**	**961**	**886**	**-7.9%**	**2.0%**
Yorkshire Water	1,755	1,871	6.6%	1,834	1,721	-6.2%	0.1%
Total	22,678	21,616	-4.7%	18,401	15,126	-2.7%	-3.8%
Disputing Companies	**5,523**	**5,515**	**-0.1%**	**5,658**	**5,572**	**-1.5%**	**-0.8%**

Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data

D.24 For wholesale water, the overall hypothetical sector allowance would be reduced compared to Ofwat's PR24 FD, with our total figure allowance of £21.6 billion being 4.7% below Ofwat's. For wastewater, the total allowance is £15.1 billion, representing a 2.7% reduction from Ofwat's figure. These reductions are in part due to the higher upper-quartile efficiency challenge.

Appendix E: Enhancement Expenditure – Econometric Benchmark Modelling

E.1 In this Appendix we describe the CMA's assessment of the phosphorus (Part A below) and supply interconnectors econometric modelling (Part B below).

Part A: Phosphorus

E.2 Part A of this appendix provides a technical overview of the specification of our p-removal cost model. As noted in chapter 5 (Enhancement costs), we use a Gaussian Mixture Regression model (**GMR**) to model p-removal enhancement scheme costs.

A.1: CMA model overview

E.3 Our GMR can be expressed mathematically as follows.

$$\ln L(\beta, \sigma, \lambda) = \frac{1}{N} \sum_{n=1}^{N} \ln \sum_{g=1}^{G} \lambda_g N(y_n \mid x_n' \beta_g, \sigma_g^2)$$

where:

(a) $L(\beta, \sigma, \lambda)$ is the likelihood function.

(b) y_n is a transformation of scheme n's totex and x_n is the vector of transformed cost drivers for schemes included in the model. There are N schemes in total.

(c) There are G Gaussian components - or groups - in the model.

(i) Each group, g, has its own set of parameters, β_g , that measure the effect that the cost drivers have on totex.

(ii) Group g's cost model errors are assumed to follow a Normal distribution whose mean is zero and standard deviation is σ_g.

(d) λ_g is the mixing coefficient for the g-th group that estimates the proportion of schemes in the sample that belong to group g, where $\sum_{g=1}^{G} \lambda_g = 1$.

(e) $N(y_g \mid x_n' \beta_g, \sigma_g^2)$ is the probability density function of the Gaussian distribution for the g-th component, defined as:

$$N(y_n \mid x_n' \beta_g, \sigma_g^2) = \frac{1}{\sqrt{(2\pi)}\sigma_g} \exp\left(-\frac{\left(y_n - x_n' \beta_g\right)^2}{2\sigma_g^2}\right)$$

E.4 We transformation scheme totex using the inverse hyperbolic sine transformation ($asinh$) used to better visualise model output in the figures in chapter 5 (Enhancement costs). As noted above, the same transformation is applied to continuous cost drivers. These include:

(a) the size of the population served by the scheme;

(b) the 'enhanced consent' level (ie the phosphorus reduction target measured in mg/l);

(c) the change in permit consent-level associated with the scheme;

(d) variables measuring heterogeneity in local population density; and

(e) average hourly median construction wages in the area operated by each firm.

E.5 In addition, the expected increase in future costs affecting all firms' totex forecasts over the next price control enters as a dummy variable.

A.2: Estimation

E.6 As noted in chapter 5 (Enhancement costs), our model is estimated on the combined historical and forecast data (ie pooled data). Prior to estimation we exclude some, but not all, schemes Ofwat identifies as statistical outliers. The excluded schemes are the statistical outliers that are awarded non-zero cost recovery ratios through deep dives by Ofwat.[33] These correspond to the top 1.5% most expensive schemes and tend to be considerably larger than other schemes.

E.7 To estimate the model's parameters, we maximise the log-likelihood described above using an EM algorithm. To implement the EM algorithm, we use the 'mixtools' package in R. The standard errors are computed using a bootstrap. Specifically, they are calculated using the standard deviation of the sample of parameter values resulting from 1,000 bootstrap iterations.

A.3: Model Specification

E.8 In arriving at our preferred model, we considered 4 different specifications of the model. Each specification included a different set of cost drivers, as follows.

(a) **Model A** includes population served, the change in the permit level, and the new permit level. We also include a dummy variable that takes the value 1 if it is a new scheme (ie from forecast data) and is 0 otherwise.

[33] In line with Ofwat's approach to setting outlier scheme's allowances, these schemes are awarded a positive fraction of the unexplained portion of cost in the model when the modelled totex is less than the requested totex.

(b) **Model B** is the same as model A but includes a variable controlling for the population density typically served by each company.[34]

(c) **Model C** is the same as model A but includes a variable measuring the average hourly median construction wages in the area operated by each company in each price control period.[35]

(d) **Model D** is the same as model A but includes both the average wage and population density variables from models B and C.

A.4: Model Selection

E.9 For each model, we estimate the GMR model assuming that there are 2, 3 or 4 mixture components (groups). We use the Bayesian Information Criterion (**BIC**) to choose the number of groups. The BIC trades off the fit of the model with a penalty that is increasing in the number of parameters in the model. For a given cost model specification, the number of groups chosen is the one that results in the lowest value of the BIC.

E.10 Table E.1 below shows the BIC scores for each of the models assuming that there are 2, 3 or 4 groups. For each model, the lowest BIC score is achieved with 3 groups. Across the groups, model D always has the lowest BIC score. These suggests that the inclusion of regional construction wages and a measure of local population density both lead to significantly improved model fit. As such, model D with 3 groups is our preferred model.

Table E.1: BIC scores for models A, B, C and D

Number of Groups	Model A	Model B	Model C	Model D
G=2	2,541.8	2,398.7	2,545.8	2,351.8
G=3	2,498.7	2,333.1	2,499.3	2,269.1
G=4	2,563.4	2,432.1	2,581.0	2,390.3

Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data

[34] This variable is added by Thames Investor Group advisers Compass Lexecon in its analysis of Ofwat's p-removal models. It motivates its inclusion by noting its importance for base models and stating that the cost of building additional capacity at a sewage treatment works can depend on how rural or urban the site is. Compass Lexecon uses the MSOA-weighted average density for each company averaged over AMP7 for historical schemes and averaged over AMP8 for forecast schemes. It also demonstrates that when added to Ofwat's models there is a considerable increase in the R-squared values – especially for AMP8 schemes. See Thames Water Investor Group (2025) Third party submission on the Water PR24 References, Annex 4: Compass Lexecon (2025) Third-party submission on behalf of Investor Group, p50, paragraphs 4.41-4.43.

[35] As a risk protection measure, Ofwat has put in place an RPE and an ex-post 'true-up' using construction labour costs for enhancement expenditure. In line with this approach and noting that construction wages are likely to vary geographically and affect build costs, we consider that there is a clear economic and engineering rationale to include regional construction labour costs in its modelling. Wage data is constructed from median construction ONS ASHE wage data for differing regions in England. See chapter 4 (Base costs), paragraph 4.51.

A.5: Model Results

E.11 Table E.2 below shows the estimated parameters of the four models with 3 groups. It shows that the coefficients on the transformed cost drivers and the forecast scheme dummy included in model A (and Ofwat's models) have the expected sign and are relatively stable within groups across models. However, the magnitude of their coefficients differs across groups. This suggests that the model is grouping together different types of schemes with different relationships between cost and cost drivers.

(a) **Group 1**: Compared to the other groups, the larger the gap between the existing and new permit levels, the higher the costs for schemes in group 1. Their costs also increase when the new permit level is tighter, though to a lesser extent than schemes in group 2. Unlike schemes in the other two groups, the size of the population does not appear to be a particularly prominent cost driver. Finally, the coefficient on the forecast indicator shows that otherwise similar schemes are expected to be moderately more expensive in AMP8.

(b) **Group 2**: The introduction of new tighter permits also appears lead to appreciably higher costs for schemes in group 2 – more so than for schemes in other groups. Schemes costs are also higher when the change in consent level increases and when serving larger populations – though to lesser extent that schemes in groups 1 and 3, respectively. Finally, it appears that schemes in this group might be especially sensitive to expected supply chain cost pressures.

(c) **Group 3**: The size of the population served appears to be key cost driver for group 3 schemes. Moreover, the effect of introducing new tighter permits also appears lead to higher scheme costs – though to a lesser degree than schemes in groups 1 and 2. However, unlike the other two groups, the change in consent level is generally statistically insignificant (at the 10% level) and does not appear to be a key cost driver for schemes in group 3. Finally, the cost associated with forecast schemes are typically higher – though only once wage and population density are controlled for.

E.12 As noted above, models B, C and D differ from model A due to the inclusion of one or both of local population density and regional construction wages. Once included in model B, the coefficient of the population density is, as expected, positive, statistically significant at the 1% level and is stable across groups. The coefficient of regional construction wages introduced in model C is, as expected, and positive – but only statistically significant at the 1% level in group 2 and at the 10% level in group 3.

E.13 However, when both population and regional construction wages are controlled for in model D, the coefficient on wages becomes negative and large – particularly for groups 2 and 3. At the same time, the intercept in these two groups is larger than in the other models. Noting that the measures of construction wages and population density that enter the model are strongly positively correlated (their correlation is 0.72), one possible explanation for the counter intuitive sign on wages and the increase in the intercept is multicollinearity.

