ST Classification: OFFICIAL COMMERCIAL

Severn Trent

CMA submission

22 May 2020

WONDERFUL ON TAP

CMA – call for submissions

In the attached document, we have set out our views on some of the key issues being considered by the CMA in its redetermination of the price review for four water companies. The decisions taken by the CMA will be an important input into the PR24 methodology and with that lens we have sought to engage constructively, focusing our comments on what we feel are the key areas: (i) incentives; (ii) cost modelling; and (iii) the package in the round.

In putting forward our views on a small number of topics, we have sought to provide a rounded view. Having been part of the Ofwat senior team at PR14 and this time round delivering business plans for one of the largest companies in the sector (Severn Trent) and the smallest (Hafren Dyfrdwy), I'm particularly conscious of the need to find balanced solutions that work for all parties and most importantly our customers.

In this paper we have set out the most critical areas that we think are relevant to delivering the best outcome. For some topics. such as base econometric modelling. we think Ofwat has substantially improved the approach and design of models compared with PR14 which built on the CMA's feedback from the Bristol redetermination. We have therefore set out some incremental improvements that we believe could further improve the robustness and therefore confidence that could be placed in the results.

For other topics such as incentives, we strongly hold the view that balanced symmetrical incentives drive the biggest improvements for customers, as we have seen from our own experience at PR14. We therefore raise some specific points across this topic.

Finally, we recognise that price reviews demand a substantial resource commitment – from extensive customer engagement, to developing detailed plans and incentives that will deliver on our customers' preferences. Given the business plan submission and Final Determination have a huge number of increasingly complex components, it will be very easy for any party to drill down on one specific point and argue that it is right or wrong. This underscores the need for considering the overall approach and outcome "in the round". We also think there are opportunities to create a different pathway which allows high performing companies that show the right behaviours to avoid such time-consuming and costly approach.

We hope our response provides a helpful and positive contribution to the CMA's deliberations and we would be happy to discuss any of these points in more detail.

Shane Anderson

Director of Strategy and Regulation

Severn Trent Plc

Introduction

Over the course of the last five years, water regulation has evolved considerably. The 2014 Price Review (PR14) marked a very welcome change to the course of price regulation in the water sector, with much greater focus put on the need for companies to identify the outcomes that really matter to consumers and to put the delivery of those outcomes at the heart of their decision making. PR19 has built on these changes in a range of important ways, most notably through the development of more robust cost models and performance commitments that were more comparable across companies.

These changes provided a much-needed shift in the way Ofwat applies incentive regulation, with much greater weight on companies having opportunities and incentives to identify and deliver new and innovative ways of improving consumer outcomes. The changes have delivered real benefits for customers over the past five years, including by fostering behavioural change, with companies strongly incentivised to improve their services and to reduce costs.

We welcome the invitation from the CMA to respond to its call for evidence. The decisions taken by the CMA will inevitably be an important input into the PR24 methodology and with that lens we have considered some of the issues raised, notably those relating to (i) cost assessment (modelling and enhancement cases); (ii) incentives; and (iii) looking at the package in the round, looking ahead to PR24 and the possible next steps in the evolution of price reviews.

In making our submission we are not opining on any specific argument but rather setting out the areas that we believe are important to ensuring the best outcome for customers.

Cost modelling

Since PR14, Ofwat has gone to great lengths to improve the process and substance of its econometric cost models. We are particularly supportive of the collaborative and consultative nature through which the PR19 base cost models were first developed ahead of business plan submission. This was typified by the cost assessment working group and its Spring 2018 consultation, which provided companies with an opportunity to input into the process and ultimately promote more robust and representative cost models. From a process perspective, looking ahead to PR24 we think this consultative approach is critical. Where new models are needed then it will be important that the same consultative manner is applied.

In terms of model substance, although no econometric model will be perfect, we think the base models used at PR19 addressed the primary cost drivers in the water and wastewater sectors. To promote the development and adoption of robust models, ahead of PR19 we worked with our operational and engineering teams to produce a cost assessment framework for base models[1]. In our view, having a robust framework is absolutely critical if the cost assessment process is to produce robust models that can be relied upon to provide value insight that can help inform decision on efficient costs.

