South West Water (SWW) Limited

Cost model consultation response

4 May 2018

Contents

1. Introduction

For our response to the cost modelling consultation, we have focused on whether the models submitted capture what we consider to be the key industry drivers of costs that are operationally robust, of the right significance and order of magnitude and best explain differences in costs between companies.

Given the large number of models submitted, we have not provided comments on each individual model that has been submitted by other companies. Instead we have focused on the Ofwat's models and have provided comments on each of them (see sections 2 to 5). In addition, with regards to the models submitted by other companies, we do have a number of general comments.

We note that some models appear to us to be overly complex, such that they are difficult to interpret. Moreover, in some cases, when these models are examined in further detail, we find that the results provide counter-intuitive relationships across companies and/or do not seem to be robust to changes in the data set. As such, we would not support the use of models exhibiting these traits.

It is important that any model used for PR19 makes operational sense for all companies and thus, if more complex models are to be used, they should be tested to ensure that they are aligned with industry expectations.

As per our main response on cost adjustments, there are also a large number of models submitted that do not appropriately capture, in our view, the key drivers of costs in the industry. Namely,

- an appropriate scale driver for the costs being modelled
- sparsity/density/topography and the associated complexity of network and asset base
- raw water source type/complexity of water treatment
- local environmental sensitivities/wastewater treatment complexity
- resilience/condition/age of network and the impact on maintenance costs.

In many cases the omissions are across many of these key factors.

Equally, models should be balanced as far as possible. For example, we find that both sparsity and density increase costs in water services. We note that some submitted water service models only capture density. A model that only captures one aspect would provide a biased picture of some companies' efficient cost level. As such, we would not support the use of such models. In contrast, while we have tested for a similar 'balance' for wastewater services, we find that sparsity is the dominant factor. In either case, it is important that it is demonstrated that the model appropriately captures the characteristics for the activity being modelled.

Generally, we are disappointed to see that the vast majority of the submitted models focus on BOTEX. Benchmarking companies based on their totex spend plays an important role in capturing the synergies between opex and capex spend and ensuring that companies are rewarded for innovative solutions that reduce costs overall rather than in one particular area. We consider that this, combined with developing the enhancement cost modelling, will be a key area of future development.

We note that, across the value chain, some models seem more robust than others, in that some models (e.g. water resources, water treatment, bioresources, enhancement expenditure for water and wastewater) result in broad ranges in estimated efficiency scores that cannot be explained by differences in efficiency alone. In several cases, this is probably due to the trade-offs that exist across the value chain and this will need careful consideration when applying the models to determine efficient cost allowances.

Overall, we have found this consultation to provide a useful starting point in the development of the models for PR19. While there are many models that we do not think are robust enough to be used for the purpose of setting cost allowances, we also consider that there are some models that have been submitted that could be useful in that they appear to capture many of the key drivers of costs in the industry, are transparent, appear aligned with industry expectations and perform reasonably well in terms of the range of estimated residuals, for example.

Clearly, there is still more work to do to develop the suite of models for PR19, including further data adjustments and a further year of data. We would also welcome further opportunities to assist Ofwat and industry in developing this key area for PR19.

2. Summary

This document represents our response to the cost models proposed by Ofwat. In this section, we have used Ofwat's template to highlight whether we have concerns for each of the models and provide a brief summary of what those concerns are. As per Ofwat's template, the colours signify:

- **Red -** major concerns with proposed model.
- **Amber -** some concerns with proposed model.
- **Green -** minor or no concerns with proposed model.

2.1 Wholesale water model summary

Modelling area	Model ID	RAG status	Comments (please include your reasoning for the chosen RAG status)
Water resources	OWR1	●	Ignores trade-offs. Wide efficiency range
	OWR2	●	Ignores trade-offs. Wide efficiency range. Pumping driver is not significant
Water treatment	OWT1	●	Ignores trade-offs. Wide efficiency range
	OWT2	●	Ignores trade-offs. Wide efficiency range
	OWT3	●	Ignores trade-offs. Wide efficiency range. Potential pumping allocation differences
	OWT4	●	Ignores trade-offs. Wide efficiency range. Potential pumping allocation differences
	OWT5	●	Ignores trade-offs. Wide efficiency range. Treatment complexity driver should include source type. Potential pumping allocation differences
	OWT6	●	Ignores trade-offs. Wide efficiency range. Treatment complexity driver should include source type. Potential pumping allocation differences
	OWT7	●	Ignores trade-offs. Wide efficiency range. Treatment complexity driver should include