E.14 To explore whether multicollinearity is a likely explanation for the changes in the intercept, wage, and population density coefficients in model D we extract the principal components of the wage and population density data. By construction, the principal components of two variables, PC1 and PC2, capture their covariance by identifying the directions in which the data varies the most. These principal components are also uncorrelated with each other and do not, therefore, suffer from multicollinearity.

E.15 If, however, they capture a sufficiently large portion of the variance of the combination of the transformed wage and density variables, then their inclusion in model E in place of the original variables allows us to explore the effect of multicollinearity on the estimated parameters in model D.

Table E.2: Model results with 3 groups: Models A, B, C, D and E

Dep var: asinh(totex)	Group 1					Group 2					Group 3				
Variables	Model A	Model B	Model C	Model D	Model E	Model A	Model B	Model C	Model D	Model E	Model A	Model B	Model C	Model D	Model E
Intercept	0.315*	-0.706**	-2.982	1.721	0.190	1.181***	0.347**	-3.949**	4.271**	1.551***	1.825***	1.102***	-1.378	23.274***	1.919***
	(0.184)	(0.296)	(2.574)	(3.462)	(0.201)	(0.122)	(0.152)	(1.585)	(1.882)	(0.107)	(0.130)	(0.204)	(1.818)	(1.938)	(0.112)
asinh(PE served)	-0.073**	-0.072**	-0.069**	-0.043	-0.043	0.183***	0.171***	0.196***	0.144***	0.144***	0.305***	0.297***	0.303***	0.273***	0.273***
	(0.031)	(0.031)	(0.031)	(0.033)	(0.033)	(0.019)	(0.016)	(0.019)	(0.017)	(0.017)	(0.020)	(0.021)	(0.020)	(0.017)	(0.017)
asinh(Consent Change)	0.677***	0.739***	0.702***	0.681***	0.681***	0.251***	0.187***	0.245***	0.163***	0.163***	0.059	0.000	0.046	0.008	0.008
	(0.060)	(0.065)	(0.062)	(0.065)	(0.065)	(0.042)	(0.038)	(0.043)	(0.037)	(0.037)	(0.043)	(0.046)	(0.045)	(0.037)	(0.037)
asinh(Enhanced Consent)	-0.682***	-0.633**	-0.666***	-0.614**	-0.614**	-0.973***	-0.938***	-0.896***	-1.014***	-1.014***	-0.457***	-0.287***	-0.400***	-0.449***	-0.449***
	(0.190)	(0.209)	(0.195)	(0.208)	(0.208)	(0.098)	(0.085)	(0.095)	(0.089)	(0.089)	(0.098)	(0.100)	(0.096)	(0.085)	(0.085)
1[New Scheme in forecast data]	0.269***	0.267***	0.226***	0.347***	0.347***	0.578***	0.536***	0.536***	0.488***	0.488***	0.142**	-0.007	0.067	0.292***	0.292***
	(0.086)	(0.090)	(0.092)	(0.096)	(0.096)	(0.058)	(0.051)	(0.061)	(0.051)	(0.051)	(0.060)	(0.063)	(0.065)	(0.051)	(0.051)
asinh(MSOA Density)		0.556***		0.523***			0.591***		0.787***			0.470***		1.253***	
		(0.129)		(0.178)			(0.067)		(0.093)			(0.096)		(0.108)	
asinh(Hourly Construction Wage)			0.923	-0.685				1.438***	-1.149**				0.916*	-6.654***	
			(0.719)	(1.028)				(0.444)	(0.554)				(0.507)	(0.570)	
asinh of density and wage: PC1					-0.120***					-0.175***					-0.030
					(0.043)					(0.025)					(0.031)
asinh of density and wage: PC2					0.191*					0.294***					0.716***
					(0.097)					(0.050)					(0.054)
λ_g: group g share	0.155***	0.158***	0.157***	0.154***	0.154***	0.467***	0.511***	0.476***	0.508***	0.508***	0.378***	0.332***	0.367***	0.338***	0.338***
	(0.020)	(0.018)	(0.019)	(0.020)	(0.020)	(0.047)	(0.042)	(0.046)	(0.036)	(0.036)	(0.045)	(0.040)	(0.044)	(0.033)	(0.033)
σ_g : group g sd.	0.357***	0.364***	0.360***	0.382***	0.382***	0.384***	0.374***	0.380***	0.374***	0.374***	0.403***	0.374***	0.397***	0.314***	0.314***
	(0.035)	(0.034)	(0.035)	(0.038)	(0.038)	(0.027)	(0.021)	(0.025)	(0.020)	(0.020)	(0.027)	(0.027)	(0.028)	(0.020)	(0.020)
Number of Observations	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378	1,378

*** indicates significance at 1% level, ** at 5% level, * at 10% level

Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data

E.16 Before analysing any changes is estimated model parameters, we explore whether PC1 and PC2 provide an equally good fit to the data. Given that both models D and E have the same number of parameters, we can directly assess this by comparing their BIC scores.

E.17 The BIC score for Model E with 3 groups is 2,269.1 – approximately the same as model D. As a result, we find that the principal components capture a large fraction of the covariance of the two original variables. As a result, we consider that that the results of model E provide us with insights into the effect that multicollinearity has on parameters in model D.

E.18 Even though the signs and magnitudes of coefficients on the principal components are difficult to interpret, we can assess the effect they have on scheme totex by comparing them across groups. Compared to model D, the results for model E in Table E.2 above shows that replacing the original variables with their principal components:

(a) Leads to much more stable coefficients on PC1 and PC2 across models. For example, both principal components are statistically significant at (at least) the 10% level in groups 1 and 2 and have similar coefficient values - though the coefficients are slightly closer to zero for group 1 schemes.

(b) Only PC2 is statistically significant at the 1% level in group 3, but both wage and population density are in group 3 of model D. This suggests that the high statistical significance of both original variables in model D was largely driven by a shared correlation between them. As a result, the coefficients become considerably larger in opposing directions and the intercept term adjusts accordingly.

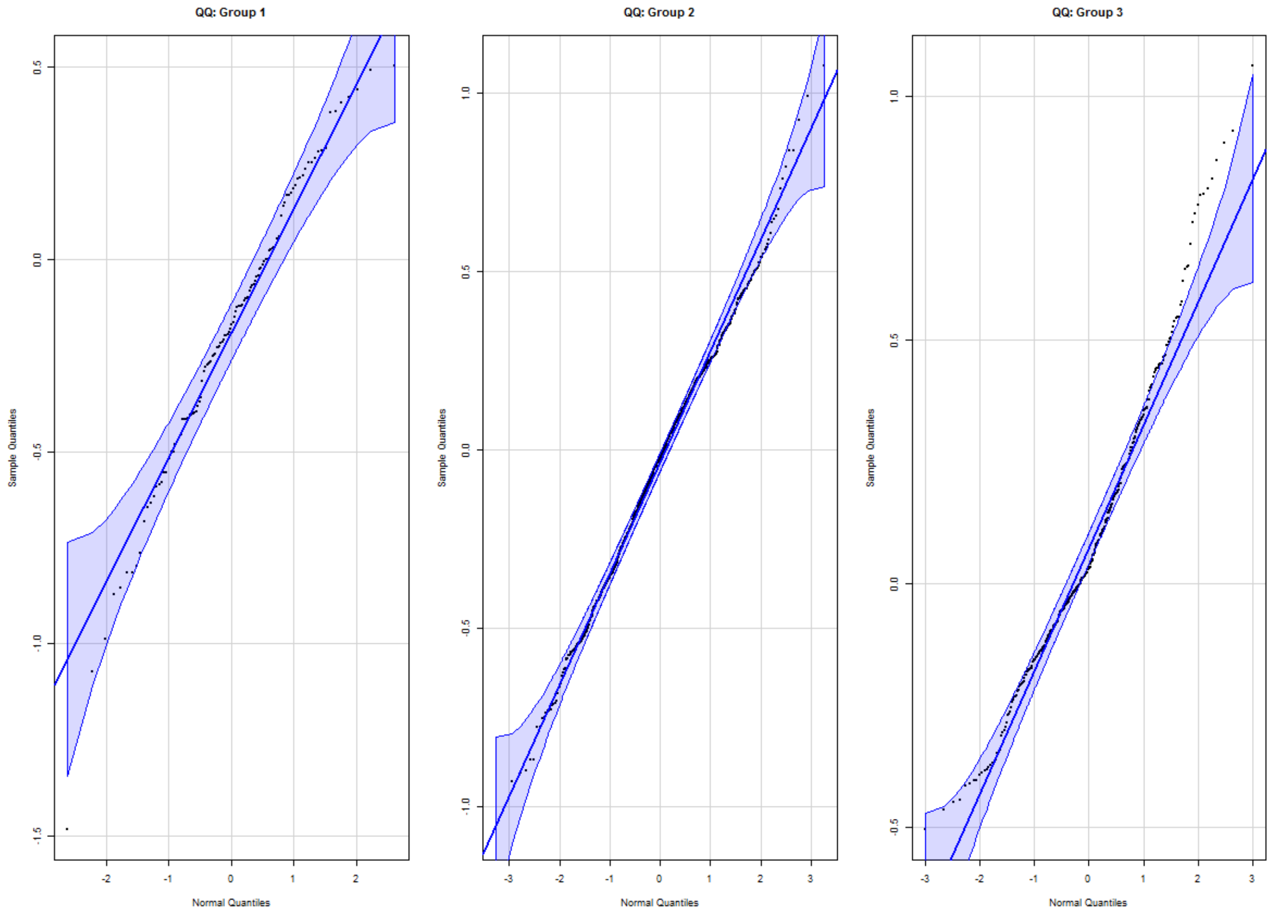
(c) The intercept term in group 2 in model E is also much lower than model D and more comparable to the other model's intercepts. This indicates that multicollinearity may also be affecting group 2's parameters, but in a less pronounced way than in group 3.