The framework provided a means for assessing whether the set of explanatory variables in a given base model could be expected to adequately capture all of the identified primary cost drivers – of which there were eleven in water and ten in waste – see the table below.

[1] https://www.severntrent.com/content/dam/stw-plc/our-plans/Severn-Trent-water-cost-modelling-framework-Final.pdf

Primary cost drivers for base expenditure (botex)

Water network plus base expenditure	Wastewater wholesale and network plus botex
1 Scale drivers of cost	**1 Scale drivers of cost**
• distance water must be transported. • number of customers to whom it is distributed. • quantity of water that has to/may have to be transported	• distance sewage has to be transported (network size). • total nutrient load within sewage to be removed before it can be safely returned to the environment (treatment requirement).
2 Network-specific drivers of cost	**2 Network-specific drivers of cost**
• geography and topography over which water must be transported • opportunities for Economies of Scale in the transportation of water • extent to which transportation activities are affected by 'congestion'	• challenges of geography and topography within the network • opportunities for Economies of Scale in the transportation of sewage (Network density) • extent to which transportation activities are affected by 'congestion'
3 Treatment-specific drivers of cost	**3 Treatment-specific drivers of cost**
• opportunities for the economies of scale in water treatment • extent and forms of treatment that are required	• opportunities for the economies of scale in sewage treatment • extent and forms of treatment that are required (Treatment complexity)
4 Other possible underlying non-primary cost drivers	**4 Other possible underlying non-primary cost drivers**
• regional differences in relevant input costs • service quality variations • significance of other customer characteristics	• regional differences in relevant input costs • service quality variations • significance of other customer characteristics

Once Ofwat made changes to account for (i) treatment complexity; and (ii) population density (see our appendix) we considered the final set of base models were robust when considered from an engineering/operational perspective.

Looking ahead to PR24 we think there will inevitably be opportunities to improve the approach to cost assessment, as occurred between PR14 and PR19. We have identified three areas that we think are worth considering:

- Treatment complexity – although the PR19 base models provided some coverage of this cost driver, the use of treatment bands 3-6 encompassed 88% of total water supplied and so the explanatory power was limited. We think there is more logic in using treatment bands 4-6 given there is a significant jump in treatment costs at bands 3 to 4, a point made in Ofwat's Regulatory Accounting Guidelines. This would also provide greater explanatory power because it excludes the cheapest 20%/35% of surface/ground water.

- Considering cost and service – one potential area for development in the PR24 models is to consider how cost and asset health could be integrated. This is relevant in the context of the efficiency challenge which is set by reference to those companies that spend the least. With some stakeholders raising concerns that conceptually this approach leads to "lower quartile" maintenance, an integrated approach (or some form of cross-checks) would be helpful at PR24. This would help prove or disprove the challenge on maintenance spend. Whilst the outcomes framework could address this, the time-lag between investment and many ODIs presents some challenges.

- We therefore think for PR24 there is merit in considering the development of leading asset health measures. This could then inform not only the adequacy of a company's plan (in terms of capital maintenance) but also could be integrated into the regulatory framework. For example, the base models could include these variables or they could be reflected in the outcomes regime.
- Growth – A key challenge at PR14 and PR19 was setting the cost allowance for growth (ie, developer services). Some of the challenges that we observed at PR19 included (i) inconsistent data; (ii) consistency and coherence issues regarding the accounting treatment of contestable activity; and (iii) complexity and lumpiness affecting the relationship between off-site network reinforcement requirements and short term new development volumes (see Section 3.2 of our Draft Determination response). Over the course of 2019 Ofwat sought to address these issues, including through adjustments to its approach and additional data requests. While these changes addressed the issues with inconsistent cost allocation between developer services and base costs, some issues still remained. As we noted in our draft determination response, integrating growth into the base model helped address these points.
- Looking to the future, we think it's beneficial to consider whether a new approach could be adopted. For example, removing developer services, or at least the shallow connections, from the price review completely and relying on the combination of (i) charging rules; and (ii) Ofwat's enforcement powers in both the NAV/self-lay market and charging rules to protect consumers.