			source type. Potential pumping allocation differences
	OWT8	🔴	Ignores trade-offs. Wide efficiency range. Treatment complexity driver should include source type. Potential pumping allocation differences
	OWT9	🔴	Ignores trade-offs. Wide efficiency range. Potential pumping allocation differences
	OWT10	🔴	Ignores trade-offs. Wide efficiency range. Potential pumping allocation differences
Water Resources Plus	OWRP1	🟡	Direct measure for economies of scale in resources. No measure for treatment
	OWRP2	🟡	Direct measure for economies of scale in resources. No measure for treatment. Economies of scale are represented by population
	OWRP3	🔴	No direct measure for economies of scale
	OWRP4	🔴	No direct measure for economies of scale
	OWRP5	🔴	No measure for economies of scale
	OWRP6	🔴	No measure for economies of scale
	OWRP7	🔴	No direct measure for economies of scale
	OWRP8	🔴	No direct measure for economies of scale
Treated Water Distribution	OTWD1	🔴	Network costs not fully captured
	OTWD2	🔴	Network costs not fully captured
	OTWD3	🔴	Network costs not fully captured
	OTWD4	🔴	Network costs not fully captured
	OTWD5	🟢	Model captures U-shape relationship through use of mains as a driver and property density
	OTWD6	🟢	Model captures U-shape relationship through use of mains as a driver and property density
	OTWD7	🟢	Model captures U-shape relationship through use of mains as a driver and property density
	OTWD8	🟢	Model captures U-shape relationship through use of mains as a driver and property density
Network Plus Water	ONPW1	🔴	No treatment complexity. Network costs not fully captured
	ONPW2	🔴	No treatment complexity. Network costs not fully captured
	ONPW3	🔴	Network costs not fully captured
	ONPW4	🔴	Network costs not fully captured
	ONPW5	🔴	No treatment complexity
	ONPW6	🔴	Magnitude of density impact too high
	ONPW7	🔴	No treatment complexity
	ONPW8	🟢	Treatment complexity and network costs for companies operating in areas with sparse populations captured
Wholesale Water	OWW1	🔴	No network complexity. No treatment complexity
	OWW2	🔴	No treatment complexity

	OWW3	🔴	No treatment complexity
	OWW4	🟡	No network complexity measure. Network costs not fully captured
	OWW5	🟡	Network costs not fully captured
	OWW6	🟡	Network costs not fully captured
	OWW7	🔴	No network complexity. No treatment complexity
	OWW8	🔴	No treatment complexity
	OWW9	🔴	No treatment complexity
	OWW10	🔴	No network complexity. No treatment complexity
	OWW11	🔴	No treatment complexity
	OWW12	🔴	No treatment complexity

2.2 Wholesale wastewater model summary

Modelling area	Model ID	RAG status	Comments (please include your reasoning for the chosen RAG status)
Bioresources	OBR1	🟡	No direct measure for economies of scale
	OBR2	🟡	No direct measure for economies of scale
	OBR3	🟡	No direct measure for economies of scale. Doesn't need secondary inter-siting driver
Sewage Treatment	OSWT1	🔴	Constant returns to scale. No treatment complexity
	OSWT2	🔴	Constant returns to scale. No treatment complexity
	OSWT3	🔴	Constant returns to scale. Treatment complexity driver not appropriate
	OSWT4	🔴	Constant returns to scale. Treatment complexity driver not appropriate
	OSWT5	🔴	Constant returns to scale. Treatment complexity driver not appropriate. Double counting of load and trade effluent
	OSWT6	🔴	Constant returns to scale. Treatment complexity driver not appropriate. Double counting of load and trade effluent
Bioresources Plus	OBP1	🔴	No treatment complexity
	OBP2	🔴	No treatment complexity
	OBP3	🔴	No treatment complexity
	OBP4	🔴	No treatment complexity
	OBP5	🔴	No treatment complexity
	OBP6	🔴	No treatment works scale. Treatment complexity driver not appropriate
	OBP7	🔴	No treatment works scale. Treatment complexity driver not appropriate
Sewage Collection	OSWC1	🟡	Properties better scale driver
	OSWC2	🔴	No driver for complex wastewater network