E.19 The above analysis suggests that the counterintuitive signs on wages in model D are likely to be the result of multicollinearity, rather than model misspecification. Since multicollinearity, unlike model misspecification, does not affect the quality of model predictions, we consider that model D - with the lowest BIC score - is best suited to use to set p-removal enhancement allowances.

E.20 Finally, as a cross-check on the implicit assumption that the errors of the GMR are normally distributed, we visually compare the distribution of model errors to a normal distribution in Figure E.1 below.[36] The figure contains three Q-Q charts. Each chart plots each scheme's modelled residual in the group it has the highest probability of belonging to against a theoretical normal distribution as a 'dot'. If, in each chart, the dots fall along the straight diagonal line, the data are close to normal. If the dots bend away from the line, especially in the corners, it shows that the data are skewed or have heavier tails than a normal distribution.

E.21 From left to right, the figure contains a Q-Q plot for group 1, 2, and then 3, respectively. Except for a handful of schemes in group 3, almost all scheme's 'dots' are covered by, or are adjacent to, the blue band representing a 95% confidence interval for normal distribution.

Figure E.1: Q-Q plots of model errors for schemes in each of the groups they have the highest probability of belonging to



Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data

[36] A Q-Q plot compares the model residuals to a normal distribution. If the dots fall along the straight diagonal line, the data are close to normal. If the dots bend away from the line, especially in the corners, it shows that the data are skewed or have heavier tails than a normal distribution.

A.6: Future forecast cost pressure pass-through uncertainty

E.22 In this sub-section we use simple regression analysis to test the hypothesis that companies have a common view of the effect of expected increases in input cost over 2025-30 on the totex needed to implement AMP8 p-removal schemes. To implement this test we choose one of Ofwat's p-removal cost model specifications (PR1 and PR3), extend it, and estimate on a pooled data set including all historical and forecast schemes.

E.23 Table E.3 below shows the regression results of two extensions of Ofwat's models (PR1 and PR3). The rightmost column, the 'full model', extends Ofwat's model to include company fixed effects, a forecast dummy, and their interactions. The second column a restricted version of the 'full model' that restricts the coefficients on the interactions between the forecast and company indicators to be equal to zero.

E.24 If companies do have a common view on the average expected totex increase in AMP8 due to future expected cost increases over the period 2025-30, then the restriction under the null model should hold. We test this using a likelihood ratio test but find that we reject his hypothesis at the 1% significance level.

E.25 This provides statistical support for the possibility that there may be considerable uncertainty about the magnitude of these cost pressures across the sector, and different approaches to reflecting these cost pressures in cost forecasts.

Table E.3: Pooled Ordinary Least Squares (OLS) version of Ofwat's PR1 and PR3 models

Variable	*Null Model* Dep Var: totex	*Full Model* Dep Var: totex
Intercept	3.405***	4.321***
	(0.706)	(0.799)
PE served	0.092***	0.092***
	(0.003)	(0.003)
Enhanced Consent	-9.535***	-10.434***
	(1.716)	(1.743)
Enhanced Consent squared	3.926***	4.418***
	(1.049)	(1.058)
Consent Change	0.249*	0.272**
	(0.103)	(0.103)
1[forecast scheme]	1.502***	0.193
	(0.331)	(0.644)
1[forecast scheme] x 1[Company = HDD]		-1.920
		(6.901)
1[forecast scheme] x 1[Company = NES]		0.002
		(2.093)
1[forecast scheme] x 1[Company = UU/NWT]		1.786
		(1.191)
1[forecast scheme] x 1[Company = SRN]		0.300
		(1.099)
1[forecast scheme] x 1[Company = SVE]		3.524***
		(0.982)
1[forecast scheme] x 1[Company = SWB]		-0.020
		(1.824)
1[forecast scheme] x 1[Company = TMS]		3.949
		(2.060)
1[forecast scheme] x 1[Company = WSH]		-3.671*
		(1.806)
1[forecast scheme] x 1[Company = WSX]		2.493*
		(1.086)
1[forecast scheme] x 1[Company = YKY]		1.321
		(1.189)
Company Fixed Effects	Yes	Yes
Observations	1,399	1,399
R-squared	0.552	0.561

**** indicates significance at 1% level, ** at 5% level, * at 10% level*
Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data

Part B: Supply Interconnectors

E.26 Part B of this appendix provides key technical details behind our redetermination of enhancement allowances for supply interconnectors.

B.1: Exclusion of a forecast indicator from Ofwat's pooled models

E.27 In its post-PR24 FD response, Ofwat tested a pooled version of its cost model (ie estimated on both the historical and forecast data) for the inclusion of a forecast scheme indicator variable. Ofwat reported that the forecast variable is statistically insignificant and that this suggests that the historical and forecast datasets are not statistically different.[37]

E.28 On this basis, Ofwat excluded the forecast indicator from its pooled model. The submitted output of the resulting pooled model is reproduced in the second column of Table E.4 below.[38] It shows the number of observations, the R-squared values, the model coefficients and their robust standard errors.

E.29 The third column in Table E.4 below shows the output of the pooled model estimated on the same sample of schemes - but with a forecast indicator included. As was the case in Ofwat's pooled model, the statistical significance of the model coefficients is evaluated using robust standard errors. In this regression, the forecast indicator is significant at the 10% level and has a p-value of 0.066. Given that such a small sample is used, our view is that this is an acceptable level of statistical significance and the exclusion of the forecast variable from the model is not warranted.

E.30 If, however, we deviate from the assumptions on the nature of standard errors in Ofwat's pooled model, then the forecast indicator variable can be shown to be insignificant at the 10% level. For example, if the modelling errors were assumed to be clustered at the company level within each AMP, then the forecast indicator's p-value is greater than 0.10.[39] However, in this case there are only 11 clusters – arguably too few to conduct reliable inference.[40]

E.31 Another notable aspect of the output from Ofwat's pooled model in the second column of Table E.4 below is that it is estimated using 36 of the full sample of 39

[37] Ofwat (2025) Response to common issues on expenditure allowances, pp99–100, paragraph 4.16.
[38] Ofwat (2025) Water – Supply interconnectors; enhancement expenditure model, sheet 'Model Coefficients'.
[39] Stata and R have different approaches to computing cluster robust standard errors and can have different p-values – particularly in small samples. The p-value in R using the default settings in its 'sandwich' library is 0.1695 and in Stata it is 0.190.
[40] If the errors were assumed to be clustered at the company level across AMPs (notwithstanding the fact that this pools errors in outturn and forecast, business plan data), then the p-value is 0.249 in R and 0.274 in Stata. However, this results in only 9 clusters – too small for reliable inference.

schemes.[41] This is because it Ofwat's post-PD implementation of pooled model combines:

(a) 18 schemes not judged to be statistical outliers by its PR24 FD historical model; and

(b) 18 schemes not judged to be statistical outliers by its PR24 FD forecast model.

E.32 However, if Ofwat's PR24 FD sequential procedure that used Cook's distance to identify and remove statistical outliers is applied to Ofwat's pooled model, then only 2 of the 39 schemes are identified as statistical outliers. As a result, the version of the pooled model that is consistent with the Ofwat's PR24 methodology should be estimated on this larger sample of schemes.

E.33 The output of pooled model estimated on the revised sample of 37 schemes is shown in the fourth column of Table E.4 below. As above, and in line with Ofwat's post-FD pooled model, we report robust standard errors. To see whether this revised pooled model estimation more strongly supports Ofwat's decision to omit the forecast indicator variable, we repeat the testing of its statistical significance in the pooled model above.

E.34 Table E.4 below shows the coefficient on the forecast indicator variable is statistically significant at the 5% level and has a p-value of 0.017. Even if the modelling errors are assumed to be clustered at the company level within each AMP and inference is based on only 11 clusters, then the forecast indicator's p-value is still statistically significant at the 10% level.[42] Only when clustering at the company level across AMPs and inference is based on only 9 clusters is the forecast indicator variable insignificant at the 10% level.[43]

E.35 In summary, we again find little empirical support to drop the forecast indicator variable. If anything, the output of the revised pooled model estimation more strongly supports its inclusion.

[41] Ofwat (2025) Response to common issues on expenditure allowances, p104, paragraph 4.31, states that the sample size for the pooled model was 39 (ie. all schemes in both the historical and forecast data),
[42] The p-value in R using the default settings in its 'sandwich' library is 0.066 and in Stata it is 0.087. Though, again, we caution there are only 11 clusters and this is arguably too few to conduct reliable inference.
[43] The p-value in R using the default settings in its 'sandwich' library is 0.136 and in Stata it is 0.165.