Enhancement cases

There will always be a need for the regulatory framework to support enhancement activities given the changing nature of customers' expectations, legal requirements and long-term challenges such as climate change. In our 2019 Business Plan, we submitted wholesale enhancement cases totalling £1,110m and our Final Determination included a cost allowance of £863m, with the biggest gaps relating to security and resilience projects.

Looking ahead to PR24, we think there is scope for improvement in this area. This applies to our own work (such as higher quality business cases) but also in terms of the approach used by Ofwat to assess business cases. For example, greater clarity about the use of modelled versus un-modelled adjustments and clearer guidance on business case requirements would ultimately lead to a better outcome for all parties by supporting more focused and higher quality submissions.

Incentives

One of the key strengths of the water regulatory framework is the use of incentives. However, designing an appropriate package of incentives that not only allows companies to finance their functions, but also drives leading companies to innovate and drive future efficiency and improved services to customers, is not a straightforward matter.

In this note we highlight three aspects from PR19 that are important to retain and build upon at PR24:

- cost of debt;
- outcome delivery incentives; and
- business rates.

Cost of debt

An important strength of the regulatory framework is incentivising companies to reduce their financing costs. We believe the current approach of setting a sector-wide allowance for the cost of debt has worked well. It provides a strong incentive for companies to reduce debt costs over time that ultimately benefits consumers when prices are reset (ie, Ofwat uses the information to reset the cost of debt allowance). We think it is critical to retain this feature of the regulatory framework to ensure customer interests are served over multiple AMPs.

ODIs

Symmetric incentives

When considering the role of ODIs we think it is critical that there is genuine and equal scope for upside and downside. We do not think asymmetric incentives are in the best interest of customers as they will not drive the innovation needed to address the significant challenges of climate change, population growth and growing customer expectations.

In the water sector past experience clearly illustrates the importance of genuine upside opportunities to drive dynamic efficiency improvements. The 2009 Cave review highlighted the potential benefits of innovation for customers and the environment but also identified the water sector as exhibiting weak incentives for innovation. The Gray review identified ways in which the regulatory framework could engender a lack of ambition, and highlighted a concern that the balance of risk and reward had been tilted too far towards uncertain and potentially large penalties for failure, with relatively limited rewards for outperformance or innovation.

Research on the implications that rewards and penalties within organisations can have on innovation also provides support for this assessment.[2] A distinction has been drawn between 'radical' and 'incremental' innovation (where radical innovation refers to substantial shifts from existing services or procedures, and incremental innovation refers to more minor shifts). This distinction suggests that, while the use of penalties has been identified as conducive to incremental innovation, the availability of rewards has been identified as more important for radical innovations. For example, over AMP6 we have moved from lower quartile on external sewer flooding to upper quartile/frontier.

Therefore, when thinking about the future design of service incentives, we strongly support the need for symmetrical incentives to drive the step change in performance that is needed to address the challenges of the future.

We see this as particularly relevant in the context of a number of sewerage measures, where we are facing an incentive rate on the penalty side that is notably larger than the corresponding reward. For example, the penalty rate is two times higher than the reward for public sewer flooding, 2.4 times higher for external sewer flooding and three times higher for sewer collapses. Our own experience is that this adds a layer of complexity to decision making. For example, a business case may be cost-beneficial to avoid a penalty, but it will not deliver improvements beyond the target. One solution might be to set even more stretching targets; however, this creates two issues:

- outperformance payments are a means to fund future improvements, and so assuming even more service improvements can be delivered through the base cost allowance would make the package unbalanced; and
- penalty only measures leads to incrementalism and avoids the types of innovation and culture change that are needed to help address the challenges of the future (see above).

To create the right culture and long-term incentives for customer service we think it is important that incentives are balanced.