	OSWC3	🟡	Properties better scale driver. No driver for complex wastewater network. % gravity sewers rehabilitated has an insignificant and large coefficient
	OSWC4	🟡	No driver for complex wastewater network. % gravity sewers rehabilitated has an insignificant and large coefficient
	OSWC5	🟡	No driver for complex wastewater network. % gravity sewers rehabilitated has an insignificant and large coefficient
Network Plus Wastewater	ONPWW1	🔴	No treatment complexity. No driver for complex wastewater network
	ONPWW2	🔴	No treatment complexity. No driver for complex wastewater network
	ONPWW3	🔴	No treatment complexity. No driver for complex wastewater network
	ONPWW4	🔴	No treatment complexity. No driver for complex wastewater network
	ONPWW5	🔴	No treatment complexity. No driver for complex wastewater network
	ONPWW6	🔴	No treatment complexity. No driver for complex wastewater network
	ONPWW7	🔴	No treatment complexity. No driver for complex wastewater network
	ONPWW8	🔴	No treatment complexity. No pumping costs/asset complexity. No driver for complex wastewater network
	ONPWW9	🔴	Treatment complexity driver not appropriate. No driver for complex wastewater network
	ONPWW10	🔴	Treatment complexity driver not appropriate. No driver for complex wastewater network
Wholesale Wastewater	OWWW1	🔴	No treatment complexity. No driver for complex wastewater network
	OWWW2	🔴	No treatment complexity
	OWWW3	🔴	Treatment complexity driver not appropriate. No driver for complex wastewater network
	OWWW4	🔴	No treatment complexity. No driver for complex wastewater network
	OWWW5	🔴	No treatment complexity. No driver for complex wastewater network
	OWWW6	🔴	Treatment complexity driver not appropriate. No driver for complex wastewater network
	OWWW7	🔴	No treatment complexity. No driver for complex wastewater network
	OWWW8	🔴	No treatment complexity. No driver for complex wastewater network

2.3 Retail model summary

Modelling area	Model ID	RAG status	Comments (please include your reasoning for the chosen RAG status)
Retail Bad Debt	ORDC1	🔴	Constant returns to scale imposed
	ORDC2	🔴	Constant returns to scale imposed
	ORDC3	🟢	Model captures bill size, deprivation and economies of scale in debt management
	ORDC4	🟢	Model captures bill size, deprivation and economies of scale in debt management
	ORDC5	🔴	Constant returns to scale imposed
	ORDC6	🔴	Averaging of cost drivers inappropriate given observed and expected changes to efficiency in AMP6
Totex less bad debt	OROC1	🔴	Constant returns to scale imposed. Doesn't control for metering
	OROC2	🔴	Constant returns to scale imposed
	OROC3	🔴	Doesn't control for metering
	OROC4	🟢	Model captures dual customers, metering and economies of scale
Retail Total Expenditure	ORTC1	🔴	Constant returns to scale imposed. Doesn't control for deprivation
	ORTC2	🔴	Constant returns to scale imposed. Doesn't control for deprivation. Doesn't control for metering
	ORTC3	🔴	Constant returns to scale imposed
	ORTC4	🟡	Should be robust to using alternate deprivation measures

2.4 Enhancement model summary

Modelling area	Model ID	RAG status	Comments (please include your reasoning for the chosen RAG status)
Enhancement - lead	OE1	🔴	Model predicts negative costs
	OE2	🔴	Model predicts negative costs
	OE3	🟡	Model captures two key drivers of costs: the number of pipes and the number that need to be replaced
Enhancement - new developments & new connections	OE4	🔴	Inappropriate growth driver
	OE5	🟡	Model controls for appropriate driver
Enhancement - first time sewerage	OE6	🔴	Wide efficiency range. Potential smoothing data issue
	OE7	🔴	Potential smoothing data issue
	OE8	🔴	Potential smoothing data issue
Enhancement - sewage growth	OE9	🔴	Wide efficiency range. Potential smoothing data issue
	OE10	🔴	Wide efficiency range. Potential smoothing data issue
	OE11	🔴	Wide efficiency range. Potential smoothing data issue
	OE12	🔴	Wide efficiency range. Potential smoothing data issue