Table E.4: Results of Ofwat's regression models for supply interconnector schemes

Cost Drivers	*Ofwat – Pooled Post-FD* Dep Var: log(Cost)	*Ofwat – Pooled Post-FD* Dep Var: log(Cost)	*Ofwat – Pooled PR24 FD method* Dep Var: log(Cost)
Intercept	0.458* (0.256)	0.374 (0.285)	0.362 (0.255)
log(Benefit)	0.706*** (0.088)	0.678*** (0.088)	0.537*** (0.071)
log(Length)	0.506*** (0.071)	0.509*** (0.078)	0.632*** (0.076)
1[Forecast Scheme]		0.286* (0.150)	0.382** (0.152)
Number of obs.	36	36	37
R-squared	0.88	0.89	0.90

**** indicates significance at 1% level, ** at 5% level, * at 10% level. Robust standard errors are reported.*

Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data

B.2: CMA cost model

E.36 The estimation of our cost model, like Ofwat's pooled model, is based on the following cost function for scheme i:

$$Cost_i = Benefit_i^{\beta_1} Length_i^{\beta_2} \exp(\beta_0 + \beta_3 1[Forecast_i])$$

E.37 In our case, this model is directly estimated using a Poisson likelihood function however the estimation does not assume the data follows a Poisson distribution or requires costs to take integer values.[44]

E.38 Our pooled model is estimated on the full sample 39 schemes – 20 historical and 19 forecast. The R-squared value in our model is 0.95 – indicating that the fit of the model using the Pseudo-Poisson Maximum Likelihood (**PPML**) is good.[45] The model's coefficients and their robust standard errors are shown in the rightmost column in Table E.5 below.

E.39 The relationship between cost and the two cost drivers used by Ofwat can be compared to their historical, forecast and pooled Ordinary Least Squares (**OLS**) cost models. For ease of reference, the outputs of these models reproduced in the second to fifth columns of the Table E.5 below.

E.40 The coefficient on the forecast indicator variable is statistically significant at the 1% level – even if when standard errors are clustered at the company level. This reinforces our view that, on balance, the forecast indicator variable should be included in the cost model when estimated using pooled scheme data. Once included, our model implies that forecast schemes are 33% more expensive than

[44] To get an estimation equation for Ofwat's pooled model the logarithmic transformation is applied to both sides of the cost model and an error term is added. Under some (restrictive) assumptions on the relationship between the error term and the cost drivers, the parameters of the model can be consistently estimated using OLS.
[45] Formally, this is McFadden's proxy for R-squared commonly used in nonlinear and generalized linear models. See Hardin, J. W., Hilbe, J. M. (2007). Generalized linear models and extensions. USA: Taylor & Francis. Page 60.

similar historical schemes – similar to the 32% cost uplift implied by post-FD pooled model estimated on 36 schemes.

E.41 We can also use the model outputs in Table E.5 to compare the estimated relationship between costs and the two cost drivers across all models. We find that the effect that the cost drivers have on cost in our model is very similar to Ofwat's PR24 FD cost model estimated only on forecast data.

E.42 Both of these findings are consistent with Southern's contention that historical schemes in supply interconnectors are poor predictors of future costs and that they tend to systematically understate them.

Table E.5: Results of our PPML model and Ofwat's historical, forecast and pooled cost models for supply interconnectors

Cost Drivers	*Ofwat – Historical PR24 FD* Dep Var: log(Cost)	*Ofwat – Forecast PR24 FD* Dep Var: log(Cost)	*Ofwat – Pooled Post-FD* Dep Var: log(Cost)	*Ofwat – Pooled PR24 FD method* Dep Var: log(Cost)	*CMA – Pooled PPML* Dep Var: Cost
Intercept	0.465 (0.413)	0.543* (0.222)	0.374 (0.285)	0.362 (0.255)	0.333 (0.212)
log(Benefit)	0.719*** (0.176)	0.659*** (0.067)	0.678*** (0.088)	0.537*** (0.071)	0.652*** (0.059)
log(Length)	0.433*** (0.139)	0.575*** (0.030)	0.509*** (0.078)	0.632*** (0.076)	0.567*** (0.041)
1[Forecast Scheme]			0.286* (0.150)	0.382** (0.152)	0.287*** (0.088)
Number of obs.	18	18	36	37	39

**** indicates significance at 1% level, ** at 5% level, * at 10% level. Robust standard errors are reported.*
Source: CMA analysis of Ofwat (2025) PR24 Final Determination models data.

Appendix F: Multi-factor models and inference analysis

F.1 This appendix comments on technical aspects of two specific pieces of analysis put to us by the Disputing Companies in relation the allowed return.[46]

Multi-factor models

F.2 This section sets out KPMG and Kairos' multi-factor model (**MFM**) methodology, and a more detailed discussion of the technical aspects of the analysis.

F.3 Kairos estimated the MFM cost of equity under a q-factor model[47] for a United Utilities and Severn Trent portfolio, and a United Utilities, Severn Trent and Pennon portfolio.[48] Kairos' estimated MFM cost of equity range is 6.1-6.6% (CPIH real), compared to its CAPM cost of equity range of 5.5-5.9% (CPIH real).[49] Kairos noted that the CAPM is not providing adequate remuneration for systematic risks proxied by factors including firm size, level of investment and profitability.[50]

F.4 KPMG also estimated the MFM cost of equity using a q-factor model. KPMG estimated the cost of equity differentials between the q-factor and CAPM models of 43 to 181bps (with the lower bound based on a United Utilities/Severn Trent portfolio and the upper bound on Pennon). KPMG concluded the differential reflected the water portfolio's exposure to factors not captured by the CAPM.[51]

F.5 Kairos and KPMG estimated the same Hou et al (2015) q-factor model[52], using the factor and test portfolio data (available on Northumbria University website) as described in Tharyan et al (2024).[53]

F.6 The formulation of the q-factor model tested in Tharyan et al (2024) on UK data is expressed as follows.

$$R_i = R_{ft} + \beta_i \left(R_{mt} - R_{ft}\right) + s_i SIZE + j_i \, INV_t + r_i \, ROE_t + \varepsilon_{it}$$

F.7 Where R_i is the stock's return, R_{mt} is the market return, R_{ft} is the risk-free rate, SIZE, INV, and ROE are size (small minus big), investment (low minus high) and profitability (high minus low) factors respectively. β_i, s_i, j_i, r_i are the factor loadings o('betas'), which measure the sensitivity of the stock's return to the return on each factor premium. Tharyan (2024) construct the q-factors by sorting stocks into 2 by

[46] We note that Professor Jason Sturgess of Queen Mary University, who is a member of the CMA's Corporate Finance panel, has reviewed this appendix.
[47] Kairos used market capitalisation weighting, with zero-weight to Pennon prior to the completion of the Viridor spinoff. Kairos also adjusted to account for the effect of the restrictions during the COVID-19 period.
[48] Kairos (2025) Setting the Allowed Return on Equity for PR24, p64, paragraph 218.
[49] Kairos (2025) Setting the Allowed Return on Equity for PR24, p66, paragraph 222.
[50] Kairos (2025) Setting the Allowed Return on Equity for PR24, p66, paragraph 222.
[51] KPMG (2025) Estimating the Cost of Capital for PR24, p17, paragraphs 9.2.11–9.2.12.
[52] Hou et al (2015) 'Digesting Anomalies: an Investment Approach' *The Review of Financial Studies,* pp650–705.
[53] Chen, B, Gregory, A and Tharyan, R, (2024) 'An investigation of multi-factor asset pricing models in the UK'.

size, 3 by investment, and 3 by profitability, and create 18 portfolios in total through the intersection of these individual portfolios, in line with Hou et al (2015). The SIZE factor estimates the average excess return on the 9 small size portfolios relative to the return on the 9 big size portfolios, the INV factor estimates the average excess return on the 6 low investment portfolios relative to the return on the 6 high investment portfolios, and the ROE factor estimates the average excess return on the 6 high profitability portfolios relative to the return on the 6 low profitability portfolios.[54]

F.8 While the market beta factor is equal to one by construction, the average factor loadings ('betas') for the additional factors are zero by construction.

F.9 Both Kairos and KPMG estimate statistically significant coefficients for SIZE and ROE factors for their chosen water portfolios/stocks.[55] The ROE factor appears to be the main driver of the positive difference between the MFM and the CAPM cost of equity estimates.

The Hou et al (2015) q-factor model

F.10 The economic intuition behind the q-factor model is to price assets from the perspective of suppliers (firms), rather than buyers (investors). The motivation behind the INV and the ROE factors is based on the basic net present value (**NPV**) rule of corporate finance, which says that firms should only invest in projects when the NPV is greater or equal to zero.[56]

F.11 NPV is the discounted value of all future cash flows minus investment costs today. In a single period set up, this relationship can be rearranged as follows: discount rate = expected profitability / investment costs.[57]

F.12 In the context of the q-factor model, we understand this to imply that firms with relatively high profitability or relatively low investment will have relatively higher required rates of return. If this was not the case, the firm would continue to invest at the margin increasing investment and lowering profitability (because the firm would increasingly invest in less NPV positive projects until the marginal benefit (profit) from further investment equals the marginal investment cost).

[54] Hou et al (2015) 'Digesting Anomalies: an Investment Approach' *The Review of Financial Studies*, p660.
[55] At 1% significance, see Kairos (2025) Setting the Allowed Return on Equity for PR24, p87; KPMG (2025) Estimating the Cost of Capital for PR24, p158.
[56] See Allen, F, Brealey, RA, Edmans, A and Myers, SC (2022) *Principles of Corporate Finance: Fourteenth edition*.
[57] Zhang, L (2019) 'q-factors and investment CAPM' (working paper), *National Bureau of Economic Research.* The rationale for the q-model is also set out in Hou et al (2015) 'Digesting Anomalies: an Investment Approach' The Review of Financial Studies, section 1.