Reward incentives

The ability of incentives to drive behaviour once rewards are included is something that we feel is worth drawing out. In our experience, having reward incentives available alongside penalties is what

[2] See, for example, Chen, C.X., Lill, J.B. & Lucienetti, L. (2015) Carrots or Sticks? The effect of incentive framing on radical or incremental innovation.

really drives performance. If we look at pollutions across the sector in AMP6, we see that performance was strongest where companies had financial incentives made up of both penalties and rewards. The available data on pollutions performance indicates that where penalty and reward incentives were applied, companies consistently outperformed their targets. By contrast, those with penalty-only incentives appear to have fallen some way short of this consistency. We therefore think that it is important that the potential for such outcomes is considered when deciding on the design on incentives.

Aligning incentives

A key feature of well-designed incentives is making sure that they are aligned with (i) each other, so that a company is not pulled in competing directions, and (ii) incentive and enforcement regimes already in place with other regulators such as the DWI and the Environment Agency.

There is one ODI, CRI[3], where we think that there is potential for much greater alignment between regulators. This is an incentive that we consider should be reputational only on the basis that the DWI has its own enforcement powers. In PR19 this has been set as a penalty-only incentive – effectively doubling-down on the incentives already in place with the DWI. The result is that CRI is now an extremely high-powered incentive – the third strongest ODI on average across the sector in financial terms before the DWI's own enforcement powers are taken into consideration.

Our concern with doubling down is amplified by whether the ODI metric provides a sufficiently robust basis for setting incentive rates. The CRI is an innovative measure; however, it is very much in its infancy and naturally does not have the same rigour as other established ODIs like sewer flooding. This means that assessments that are more subjective in nature and hence less suited to mechanistic incentives like ODIs.

Business rates

Consistent with the two points above, we also believe the approach to business rates needs to consider the role of incentives. As highlighted in our Draft Determination Response we think it is important that incentives are retained to reduce customer bills through the engagement with the Valuation Office Agency (thereby keeping bills low) whilst also acknowledging that to a large degree the costs are outside management control. Retaining some form of cost sharing on this item (and items with similar features where costs are primarily outside management control) is critical to maintaining this balance.

Package in-the-round

The final point that we want to make about PR19 relates to ensuring there is an overall consideration of the package in the round. This applies to both how prices and services are set, but also how performance is assessed over 2020-25.

The PR19 settlement was one of the most stretching in the sector's history, with the challenge on cost and service exceeding all past reviews. We are pleased to have met the challenge of PR19 – attaining fast track status has provided us with the opportunity to prepare (for example through additional totex investment last year) and, ultimately, positively embrace AMP7. This is reflected in our Q3 Trading Update published in January 2020.

We recognise that price reviews demand a substantial resource commitment – from extensive customer engagement, to developing detailed plans and incentives that will deliver on our customers'

---

[3] Compliance Risk Index (CRI) is a measure designed to illustrate the risk arising from treated water compliance failures and aligns with the current risk-based approach to regulation of water supplies used by the Drinking Water Inspectorate (DWI).

preferences. With any review of this nature, individual companies can expect to see variations in the level of stretch and challenge across their own business and in comparison with the rest of the sector. We therefore think it is important that all parties consider the package in-the-round when assessing the merits of any particular decision.

In our view, the value of such in-the-round assessments should not be underestimated. Our concern is that it may easy to identify specific elements of a price review that, in isolation, could make it look like a regulator has reached the wrong decisions on its final determination. Were we to be presented with evidence of this nature, our instinct would be take a step back for a broader perspective before taking any decision on the next course of action.

Looking ahead to PR24, we also believe that there is an opportunity for regulatory innovation in this space. For example, it could establish a mechanism or process that allows for this wider in-the-round view to be captured, tested and factored into the early stages of decision making process. This would also help address concerns that might be raised about issues relating to financeability.

One consideration for PR24 is it could reinforce the benefits of Fast Track status. We feel that these were not quite as strong at PR19 as they were at PR14. For example, PR19 offered early certainty on a narrower range of a Business Plan than at PR14. Fast Track companies also saw a number of interventions made on their Business Plans, which could act to increase the asymmetric information challenge for Ofwat at PR24. We see that these interventions will have signalled that companies can expect interventions irrespective of the quality of their individual plans. If that is a case, we can see that companies might choose to hold back from revealing their full hand in their Business Plans so that they have some cushioning available when interventions take place.