3. Key drivers of costs in the water industry

The ongoing operation of water and wastewater services is relatively simple. Indeed, the general costs of running a water company are driven by only a handful of key drivers which are summarised by service area below.

3.1 Water cost value chain

On the wholesale water cost side, the key drivers include:

- **scale -** which represents the size of the company and is the main cost driver. Different measures of scale are more relevant to different parts of the value chain such as volume of water treated for water treatment costs and properties or length of main for water distribution costs. Across the water industry the companies vary significantly in size and across the value chain there can be significant benefits from economies of scale. For example:
  - overheads - many back office functions benefit from economies of scale such as regulation or finance teams
  - water treatment costs
- **density / sparsity** - which affects the location of sources versus the population, asset complexity and whether economies of scale can be achieved. This drives network cost representing 58% of total costs. There are increased costs associated with operating in densely populated urbanised areas because access and maintenance to the network is complex due to traffic congestion road closures and congested underground utilities. Equally, there are increased costs associated with operating in sparsely populated rural areas due to requiring increased infrastructure to reach the population (including additional pumping and leakage control), smaller works which have higher unit costs and increased travel costs
- **source water quality -** which drives the required complexity of water treatment and therefore the treatment cost, which represent 31% of total costs. This is generally driven by the type of sources that a company has in its region
- **resilience / condition / age of network -** which affects maintenance and requirement for infrastructure upgrades.

Input prices affect the whole value chain from chemicals in treatment to labour costs. However, in general, there are not significant differences in input prices across the industry.

3.2 Wastewater cost value chain

On the wholesale wastewater cost side, the key drivers include:

- **scale -** drives the load to be treated and disposed. In wastewater scale is a key driver because smaller treatment works have much higher unit costs. Some companies have very large wastewater treatment works (WWTW) that treat a population equivalent of up to 3.57 million1 population equivalent (over three time greater than that of SWW's entire operating area) which are able to take advantage of significantly lower unit costs. Different measures are more relevant to different parts of the value chain such as load is the most direct driver

[1] Beckton treatment works

for wastewater treatment costs, while sludge produced is the most direct driver for bioresource costs

- **density / sparsity -** which affects the wastewater network differently to the water network2 because the sewer network is expensive to construct, so sparse networks are generally built to serve small catchment areas. Densely populated urbanised areas have increased network costs associated with operating in congested areas but have reduced treatment and sludge costs as a result of having larger treatment works serving densely populated areas. Sparsely populated rural areas have increased treatments costs due to requiring many small works scattered across a sparsely populated region
- **local environmental sensitivities -** such as bathing waters drive the tightness of discharge permits which in turn determine the required complexity of wastewater treatment. This affects treatment cost, which represent 46% of total costs
- **resilience / condition / age of network -** which affects maintenance and requirements for infrastructure upgrades.

Input prices affect the whole value chain from chemicals in treatment to labour costs. However, in general, there are not significant differences in input prices across the industry.

3.3 Retail cost value chain

On the retail cost side, the key drivers include:

- **scale -** affects costs directly as the business focuses on how each customer is treated. There may be some economies of scale within retail costs (excluding bad debt costs) through more efficient overhead operation
- **scope -** dual service customers can be more expensive to serve than single service customers, subject to some economies of scope in some retail services (for example meter reading)
- **bill size and deprivation -** affects costs as customers who face higher retail bills and are in more challenging circumstances require companies to take greater steps to implement affordable bill repayment schemes and other debt management measures, as well as being more likely to default on water bills
- **meter penetration** - customers with meters incur additional metering costs. Whilst there may be some economies of scale in metering opex, as it's more likely that several metered customers reside close to one another, we might expect this to be offset by the profile of customers who are metered. In particular, if comparing a company with 40% metering penetration to 80%, the company with 80% may have proportionally more customers residing in rural communities, depending on the dynamics of which customers are metered first.