Applicability of the q-factor model to regulated utilities

F.13 One of the common issues with the use of MFMs is whether the additional factors which appear to explain observed returns are picking up spurious relationships and do not provide any insight into the underlying drivers of expected returns. When it comes to the q-model, there does appear to be an economic intuition to it, which may suggest we should give greater weight to this MFM over others.

F.14 However, we are not aware of any theoretical or empirical work on the q-model for firms in regulated markets. The economic intuition which we set out above – that firms will continue to invest until all marginally profitable opportunities are exhausted – does not obviously apply to regulated water companies. Investment levels are effectively set for five-year periods, and the regulator's intention is to set prices such that the NPV of these investments is expected to be zero. While firms have some flexibility around investment during the period, and there is scope for value generation through out-performance, we question the direct applicability of the intuition of the q-factor model in a regulated setting.

F.15 Kairos and KPMG's estimates of the MFM for the water companies estimate positive factor betas both for the investment and the profitability factors although only the factor beta on the profitability factor is statistically significant. (Kairos and KPMG also estimate a statistically significant coefficient for size but the sign differs depending on the comparator/portfolio used).[58]

F.16 The inference from the estimated q-model is that water companies should have a higher cost of equity because they have higher profits and lower investment, else they would continue to invest positive NPV projects. This does not seem logical given that these are capital-intensive industries with returns constrained through price controls.

F.17 For these reasons we do not consider that we can place weight on the q-factor model as a cross-check on the CAPM cost of equity. To do so in future price controls we consider that it would be necessary to develop the economic rationale for this model further, specifically in the context of regulated firms, supported by empirical testing.

Other issues raised by the parties

F.18 We do not repeat the ongoing dialogue between Ofwat and the Disputing Companies on MFMs, as we rule out the MFMs mainly for the reasons set out above – a lack of a clear economic intuition for the q-factor model and sufficient testing in the context of regulated firms.

[58] Kairos (2025) Setting the Allowed Return on Equity for PR24, Appendix B; KPMG (2025) Estimating the Cost of Capital for PR24, pp158–159, Tables 65 and 66.

F.19 We provide some high-level comments on several specific issues raised which we consider to be further contributing reasons for not placing weight on MFMs.

Stability and statistical significance of factor betas

F.20 In its PR24 FD, Ofwat stated that betas of water companies have had a strikingly stable mean since the early 2000s, whereas rolling estimates of additional factor betas for MFMs show clear signs of drifting even over long rolling samples and over shorter rolling samples some factor betas change sign.[59]

F.21 KPMG stated that the CAPM market beta has an expected coefficient mean of 1 (ie the beta of the market) while the additional factor portfolios are all hedge portfolios with an expected coefficient mean of zero, and therefore, it is more likely for any portfolio to have changes in beta signs for the additional factor as it is closer to zero.[60]

F.22 Tharyan, Gregory and Chen submitted that it considered that the consistency in factor beta signs was not an appropriate criterion for assessing the stability of additional factors, while the CAPM beta is unlikely to turn negative, it is more likely for the additional factors to change sign over time.[61]

F.23 We consider that in principle, factor betas may change sign as, by design, the average factor loading must be zero. However, especially given the low statistical significance of some of the factor betas, it is difficult to place reliance on spot estimates of the factor betas and to interpret them without a richer set of rolling estimates, covering different time periods and data frequencies, to understand the underlying trends in these factor betas.

F.24 This is further complicated by the fact that both Kairos and KPMG include adjustments for COVID-19 (which, as explained in chapter 7 (Allowed Return), we disagree with), and that additionally, KPMG de-levers and re-levers the factor betas in the same way as the CAPM beta, without any evidence on the relationship between leverage and the factor premia.

Stability and statistical significance of factor excess returns

F.25 In the PR24 FD, Ofwat stated that UK factor excess returns have only been measured since the early 1980s, and in the USA since the early 1970s, and these are only marginally statistically significant from zero. Ofwat also noted that

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[59] Ofwat (2025) PR24 final determinations: Aligning risk and return - Allowed return appendix, p72, Table 17.
[60] KPMG (2025) Estimating the Cost of Capital for PR24, section 15.3.
[61] Chen, B, Gregory, A and Tharyan, R (2025), Responses to Mason, Robertson and Wright, p3 (see KPMG (2025) Estimating the Cost of Capital for PR24, section 15.2).

academic literature usually points to a need for higher levels of statistical significance given the increased risk of data mining.[62]

F.26 KPMG submitted that the early 1980s is the furthest period to go back to with comprehensive daily and monthly return and accounting data for the construction of MFM.[63]

F.27 Tharyan, Gregory and Chen questioned Ofwat's approach to only apply the test of stability to factors additional to the CAPM. They stated that if Ofwat demands the requirement of stability, then the basic CAPM fails the test, as the market risk premium shows considerable variability.[64]

F.28 We agree that the market risk premium is variable, and therefore, a finding of variable factor premia in itself is not a reason to discount the q-factor model. However, while the expected market risk premium is highly uncertain, this is an area of extensive research and the approach to estimating the TMR/ERP in a regulatory setting is one which has evolved over many years, taking different evidence into account. In contrast, the only estimates of the UK factor premia we have come from Tharyan et al (2014).

F.29 We recognise that expecting the same breadth and depth of research into these additional factors as we have for the market risk premium is unrealistic, however, we are cautious about relying on results of a single academic paper on the topic.

F.30 With regard to statistical significance, Tharyan, Gregory and Chen agree with Mason, Robertson & Wright that the observed factor premia should be statistically significant from zero. The 'price' of size and profitability is not statistically significant at portfolio level (in Tharyan et al (2024)), however, this is not the case for the investment factor, which carries a substantial positive risk premium. However, Tharyan, Gregory and Chen caution against removing variables as it would introduce omitted variable bias into the regressions, which can distort the regression results.[65]

F.31 While we understand the issues with omitted variable bias, we are also mindful of the concerns around the risks of data mining in empirical finance, and that statistical significance is an important criterion for factor inclusion.[66] The UKRN (2018) study noted that if the missing factors are not statistically significant, they disappear in expectation, leaving only the impact of the expected market return.[67]

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[62] Ofwat (2025) PR24 final determinations: Aligning risk and return - Allowed return appendix, p72, Table 172.
[63] KPMG (2025) Estimating the Cost of Capital for PR24, section 15.3.
[64] Chen, B, Gregory, A and Tharyan, R (2025), Responses to Mason, Robertson and Wright, p3 (see KPMG (2025) Estimating the Cost of Capital for PR24, section 15.2).
[65] Chen, B, Gregory, A and Tharyan, R (2025), Responses to Mason, Robertson and Wright, p6 (see KPMG (2025) Estimating the Cost of Capital for PR24, section 15.2).
[66] Hou et al (2015), p662.
[67] UKRN (2018) Estimating the cost of capital for implementation of price controls by UK Regulators, pG-151.

This reinforces our view that further work is needed on MFMs in the UK before they can be applied in a regulatory setting.

Conclusions

F.32 While the CAPM may 'have fallen out of favour' in the academic world, and has a number of known limitations, in the context of estimating the allowed return in a consistent and predictable manner, in particular for regulated firms, we do not consider that the development of MFMs in the UK is sufficiently advanced to allow us to draw any inference on the appropriate cost of equity for UK water companies.

Inference analysis

F.33 This section sets out KPMG's inference analysis methodology, and a more detailed discussion of the technical aspects of the analysis.

F.34 KPMG's inference analysis is derived based on Merton's (1974)[68] contingent claim framework and its empirical application by Campello, Chen and Zhang (2008).[69]

F.35 KPMG explains that in Merton's framework, debt and equity are considered contingent claims on a firm's assets. When the firm's asset value rises, equity holders benefit from larger residual claims, and the debt holders benefit from a decrease in leverage and a lower likelihood of default. Conversely, an increase in asset value reduces residual claims and increases the likelihood of default. Therefore, all else equal, the expected returns on debt and equity are expected to be positively correlated.[70]

F.36 In the Merton framework, the relation between debt and equity returns is expressed as an elasticity, $\frac{\partial E/E}{\partial D/D}$ and it is assumed that the elasticity is a function of the nominal risk-free rate, the firm's leverage, and the stock's volatility.

$$Elasticity = \alpha + \beta_{rf}\, RFR + \beta_{lev}\, leverage + \beta_{vol}\, volatility$$

F.37 KPMG ran such a regression for UU and SVT and then used the estimated regression coefficients to estimate expected elasticities and an implied cost of equity using the following relationship.

$$R_e = r_f + elasticity\,(R_d - r_f)$$

[68] Merton, R. C. (1974) 'On the pricing of corporate debt: The risk structure of interest rates' *The Journal of Finance*, pp449–470.
[69] Campello, M, Chen, L and Zhang, L (2008) 'Expected returns, yield spreads, and asset pricing tests', *The Review of Financial Studies*, pp1297–1338.
[70] KPMG (2025) Estimating the Cost of Capital for PR24, section 9.2.3.