One way to address this would be to increase the procedural benefits of a fast track pathway. For example, giving companies a lighter-touch review at PR24 if they showed the right behaviours and performance throughout AMP7 – ie putting more weight on actions than words. This would provide an extremely powerful incentive for companies to deliver throughout the AMP and place less weight on what is submitted in a plan.

Appendix – Base services: Cost assessment

Establishing robust econometric models is a key a central features of price reviews. It is vitally important for making sure customers receive the future services that they desire, at an affordable price.

We recognise that developing robust econometric cost models in the water sector is very challenging. Ofwat's modelling approach for PR19 represented a major improvement on that used for PR14. It also addressed the majority of the concerns raised by the CMA, following the Bristol appeal and also applied a much more transparent process for developing its models.

Base services – cost assessment framework

We are conscious that the process for developing models is not straightforward because costs are impacted by a range of interrelated factors. At PR19, we worked with our operational and engineering teams, along with specialist consultants, to produce a framework to arrive at a good set of models for the sector. The framework provided a means for assessing whether the set of explanatory variables in a given model can be expected to adequately capture all of the identified primary cost drivers – of which there were eleven in water and ten in waste (see the table below).

Primary cost drivers for base expenditure (botex)

Water network plus base expenditure	Wastewater wholesale and network plus botex
1 Scale drivers of cost	**1 Scale drivers of cost**
• distance water must be transported. • number of customers to whom it is distributed. • quantity of water that has to/may have to be transported	• distance sewage has to be transported (network size). • total nutrient load within sewage to be removed before it can be safely returned to the environment (treatment requirement).
2 Network-specific drivers of cost	**2 Network-specific drivers of cost**
• geography and topography over which water must be transported • opportunities for Economies of Scale in the transportation of water • extent to which transportation activities are affected by 'congestion'	• challenges of geography and topography within the network • opportunities for Economies of Scale in the transportation of sewage (Network density) • extent to which transportation activities are affected by 'congestion'
3 Treatment-specific drivers of cost	**3 Treatment-specific drivers of cost**
• opportunities for the economies of scale in water treatment • extent and forms of treatment that are required	• opportunities for the economies of scale in sewage treatment • extent and forms of treatment that are required (Treatment complexity)
4 Other possible underlying non-primary cost drivers	**4 Other possible underlying non-primary cost drivers**
• regional differences in relevant input costs • service quality variations • significance of other customer characteristics	• regional differences in relevant input costs • service quality variations • significance of other customer characteristics

A key feature of our framework was the objective to adequately capture – rather than fully capture – these primary cost drivers. This meant that models could remain suitably simplistic by avoiding the need to have an explanatory variable to reflect each one of the primary cost drivers. This approach recognises that drivers may be captured indirectly, or outside of the model (say, through pre-modelling adjustments), while also providing a basis for identifying where drivers are significant, but not captured in one of these ways. To our mind, following this type of framework is critical for making sure that material factors are not unwittingly omitted from the models without a clear basis.

We used this framework to develop our own models at PR19 and feed our views into Ofwat thoughts at various stages of consultation, including the specific consultations that it held on econometric cost modelling. We also note that our approach aligns with what Ofwat did at PR19.

In our view, the logic for such a framework is extremely powerful, because without one there is every risk that the models will be mis-specified and consequently fail to provide sufficiently robust estimates of the sector's costs.

The PR19 base cost models

As noted above, robust econometric models are a crucial part of the process for making sure that the price of future services is affordable for customers through a fair efficiency challenge. In developing the cost models for PR19, Ofwat regularly consulted with the sector companies on its plans and proposals for the models. By drawing on the expertise and insight available in the sector, Ofwat was able to build on a greater breadth of information and knowledge, and so improve the robustness of the models.

Our experience of the process was positive and we were able to make a number of important contributions that helped to significantly enhance the robustness of the final models. The most notable of these were in relation to:

- treatment complexity and
- the ability of the models to understand the intricate interactions between asset structure and economies-of-scale.