We do not consider differences in input prices between companies (in particular labour costs) to be material retail cost drivers.[3] Given that a call centre can be located anywhere in the UK, we do not

[2] As stated by CEPA in PR14 'In network models, we expect it to carry a positive coefficient due to increased costs associated with operating in urbanised areas. In treatment/ sludge models we expect a negative coefficient due to the ability to have larger, more efficient treatment plants serving densely populated areas. For these reasons, the expected sign of the density coefficient in combined models (capturing both network and treatment & sludge) is ambiguous'. Based on our modelling, we find that sparsity more than offsets any density effect, and thus we found no evidence of a u-shape.

[3] For which the main input in the retail business is labour.

consider this to be material 'in the round'. Equally there are not significant differences in regional wages, other than in London. We will be developing a position on whether input prices vary materially over time for September 2018, in support of our business plan submission.

4. Wholesale water model responses

Our general comments on Ofwat's wholesale water service models are provided below.

4.1 Resources models

Ofwat only considers two simple water resources models. One model controls for scale only (OWR1) and the other controls for scale and average pumping head in water resources (OWR2).

We consider the key issues in the submitted water resources models to be:

- **scale -** Ofwat uses connected properties as a scale driver in both water resources models. We believe volume of water treated or delivered to be a better scale measure conceptually for this service, as it links directly to the volume of work done (in particular pumping). Ofwat notes that volume is more intuitive but that it suffers from endogeneity, however, we believe that the use of connected properties does not account for high use industry. We therefore believe that volume should be used in the models
- **wide range of efficiency estimates / application of an upper quartile (UQ) benchmark to a model with omitted variables** - water resources models suggest an implausibly wide range of company outcomes with a total range of over 160% for both models. By comparison the maximum range of efficiency scores across wholesale water models submitted across all companies is 100%. All but two wholesale water models give a range of less than 70%, less than half that of the water resources models. Given the possibility that a large proportion of the error term is down to omitted variables in the model, we would consider a UQ benchmark based on these cost assessment models to be an inappropriate target to apply to companies. Not only would such a target likely over-state the scope of efficiency improvements to be made, there is a real likelihood that high performing companies would be penalised within such a model
- **trade-offs across the value chain -** we think that modelling the water resource part of the value chain in isolation is problematic due to ignoring the trade-offs with water treatment[4] and the wide efficiency score that result from the modelling. Due to the ignored trade-offs between parts of the value chain, the estimated efficiencies do not relate solely to efficiency and would result in 'cherry picking'. That is, it is not possible to be UQ on resources (companies with predominantly surface water sources) and simultaneously UQ on treatment (companies with predominantly borehole sources)
- **The coefficient on average pumping head** - in model OWR2 is not statistically significant which implies there may omitted variables that on inclusion could increase the robustness of the model.

[4] For example, boreholes typically provide higher quality raw water and thus lower treatment costs, but require higher pumping costs, likewise surface water sources can require less pumping but higher treatment costs.

Overall, we do not consider either of the water resources models appropriate for cost assessment at PR19. We would recommend considering resources and treatment together to account for the trade-offs between these two service areas.

4.2 Treatment models

Ofwat has developed ten models for consideration. Our comments are below:

- **scale** – Ofwat uses either connected properties or the volume of water treated as a scale driver in water treatment models. As discussed above, we believe that volume of water is the better scale driver for resources and treatment service areas
- **quality of water source and resultant complexity of treatment** – is clearly a major driver of treatment costs, driven by the source type and quality of the source water. Ofwat includes W3 to 6 treatment in four of its ten models (OWT5 to 8), and the percentage of distribution input from boreholes in all other models (OWT1 to 4). When treatment complexity is accounted for by Ofwat, water treated above complexity band 3 is controlled for. On this choice, Ofwat state that:

  > "We considered that treatment works levels 3-6 provided a better representation of the more complex works, rather than treatment works level 4-6. Although level 3 does include traditional treatment methods there are significant three treatment stage works that would fall into this category and the boundary between levels 2 and 3 represents a clearer divide between 'basic' and 'complex' than the boundary between levels 3 and 4"

  We concur with this view (for further details refer to our cost adjustment claim submission).[5]

  However, our preference would be to control for this issue by focusing on source type, as Ofwat has done through use of the distribution input from boreholes measure. While source type does not directly estimate the impact of the type of treatment used by companies, it does consider the impact of the required treatment complexity given the sources available 'in the round' and focuses on an entirely *exogenous* factor. In contrast, to some extent, there is some choice over the type / complexity of the treatment process taken and there could be a danger of 'gold plating' if complexity of treatment is used. Equally there is some arbitrariness in how complexity is banded and where the cut offs are chosen for modelling purposes.

  While treatment process has the disadvantage of being partly controllable, it has the benefit of picking up the need for different levels of treatment depending on the *quality* of the source, which can vary even within source type

- **pumping** – Ofwat have controlled for average pumping head in treatment in eight of their ten models. While pumping head is a useful driver to explain power costs in networks, we would not expect the pumping element of water treatment to constitute a large proportion of the energy costs, with the energy costs of the water treatment process itself dominating. Additionally, given considerable differences between companies in their profile of pumping head across water resources, raw water distribution and water treatment, we would question whether all companies are following the same allocation policy

[5] South West Water Limited (2018), 'Cost adjustment claim: PR19 initial submission', 3 May.

- **population sparsity / network complexity** – as discussed in section 2, sparsity and the associated complexity of the network/asset base is a key driver of treatment costs as a sparse region tends to result in the need to have a lot of small water treatment works. In four models (OWT7 to 10), Ofwat include a density measure which is estimated to have a negative effect, as we would expect. We consider this a good starting point, but we suggest further investigation into modelling a more direct measure of economies of scale, both to aid operational interpretability and as a cross-check on the magnitude of the coefficient estimated in these models
- **wide range of efficiency estimates / application of a UQ benchmark to a model with omitted variables –** as with water resources modelling, Ofwat's water treatment models lead to a wide range of company efficiency scores, at least 100% across all specifications. As we note for water resources models above, we would question the application of a UQ benchmark to models with such a wide efficiency range
- **trade-offs across the value chain -** as with the water resources model, we think this model is problematic due to ignoring the trade-offs with water resources.

Overall, we do not consider the water treatment models appropriate for cost assessment at PR19. We would recommend considering resources and treatment together to account for the trade-offs between these two service areas.

4.3 Resources plus models

Ofwat has developed eight models for consideration. Our comments are below:

- **scale –** Ofwat uses connected properties as a scale driver in resource plus models. As discussed above, we believe that volume of water is the better scale driver for the resources and treatment service areas
- **quality of water source and resultant complexity of treatment –** in all models, Ofwat control for W3 to W6 treatment or the percentage of input from boreholes. As outlined in our response to the water treatment models, we consider variables relating to source type to be more appropriate than direct measures of treatment complexity
- **pumping –** Ofwat have controlled for average pumping head in resources plus costs in four of its eight models (OWRP5 to 8). Pumping head is clearly an important element of resources and raw water distribution costs
- **population sparsity / network complexity** – as discussed in section 2, sparsity and the associated complexity of the network is a key driver of treatment costs as it tends to result in a lot of small treatment works. Ofwat do not account for this characteristic at all in models OWRP 5 and 6. Thus, we consider these two models are not robust. Ofwat include density to capture 'economies of scale at the treatment works level' in OWRP 3, 4, 7 and 8. All four estimate a negative coefficient (as per expectations). We note that the coefficients differ in magnitude and statistical significance, so it is important to examine what is an appropriate estimated impact. We consider this a good starting point, but we suggest further investigation into modelling a more direct measure of economies of scale, both to aid operational interpretability and as a cross-check on the magnitude of the coefficient estimated in these models. In two models (OWRP 1 and 2), Ofwat include more direct measures of economies of scale, using source level drivers, using either distribution input/source or number of sources. Whilst there are economies of scale in water resources, this measure will not capture the impact of a sparse population on the number and size of treatment works. Nonetheless, these models come closest to capturing the drivers that we consider necessary for a resources plus model

- **range of efficiency estimates –** we note that the range of efficiency scores has been narrowed compared to Ofwat's Resources models and Ofwat's Treatment models, potentially as a result of capturing the trade-offs across the two service areas.