F.38 Where R_e is the cost of equity, r_f is the RFR, and $R_d - r_f$ is the debt risk premium. KPMG performs the analysis for UU and SVT and uses the iBoxx benchmark index plus a 40bps uplift to estimate the debt risk premium.[71] The cost of equity is estimated in nominal terms, using nominal 20-year gilt yields as the RFR. The cost of equity is then deflated into CPIH terms using a 20-year CPI swap rate.

F.39 Similar to MFMs, the inference analysis has been subject to ongoing debate between Ofwat and the Disputing Companies. Wo do not repeat all the submissions on this topic but focus on drawing out the key themes.

Relationship between debt and equity returns

F.40 KPMG submitted that, unlike the market return input into the CAPM, the yield on debt can be directly observed, and the yield is automatically forward-looking. While the promised yield is not the same as the expected yield, there is a clear way to adjust observed yields to subtract the default risk premium.[72]

F.41 In response to the Disputing Companies' Statements of Case, Mason, Robertson and Wright noted the general challenge of accurately measuring the expected return on debt. Specifically, the pricing of risk of default is a long-standing empirical puzzle in finance, since the observed credit spreads are hard to explain in terms of observed frequency of default and plausible default risk premia.[73]

F.42 We consider that there are similar empirical challenges with the inference analysis which are present in all debt-to-equity premia cross-checks discussed in chapter 7 (Allowed Return) of the provisional determinations report. There is uncertainty around the appropriate way to isolate the underlying debt risk premium from the observed cost of debt. We do not consider that this renders any attempt at comparing debt and equity returns useless, but it is an important caveat to this type of analysis.

F.43 Specifically in the context of inference analysis, we also have some reservations about the applicability of the Merton framework to regulated firms.

F.44 We consider that certain characteristics of regulated water companies may limit the applicability of the Merton framework as a cross-check on the allowed cost of equity for regulated utilities:

(a) **Regulatory mechanisms and protections**: there are various regulatory mechanisms and protections, including the Special Administration Regime, substantial effect determinations and interim determinations, which may alter

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[71] KPMG (2025) Estimating the Cost of Capital for PR24, section 16.1.21, Table 74.
[72] KPMG (2025) Estimating the Cost of Capital for PR24, section 9.3.7.
[73] Mason, R, Robertson, D and Wright, S (2025) A report on allowed return issues in disputing companies' statements of case, paragraph 5.37.

the underlying relationship between debt and equity values compared to non-regulated firms.

(b) **Limited default risk**: the essential service nature and regulatory protections (already noted above) mean UK regulated water companies have very low probability of default, despite sustaining high degrees of leverage. This may violate the Merton model's assumptions about meaningful default risk.

Statistical significance of regression coefficients

F.45 KPMG stated that the independent variables jointly explain the variation of elasticity and are jointly significant at a 5% significance level. KPMG stated that the use of F-statistics is appropriate in this context as it assesses the overall statistical significance of the regression model based on the collective impact of all independent variables.[74]

F.46 In response to the Disputing Companies' Statements of Case, Mason, Robertson & Wright noted that the independent variables are not individually statistically significant, and that market leverage and risk-free rate specifically have high standard errors.[75]

F.47 Greater statistical significance of regression coefficients increases the confidence with which we can rely on the estimated coefficients to make inferences. Given that KPMG estimates the regression for just two firms and estimates a fixed effects model, it is potentially not surprising that the resulting estimates are very 'noisy', ie characterised by relatively high standard errors. We do not consider that this completely invalidates the analysis (given that the coefficients are at least jointly statistically significant) but it does mean the estimates are highly uncertain.

Differences between elasticities and beta estimates for Severn Trent and United Utilities

F.48 KPMG stated that the differences in elasticity between two comparable companies has no bearing on the differences in their equity betas. KPMG noted that as elasticity and beta are measuring different types of risk their values and differences between companies are not directly comparable. As a result, variations in elasticity between companies will not necessarily align with differences in beta.[76]

F.49 MRW noted that they were not arguing that elasticities and betas should be identical or even align closely. However, Mason, Robertson & Wright submitted

[74] KPMG (2025) Estimating the Cost of Capital for PR24, section 16.1.19.
[75] Mason, R, Robertson, D and Wright, S (2025) A report on allowed return issues in disputing companies' statements of case, paragraph 5.43.2.
[76] KPMG (2025) Estimating the Cost of Capital for PR24, sections 16.2.11–16.2.12.

that given the significant difference between Severn Trent and United Utilities elasticities they would expect some testing to assess the statistical soundness of using results Severn Trent and United Utilities.[77]

F.50 KPMG's analysis uses an average of the elasticities of Severn Trent and United Utilities. Given that this type of analysis is about estimating the sensitivity of the equity value of one firm to the debt value of that same firm, it is not clear why KPMG did not consider Severn Trent and United Utilities separately.

F.51 While it is only proposed as a cross-check, given that we only have two firms in the sample, with quite different implications for the implied cost of equity depending on whether Severn Trent or United Utilities is considered, it is difficult to place much reliance on this analysis.

Index versus company specific bond data

F.52 KPMG's analysis uses the iBoxx A/BBB index, plus a 40bps adjustment, as the cost of debt to derive the debt risk premium.

F.53 Mason, Robertson & Wright noted that Campello, Chen and Zhang derive firm-specific bond excess returns. MRW noted that the firm-specific approach was not available to KPMG due to data limitations but noted that data limitations lead to analytical limitations.[78]

F.54 Ofwat stated that January 2025 the yield on two United Utilities and Severn Trent bonds were 6.04% compared with the average iBoxx A/BBB yield of 6.06%. Ofwat noted that assuming a zero wedge above the iBoxx A/BBB reduces KPMG's cost of equity estimate to 4.94% CPIH-real.[79]

F.55 We agree with Mason, Robertson & Wright that the use of the iBoxx A/BBB index rather than firm-specific bond data is a limitation. Given that KPMG used company-specific bond data to estimate market leverage, it is not clear why it could not have derived company-specific debt premia for Severn Trent and United Utilities. Ofwat's calculation shows the sensitivity of the implied cost of equity to the debt risk premium assumption. This is an important caveat to the KPMG analysis.

[77] Mason, R, Robertson, D and Wright, S (2025) A report on allowed return issues in disputing companies' statements of case, paragraph 5.51.
[78] Mason, R, Robertson, D and Wright, S (2025) A report on allowed return issues in disputing companies' statements of case, paragraph 5.45. See Campello, M, Chen, L and Zhang, L (2008) 'Expected returns, yield spreads, and asset pricing tests', *The Review of Financial Studies*, pp1297–1338.
[79] Ofwat (2025) Response to common issues on risk and return, paragraph 5.153.

Conclusions

F.56 Due to the limitations noted above we do not currently consider inference analysis to be an appropriate cross-check on the allowed return on equity.

Glossary

Term	Definition
AAD	Advanced anaerobic digestion.
Act	The Water Industry Act 1991.
Adjusted interest cover ratio (AICR)	The adjusted interest cover ratio (AICR) measures the scope to make interest payments after meeting costs that have been expensed and RCV run-off. This is a financial ratio used for the assessment of financeability.
Affinity (or 'AFW')	Affinity Water Limited (also referred to as 'AFW' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
Aggregate sharing mechanism (ASM)	A mechanism that reduces the financial impact on customers and companies of very high or very low performance beyond certain thresholds through the use of cost-sharing. There are two ASMs: (a) a 'totex ASM' which is applied to costs at the end of the full five-year period at a threshold of ±200bps of **RoRE**; and (b) an 'outcomes ASM' which is applied to net outcomes delivery incentives (ODIs) payments on an annual basis. The outcomes ASM has two thresholds, at ±300bps of **RoRE** and ±500bps of **RoRE**.
Akaike Information Criterion (AIC)	Akaike Information Criterion is a tool used to compare different statistical models and helps to identify the model that explains the data most effectively while using the fewest number of variables.
Allowed return (on capital)	The allowed return on capital is multiplied by the **RCV** to provide a revenue allowance for efficient financing costs. It is set in real (**CPIH**)

Term	Definition
	terms, with respect to the **notional capital structure**.
AMI	Advanced monitoring infrastructure.
AMP	Asset Management Period, a five-year regulatory period used by **Ofwat** to set price controls for water companies.
AMP5	The period between 2010 and 2015, during which PR09 applied.
AMP6	The period between 2015 and 2020, during which PR14 applied.
AMP7	The period between 2020 and 2025, during which PR19 applied.
AMP8	The period between 2025 and 2030, during which PR24 applies.
AMR	Automated Meter Reading, a technology that enables the automatic collection of consumption data from utility meters.
Anglian (or 'ANH')	Anglian Water Services Limited (also referred to as 'ANH' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
APH	Average pumping head.
Appointee	The Appointee is a water company responsible for delivering the regulated wholesale and retail activities which are necessary for the water company to fulfil the function and duties of a **WoC** or **WaSC** under the **Act**.
APR	Annual performance report.
ASHE	Annual Survey of Hours and Earnings, a source of information on the structure and distribution of earnings in the UK.