We talk through both of these in a little more detail in the following paragraphs.

Waste – treatment complexity

Treatment complexity is a primary driver of wastewater treatment costs and – given the relative scale of those costs – of network plus and wholesale costs. Treatment complexity is not just a function of the nutrient load of the wastewater to be treated, but also of the condition and sensitivities of the receiving waters available to the company – which will be affected by a range of environmental factors.

Amongst the early models, 8-out-of-10 network plus models and 6-out-of-8 wholesale wastewater models did not account for wastewater treatment complexity. Of the other two wholesale models, account was only taken through inclusion of the percentage of load from trade effluent customers. Our views of these models were that the treatment models, most of network plus models, and all of the wholesale models did not adequately capture this primary cost driver.

In those models that sought to capture treatment complexity directly, a single measure was used – the percentage of load subject to an ammonia consent of <1mg/l. It is clearly the case that works with ammonia consents of <1 mg/l will require complex and costly treatment processes. But, in practice, most companies (all but two) have very few or no ammonia consents as stringent as the 1mg/l threshold.

In broad terms, using ammonia consents to reflect treatment complexity is sensible and logical. In practice, where the sector sees tight ammonia standards it usually sees them accompanied by stringent BOD consents – a combination that (i) serves to make the treatment process more complex and (ii) drive up costs as a result. One example of the way this comes about is the need for the BOD-related stage of the process (BOD oxidisation) to take place before the ammonia-related stage (nitrification). This results in energy needs that are 30-50% greater than treatment that involves just a tight BOD consent and no ammonia consent.

Our view on how to improve the waste models was to use broader measures (such as ‘percentage of load with ammonia consents <3mg/l’) which better capture differences between companies. This is because delivering against a <3mg/l consent requires a similar technological process, and is likely to increase costs (relative to less stringent consents) by an amount that is only marginally lower than the increase that would result from meeting a <1 mg/l consent. This view was explored, tested and ultimately supported by independent consultants (Jacobs). It was also consistent with previous work commissioned by Ofwat (2006).

In terms of the <1mg/l limit used in the early models, this effectively implied that costs were only materially affected by treatment complexity for two companies. This meant that they were not representative or realistic and would have had a knock-on impact on the adequacy of the model coverage and results. By increasing the boundary for ‘tight’ (and therefore costly) consents from 1 to 3mg/l, we saw a corresponding increase in the number and distribution of relevant sites across the industry. This is significantly more representative of the distribution of treatment complexity across the country and improves model performance.

Our view was that all the PR19 wastewater cost models should include a variable for treatment complexity. This was a change that was made in all the final models used by Ofwat for these cost categories and the variable it chose to use was the number of tight ammonia consents base on the <3Mg/l threshold. The end result was a much more powerful and robust set of models for assessing efficient wastewater costs across the sector.

Water – treatment complexity

Treatment complexity is also a primary driver of water treatment, network plus and wholesale costs. It is a function of the type of water resources available to a company and the condition of those sources. There are significant differences between companies given the different water resource options that are available (and the effect of environmental circumstances on the condition of those resources), and thus on the extent and forms of treatment that are likely to be required.

Across the ten early models that Ofwat developed for **water treatment costs**, two different variables were employed to represent treatment complexity – (i) six models used the percentage of Distribution Input (water inputted to the distribution network) sourced from boreholes (ground water) and (ii) four models used the percentage of water treated at works in bands 3-6.

The challenge with both variables is that they are very broad and so they struggle to capture material differences in circumstances that drive costs. In the case of groundwater, even though it is often thought to need only limited treatment, that is not always the case. A further complication is that highly material differences in the cost of treating surface water of differing quality are omitted from the models.

On first inspection, the variable for the percentage of water treated at works in band 3-6 might appear to offer a way of capturing relevant differences in treatment requirements. In practice, the measure is so broad – because it includes all but 12% of the total water supplied to English and Welsh customers – that it will include most surface water treatment irrespective of quality and treatment requirement differences. The reasons why this variable was preferred were unclear and contrasted with the advisory work undertaken for Ofwat by CEPA[4]. In that work, CEPA used a narrower range of treatment works – bands 4-6. In our view, this is likely to provide a much better means of trying to capture relevant cost differences, because the works in these categories use processes that incur significantly higher operating costs than the simpler practices used by works in the lower bands. We also felt it would be more consistent with Ofwat’s RAG definitions.