Overall, we consider the water resources plus modelling more appropriate for cost assessment than the separate water resources and water treatment models, in particular models OWRP1 and OWRP2. However, there is no model presented by Ofwat that captures the key drivers of scale, sparsity, treatment complexity, economies of scale and pumping costs. We would support the development of further modelling in this area to develop models which capture all of these aspects.

4.4 Treated water distribution models

Ofwat has developed eight models for consideration. Our comments are below:

- **scale** – Ofwat's model include properties or length of main as the scale driver, with the latter combined with density to capture the costs of serving a higher population per length of mains. We do not have a strong preference on whether it is more appropriate to use properties served, with an additional control to reflect the larger network required to serve customers in rural communities (as in our network plus models submissions) or the length of mains with a density variable to reflect the greater treatment costs required to serve more customers per length of main (as in Ofwat's models). However, we believe that using properties as a scale driver with a control from network size is more intuitive
- **population sparsity / topography and the associated complexity of network and asset base –** Ofwat control for 'complexity of network' in all of their treated water distribution models, controlling for booster pumping stations per length of mains or service reservoirs and water towers per length of mains. We consider that sparsity/topography manifests itself through a number of aspects, affecting the complexity of the network and the asset base more generally (e.g. a large number of small treatment works). The two network complexity measures used by Ofwat would seem to be a good starting point for picking up the resultant complexity of the network, but we have found measures of sparsity and density to better capture costs in our modelling. In particular we would prefer models where the "u-shape" effect can be modelled, whereby costs are greatest for companies operating in very dense and very sparse regions
- **density –** as outlined above, Ofwat use density measures when using length of main as the scale driver. Length of mains is driven, to some extent, by sparsity, so to include only length of mains does not explain costs in the round, so we agree with Ofwat for the need to offset this by the inclusion of density. To some extent, this is similar to our use of a U-shape sparsity/density impact in the models that we submitted as part of the consultation. The magnitude of the coefficient on the first density measure used seems un-intuitively high, with the implied impact suggested to be 1:16. We would agree with Ofwat that, of the density measures used, weighted average density measure has the more reasonable coefficient.

Overall, we would consider the treated water distribution models OTWD5 to 8 are reasonable and provide a basis for further examination with the revised data and with the addition of the 2017/18 data.

[6] I.e. a company with twice the value for this variable would be expected to have twice the costs. In the dataset Ofwat provided we note that some companies have well over twice the value of others.

4.5 Network plus models

Ofwat has developed eight models for consideration. Our comments are below:

- **scale** – Ofwat's model include properties or length of main as the scale driver, with the latter combined with density to capture the costs of serving a higher population per length of mains. Our opinion is the same as for the treated water distribution models
- **quality of water source and resultant treatment complexity** – clearly complexity of treatment is a key driver for network plus costs, as treatment costs represent 34% of the network plus cost base. However, Ofwat only control for complexity of treatment, via W3 to W6, in four of their eight Network plus models (ONPW 3, 4, 6 and 8). As such, we do not consider the other models (ONPW 1, 2, 5 and 7) to be robust. As above, we suggest the water treatment driver be linked to source type
- **population sparsity / topography and the associated complexity of network and asset base** – Ofwat control for 'complexity of network' in all of their network plus models, controlling for booster pumping stations per length of mains or service reservoirs and water towers per length of mains. As above in the treated water distribution models, we consider that the network complexity measures used by Ofwat would seem to be a good starting point for picking up the resultant complexity of the network, but we have found measures of sparsity and density to better capture costs in our modelling. In particular we would prefer models where the "u-shape" effect can be modelled, whereby costs are greatest for companies operating in very dense and very sparse regions
- **density –** as stated for the treated water distribution models, we agree that density should be included in the models with lengths of main as the scale driver. Similar to those models, the coefficient on the first density driver is un-intuitively high and therefore we prefer the weighted average density measure used
- **pumping** – average pumping head is clearly a driver of pumping costs and an important part of a water company's cost base. So it is important to control for, if possible. However, we note that average pumping head for water treatment is controlled for, instead of average pumping head for network plus. Given the relatively small role that pumping plays in water treatment costs, and issues around allocation of pumping head, as outlined in our response to the water treatment models, we would not consider this to be an appropriate driver of costs in network plus models**.** Significant differences between companies in required pumping exist across the value chain, as such, when modelling aggregate costs it is important to capture *total* pumping requirements.