Term	Definition
ASRAP	Anglian's PR24 Asset Systems Resilience Appraisal, produced in 2023.
Base Costs	Routine costs that companies incur to provide a base level of service.
Basis point (or 'bp') / basis points (or 'bps')	A basis point (often abbreviated to 'bp') is a unit of measurement equal to one hundredth of a percentage point (ie 0.01%). It is commonly used as a unit to describe differences in the yield of financial instruments.
BCEW	Business Customer Experience in Wales.
Bespoke performance commitment	Performance commitments that do not apply to all water companies. Some companies may have the same bespoke performance commitments as other companies.
Beta	Beta within the CAPM framework reflects an asset's (or a portfolio of assets') exposure to systematic (or common) risks relative to the broader market.
Bayesian Information Criterion (BIC)	Bayesian Information Criterion is a tool used to compare different statistical models and helps to identify the model that explains the data most effectively while using the fewest number of variables
Bioresources	Bioresources refers to activities associated with wastewater sludge transport, treatment, recycling and disposal.
Blind year	The last year of a price control period.
Bristol Water	South West Water Limited trading as Bristol Water (also referred to as 'BRL' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).

Term	Definition
Business customer and retailer measure of experience (BR-MeX)	Performance commitment designed to improve outcomes for business customers in England. See '**Measures of experience**'.
CAC	Cost Adjustment Claim.
CAD	Conventional anaerobic digestion.
Capex	Capital expenditure, commonly known as capex, are funds used by a company to acquire, upgrade, and maintain physical assets such as property, buildings, an industrial plant, technology or equipment.
CAPM	The Capital Asset Pricing Model describes the relationship between systematic risk and expected return for assets, particularly stocks.
Caps and **collars**	Limits on outperformance and underperformance for an **ODI**, respectively.
Catch-up challenge	Efficiency savings required by the least efficient companies in the sector to catch-up to the most efficient companies.
CED	Consumption expenditure deflator.
CES	The customer experience survey ie a survey of a water company's household customers – performance on which (alongside CSS) informs a company's performance on **C-MeX**.
CMA	The Competition and Markets Authority.
CMA PR24 Approach Document	CMA (2025) Water PR24 Redetermination References: Approach and Prioritisation.
CNB	Catchment nutrient balancing.
COMAH regulations	Control of Major Accident Hazards Regulations 2015.

Term	Definition
Common performance commitment	Performance commitments that all companies must have to allow a direct comparison across the sector (see performance commitment).
Consumer Council for Water (CCW)	The Consumer Council for Water, known as CCW, is the independent representative of household and business water consumers in England and Wales.
Consumer Objective	Refers to the duty set out in the **Act**, section 2(2A)(a) and has the meaning set out in the **Act**, sections 2(2B)–2(2D).
Contingent allowance	An expenditure allowance that is contingent on an action.
COPI	Construction Output Price Index.
Cost sharing	Cost sharing refers to **Ofwat**'s policy treatment of overspend or underspend against the efficient cost allowances set for water companies: (a) the cost sharing rate on overspend captures the share of overspend that the company needs to bear (versus what may be borne by customers); and (b) the cost sharing rate on underspend captures the share of underspend that the company gets to keep.
CPI	Consumer Price Index.
CPIH	Consumer Price Index Including Owner Occupiers' Housing Costs.
CRI	Compliance risk index.
CRT	Canal and River Trust.
CSS	The customer service survey – ie a survey of customers who have contacted a water company – performance on which (alongside **CES**) informs a company's performance on **C-**

Term	Definition
	MeX and is represented by a score out of 100 calculated from the average scores of two satisfaction surveys.
Customer measure of experience (C-MeX)	Common performance commitment designed to improve outcomes for residential customers in England and Wales. See ‘Measures of experience’.
CY	Convenience Yield
Deadband	Deadbands are a specified range around a performance commitment level where no financial incentives apply.
Defra	Department for Environment, Food & Rural Affairs.
DESNZ	Department for Energy Security and Net Zero
Developer services measure of experience (D-MeX)	Performance commitment designed to improve outcomes for developer services customers in England and Wales. See ‘**Measures of experience**’.
Direct Procurement for Customers (DPC)	Direct procurement for customers is an alternative approach, through competitive tendering, for water companies to deliver large scale, discrete programmes of work by means of a third party, which potentially may include the design, construction, financing, ownership, operation and maintenance of an asset.
Disputing Companies	Anglian, Northumbrian, Southern, South East and Wessex collectively.
DMS	Dimson, Marsh and Staunton
Drinking Water Inspectorate (DWI)	The DWI is the independent regulator of drinking water supplies in England and Wales, ensuring that water companies supply safe drinking water that is acceptable to customers and meets the standards set down in law.

Term	Definition
DSEAR	Dangerous Substances and Explosives Atmospheres Regulations 2002.
DWMP	Drainage and wastewater management plan.
Dŵr Cymru (or ''WSH')	Dŵr Cymru Cyfyngedig (also referred to as 'WSH' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
EA	Environment Agency.
EDM	Event Duration Monitors, a means by which water companies record the frequency and duration of spills.
Efficiency Duty	Refers to the duty set out in the **Act**, section 2(3)(a).
Enhanced ODI	Performance payments that apply to outperformance only and are designed to incentivise further performance improvements from well-performing companies.
Enhancement Costs	Costs required to enhance the capacity or quality of service beyond the base level.
Environmental Performance Assessment (EPA)	The Environmental Performance Assessment was introduced by the Environment Agency in 2011 as a non-statutory tool for comparing performance between water and sewerage companies (**WaSCs**) operating wholly or mainly in England.
EOS	Emergency overflow sites.
ERP	Equity risk premium.
Financing Duty	Refers to the duty set out in the **Act**, section 2(2A)(c).
Frontier Shift	Frontier shift (or 'Ongoing Efficiency') is the rate of efficiency improvements that even the most efficient companies in the industry can achieve from improvements in working

Term	Definition
	practices and the introduction of new technology.
Functions Duty	Refers to the duty set out in the **Act**, section 2(2A)(b).
Funds from Operations (FFO)/Net Debt	Funds from operations divided by net debt measures companies' debt burden in relation to operational income. This is a financial ratio used for the assessment of financeability. It is also a key ratio for rating agencies, although each rating agency may make specific adjustments to FFO and/or net debt for its calculations.
FY	Financial Year.
Gated Allowance	An expenditure or contingent allowance provided to the company [in Ofwat's PR24 FD], where the company needs to pass through a series of gates to access additional funding.
Gearing	Gearing measures the percentage of a company's **RCV** that is financed by debt. It is measured by assessing net debt (total debt less cash & cash equivalents) divided by **RCV**.
GFC	The 2008 global financial crisis.
GIIA	The Global Infrastructure Investment Association
GLS	Generalised Least Squares
GMR	Gaussian Mixture Regression.
GO	Gross output. GO measures aggregate output by one or more companies. The inputs used to make GO are capital, labour and intermediate inputs, including energy, materials and services.
Growth Duty	Refers to the duty set out in the Deregulation Act 2015, section 108.

Term	Definition
GSS	Guaranteed Standards Scheme.
Hafren Dyfrdwy (or 'HDD')	Hafren Dyfrdwy Cyfyngedig (also referred to as 'HDD' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
Heathrow H7	The H7 Heathrow Airport Licence modification appeals made to the CMA in 2023 (and determined by the CMA in 2024).
HMT	His Majesty's Treasury.
HSE	Health and Safety Executive.
iBoxx indices	Bond indices compiled by IHS Markit and commonly used as a regulatory benchmark for the cost of debt. The 'benchmark index' is the average of the iBoxx A and BBB non-financial 10+ indices.
IED	The Industrial Emissions Directive.
ILD	Index-linked debt.
ILG	Index-linked government gilt.
Independent Water Commission	Independent Commission on the Water Sector Regulatory System chaired by Sir John Cunliffe.
IRE	Infrastructure renewals expenditure.
Least absolute shrinkage and selection operator (LASSO)	An econometric/machine learning technique which selects explanatory variables that best predict the outcome variable of interest.
Licence Duty	Refers to the duty set out in the **Act**, section 2(2A)(d).
MARs	Market-to-asset ratio(s). Ratio of enterprise value of a listed water company to its **RCV**.
MCERTS	Monitoring Certification Scheme, monitoring emissions to air, land and water.

Term	Definition
Measures of experience (MeXes)	Performance commitments that measure the experience of residential customers (**C-MeX**), developer services customers (**D-MeX**), business customers in Wales (**BCEW**) and business customers in England (**BR-MeX**). Incentive payments are based on companies' relative performance each year.
MFM	Multi-factor models.
Monte Carlo	A simulation that involves taking multiple draws from the estimated distribution (e.g. expenditure or performance outcomes) and, for each draw, computing the resulting **RoRE** outcome.
MPE	Materials, Plant and Equipment.
MSE	Mean Squared Error
MSOA	Middle-layer Super Output Area, a statistical geography unit in England and Wales used by **Ofwat** in computing density measures.
NIC	National Infrastructure Commission.
Northumbrian (or 'NES')	Northumbrian Water Limited (also referred to as 'NES' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
Notified item	Has the meaning set out in Condition B of **WoC** and **WaSC** licences (each of which is listed in **Ofwat**'s register).
Notional capital structure	**Ofwat** sets an allowed return and tests financeability using an assumed capital structure for the notional company. **Ofwat** makes assumptions for notional **gearing**, share of index-linked debt, type of index-linked debt, dividend yield and equity issuance costs.
NPg	Northern Powergrid.
NPV	Net present value.