[4] https://www.ofwat.gov.uk/wp-content/uploads/2018/03/CEPA-cost-assessment-report.pdf

In the early models for water network plus and water wholesale, the approach to treatment complexity was much less clear. In some of the models, it looked as though different Average Pumping Head (APH) measures were introduced as a means of capturing treatment complexity, as summarised in the table below.

Variables used to capture treatment complexity in the early water models

	Models using the Band 3-6 measure	Models using APH measures
Network plus models	4 out of 8	4 out of 8
Wholesale models	3 out of 12	9 out of 12 models use APH for water resources

What these approaches indicated, and our own analysis supported, is that there is no straightforward way to capture drivers of treatment complexity costs. The key challenge for these early models was that they were blind to the fact that surface water treatment requirements can differ materially.

Our thoughts were that a broader range of variables was desirable, in order to better reflect the relevant different dimensions of treatment complexity that can materially impact costs. Expert insight from our engineers was that a more effective way of doing this would be to focus on the differences between only the most complex works and the cheapest. We therefore proposed using the proportion of water in treatment bands 4-6, thereby excluding the cheapest 20%/35% of surface/ground water and allowing the variable to better describe the true variances in treatment complexity across companies.

For its final models, Ofwat made changes to better capture treatment complexity. It did this by introducing a weighted average complexity measure. The measure was calculated by using the volume of water treated by each band of works, and then weighting these by 1-7 across each of the works band 0-6. In other words, the simpler lower-cost bands had lower weights and the higher-cost more complex bands had higher weights.

This new variable did bring some methodological advantages. By giving a higher representation to costlier treatment processes (all else equal) it avoids lower-cost band 4 works being implicitly assigned the same costs as a more expensive band 6 works – a problem that was encountered with both the bands 3-6 and bands 4-6 variables. However, the linear approach to weighting assumes that complexity-related costs increase on a linear basis across the treatment bands. This is perhaps one area for further development at PR24

Water – population density (weighted-density) and booster stations

Our view of the final PR19 models is that their ability to estimate efficient water costs was greatly improved by two of the variables that were chosen. The first of these was weighted-population density (or weighted-density), which we discuss here, and the other was booster stations, which we pick up in the following section below.

The **weighted-density** variable has the potential to play two important roles. The first is in its relationship with operating expenditure, where costs are often thought to vary non-linearly with density – at both extremes of density, costs are likely to rise due to smaller asset sizes for rural networks and because of higher congestion and labour costs for urban networks. Its second role relates to how it influences the asset structure of firms with larger/more-dense populations which can enable them to take advantage of larger and often cheaper assets. However, we would note that the natural restrictions on the availability of water resources and differences in topography in different areas means that this latter point does not always hold true, hence the importance of having an additional variable, which in this case was booster stations.

We consider the **booster stations** variable to provide a helpful way of capturing the energy costs involved with operating a water network. These are material costs for water companies because water is heavy – just one cubic metre weighs one metric tonne – and requires a lot of energy to move it around the network. In practice, the number of booster stations on any given network will have been driven by engineering-related factors such as the number of pumps needed to move water and maintain pressure in more rural areas. So, it is logical to think that the counting the number of booster stations will really help the models to understand how energy costs for water companies vary across the country.

Our analysis has found that having **weighted-density and booster stations present in the same model** brings further benefits. In the absence of an explicit measure of network asset intensity (such as booster stations), the density variable would be proxying for all factors that change as population density changes. While asset intensity and density are highly correlated, they are not perfectly so – because of differences in topography across regions. So, without a network asset intensity measure, models would not fully capture all costs related to these assets and the shape of the density curves would be biased (shifted to the right in this case). When the models include the booster stations variable, we see a lower point of inflection in the density relationship, thereby reflecting the fact that density is now interpreted separately from asset intensity.