Term	Definition
OBR	Office for Budget Responsibility.
Ofwat	**Ofwat** is the Office of the Water Services Regulation Authority, the economic regulator of water and sewerage companies in England and Wales.
Ofwat's Response	**Ofwat**'s response to the Disputing Companies' Statements of Case.
ONS	Office for National Statistics.
OLS	Ordinary Least Squares.
Opex	Operating expenditure. Operating expenses are the costs a company incurs for running its day-to-day operations.
Outcome Delivery Incentive (ODI)	Outcome delivery incentives are the financial consequences for companies associated with their performance commitments and capture outperformance and underperformance. Incentive payments are determined by multiplying a company's performance relative to its performance commitment level (ie **PCL**) by an incentive rate.
Outturn adjustment mechanism (OAM)	A new mechanism introduced in **Ofwat**'s **PR24 FD** that adjusts the impact of outturn reconciliations for all companies equally in terms of the proportion of regulated equity to keep the reconciliation of the median average of companies within a range of -50bps to +50bps **RoRE**. The mechanism applies to common performance commitments.
Overriding objective	The overriding objective to carry out redeterminations fairly, efficiently and at proportionate cost within the statutory timeframes, as set out in the Rules (Rule 4.1).
P-removal	Phosphorus removal.

Term	Definition
P10	P10 is the level at which there is only an estimated 10% chance that the outcome performance level would be worse.
P90	P90 is the level at which there is only an estimated 10% chance that the outcome performance level would be higher.
PAYG	Pay As You Go is the proportion of total allowed expenditure that is recovered in each year of the price review period. Non-PAYG total allowed expenditure is added to the **RCV**.
Performance commitment	Performance commitments are measures of performance that Ofwat uses when seeking to hold companies to account to deliver for customers and the environment.
Performance Commitment Level (PCL)	Performance commitment levels are the levels of performance for each performance commitment that efficient water companies are funded to deliver through expenditure allowances.
PFAS	Perfluoroalkyl and polyfluoroalkyl substances.
PMICR	Post-Maintenance Interest Coverage Ratio.
Portsmouth Water (or 'PRT')	Portsmouth Water Limited (also referred to as 'PRT' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
PPML	Pseudo-Poisson Maximum Likelihood model, developed by Santos Silva and Tenreyro (2006).
PR04	**Ofwat**'s periodic price review for 2004, covering the price control period from 2005–2010 and corresponding to AMP4.
PR09	**Ofwat**'s periodic price review for 2009, covering the price control period from 2010–2015 and corresponding to **AMP5**.

Term	Definition
PR14	**Ofwat**'s periodic price review for 2014, covering the price control period from 2015–2020 and corresponding to **AMP6**.
PR19	**Ofwat**'s periodic price review for 2019, covering the price control period from 2020–2025 and corresponding to **AMP7**.
PR19 Final Report	The CMA's Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations Final Report, as issued in 2021.
PR24	**Ofwat**'s periodic price review for 2024, covering the price control period from 2025–2030 and corresponding to **AMP8**.
PR24 DD	**Ofwat**'s PR24 Draft Determinations (July 2024).
PR24 FD	**Ofwat**'s PR24 Final Determinations.
Price Control Deliverable (PCD)	Price control deliverables are used to ensure that customers receive the performance and outputs they have funded through certain cost allowances.
Price reviews (or periodic reviews)	**Ofwat** is required to carry out 5-yearly price reviews (sometimes referred to as periodic reviews) which limit the revenue allowed to water companies (as a result the charges levied by those companies) from their regulated activities.
QAA	Quality and Ambition Assessment.
R&D	Research and development.
RAPID	Regulators' Alliance for Progressing Infrastructure Development, a type of gated process introduced by **Ofwat**, the **EA** and the

Term	Definition
	DWI to accelerate the development of new strategic water resource infrastructure.
Real terms	Real terms can be used for figures such as bills, **totex** and revenues. Real terms figures do not reflect the impact of inflation. They are measured in the prices of an initial or base year. For PR24, real terms figures are in 2022/23 **CPIH** prices.
References	On 18 March 2025, **Ofwat**, as required by section 12(3)(a) of the **Act**, referred five disputed determinations to the CMA.
Regulatory Capital Value (RCV)	Regulatory Capital Value is a component used by **Ofwat** to calculate price limits. It represents a measure of the capital base of a company and reflects the allowed expenditure to be recovered from future customers. Expenditure not recovered in the current period through PAYG is added to RCV and recovered in future periods through **RCV run-off**. The RCV is inflated each year to maintain the RCV at current prices.
Resilience Objective	Refers to the duty set out in the **Act**, section 2(2A)(e) and has the meaning set out in the **Act**, sections 2(2DA)–2(2DB).
Return on regulatory equity (RoRE)	RoRE is a post-tax measure of return that is calculated with reference to the level of equity in the **notional capital structure**. RoRE is often calculated and presented as a variation from the allowed return on equity based on performance against price review incentives.
RCV run-off	Non-PAYG totex is added annually to the **RCV**. This totex is then recovered through customer bills over a number of years. The rate at which it is recovered is determined by RCV run-off rates.

Term	Definition
RFR	The Risk Free Rate is the theoretical rate of return on an investment with zero risk. It is the benchmark to measure other investments that include an element of risk.
RMA	Retail margin adjustment.
RMSE	Root mean square error.
RPEs	Real price effects.
RPI	Retail prices index.
S&P	Standard & Poor's (the credit rating agency).
SELL	Sustainable economic level of leakage.
Severn Trent (or 'SVE')	Severn Trent Water Limited (also referred to as 'SVE' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
SIC	Standard Industrial Classification, a list of the **ONS** codes used to classify business establishments and other standard units by the type of economic activity in which they engage.
SMR	Sustainable materials reinstatement.
SoC / SoCs	Statement of case / statements of case.
South East (or 'SEW')	South East Water Limited (also referred to as 'SEW' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
South Staffordshire Water (or 'SSC')	South Staffordshire Water plc (also referred to as South Staffs Water in **Ofwat**'s PR24 FD and 'SSC' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
South West Water (or 'SWB')	South West Water Limited (also referred to as 'SWB' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).

Term	Definition
Southern (or 'SRN')	Southern Water Services Limited (also referred to as 'SRN' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
SPS	The UK government's strategic policy statement which sets out the UK government's priorities for **Ofwat**'s regulation of the water sector in England.
SR	Service reservoir.
STC	Sewage treatment collection.
STW	Sewage treatment works.
Sustainability Duty	Refers to the duty set out in the **Act**, section 2(3)(e).
Sutton and East Surrey Water (or 'SES')	Sutton and East Surrey Water plc (also referred to as SES Water in **Ofwat**'s PR24 FD and 'SES' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
TFP	Total Factor Productivity, a rate which is a proxy for technological progress, based on the change in the volume of outputs produced per volume of inputs (ie growth in output not attributable to changes in capital or labour inputs).
Thames Investor Group	An ad hoc group of over 100 financial institutions that are creditors of **Thames Water**, which has made submissions to the CMA as part of the redeterminations.
Thames Water (or 'TMS')	Thames Water Utilities Limited also referred to as 'TMS' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
TI	Time Incentive (eg used in relation to TI **PCD**s).
TMA	Traffic Management Act 2004.

Term	Definition
Total Market Return or TMR	The TMR is the total return that investors require for investing in a diversified basket of equities. It is the sum of the **RFR** and the equity risk premium (**ERP**), which is the part of this return that compensates investors for the additional risk associated with investing in equities, rather than in risk-free assets.
Total expenditure (Totex)	Total expenditure is capital expenditure and operating expenditure.
True-up	A true-up provides some protection to water companies by transferring risk from companies to customers. This can be an ex-post true-up where an adjustment is made after the event, comparing the actual outturn costs to what was originally forecast or an index. An ex-ante true-up is a pre-determined adjustment to a price control allowance based on a forecast.
TWD	Treated water distribution.
UKCSI	The UK Customer Satisfaction Index is a measure of customer satisfaction published twice a year by The Institute of Customer Service. It measures performance in 13 different sectors and is used to measure the improvement or decline of performance in different sectors.
UKRN	UK Regulators Network.
United Utilities (or 'UUW')	United Utilities Water Limited also referred to as 'UUW' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
UQ	Upper Quartile.
VA	Value added. VA is equivalent to gross output minus the value of intermediate inputs required to produce the final output. VA inputs are therefore labour and capital only. This means that productivity changes resulting from

Term	Definition
	variations in the use of intermediate inputs should not be captured in VA measures.
WACC	Weighted Average Cost of Capital.
WaSC	Water and sewerage company.
Water Industry National Environment Programme (WINEP)	Sets out the requirements expected of companies to meet their environmental outcomes in England.
WATS	Weighted average treatment size – a variable used in econometric modelling to account for the different sizes of water treatment works.
Wessex (or 'WSX')	Wessex Water Services Limited (also referred to as 'WSX' within eg the 'Company acronyms' in **Ofwat**'s PR24 glossary).
WHO	World Health Organisation.
WICS	Water Industry Commission for Scotland.
WINEP	Water Industry National Environment Programme.
WoC	Water only company.
WRc	Water Research Centre Group, the firm of engineering consultants assisting the CMA on technical engineering matters in this determination.
WRMP	Water Resources Management Plan.
WRP	Water resources plus.
WTW	Water treatment works.
WW	Wholesale water.
WWTW	Wastewater treatment works.

Term	Definition
Yorkshire Water (or ‘YKY’)	Yorkshire Water Services Limited (also referred to as ‘YKY’ within eg the ‘Company acronyms’ in **Ofwat**’s PR24 glossary).