Overall, we would consider the network plus modelling to be appropriate for cost assessment modelling where all relevant factors have been controlled for. As such, we consider model ONPW8 is reasonable and provides a basis for further examination with the revised data and with the addition of the 2017/18 data. Although ONPW3 and ONPW4 would seem to capture an element within each cost category, as these models do not capture the expected "u-shape" of network costs and therefore we would not support the use of these models for cost assessment at PR19.

4.6 Aggregate wholesale water models

Ofwat's twelve wholesale water models are similar to their network plus models in terms of the cost drivers used (treatment complexity, density and network complexity), as such our comments on Ofwat's network plus models (see above) are also valid here. However, we consider that the network plus models are generally better because the complexity of the network is always controlled for in those models.

- **quality of water source and resultant treatment complexity** – many of Ofwat wholesale water models do not control for the source type or the complexity of the water treatment (only three of Ofwat's twelve models, OWW4 to 6, capture W3-W6 treatment). We see this as a major omission from these models (treatment costs represent 31% of the wholesale water cost base) and thus do not consider models OWW 1 to 3 or 7 to 12 to be appropriate
- **population sparsity / topography and the associated complexity of network and asset base** – Ofwat do not control for sparsity directly, but control for 'complexity of network' (in eight of their twelve wholesale water models) by including variables of pumping stations or reservoirs per length of mains. We would consider that while the network complexity measures used by Ofwat would seem to be a good starting point for picking up the resultant complexity of the network, but we have found measures of sparsity and density to better capture costs in our modelling. In particular we would prefer models where the "u-shape" effect can be modelled, whereby costs are greatest for companies operating in very dense and very sparse regions
- **pumping –** instead of the average pumping head for water resources plus included by Ofwat, we consider that total average pumping head is the appropriate pumping head variable that should be used.

Overall, we would consider the aggregate wholesale water models to be less appropriate for cost assessment modelling than network plus models as there are no models which capture all relevant costs. OWW4 to 6 are the only models to capture the impact of treatment complexity on water treatment costs. However these models do not fully capture the cost of maintaining a large and complex treated water distribution network. In particular OWW4 contains no measures of network complexity. Models OWW5 and OWW6 partially capture the impact of the complexity of the network (through the asset measures outlined above: booster pumping stations or service reservoirs and water towers) but do not model the "U-shape" of network costs. We would not support the use of these models for cost assessment at PR19 without further development to accommodate all the relevant factors.

4.7 Enhancement expenditure models

Ofwat has provided three meeting lead standards models and two new water development models for consultation. We provide further thoughts on these below:

- **negative cost predictions -** model OE1 and 2 have negative coefficients and predicts negative cost for one of the companies and therefore is not appropriate
- **meeting lead standards drivers -** Ofwat's models use a combination of water delivered, population served, the number of lead pipes and number of replaced lead pipes which we consider to be acceptable drivers for this development
- **new development drivers -** Ofwat's first model uses a total population served which we do not consider appropriate as it assumes linear growth with population. The second model incorporates the total number of new non/household connections which we consider to be acceptable drivers for these schemes.

5. Wastewater model responses

Our comments on Ofwat's wholesale wastewater service models are provided below.

5.1 Bioresources models

Ofwat considers three simple bioresources models controlling for scale, inter-siting and disposal route. One model controls for scale using number of properties (OBR1) and the others control for scale using sludge produced (OBR2 and 3). Ofwat use gross costs as their dependent variable instead of net costs which we do not have issues with.

- **scale driver** - Ofwat use either properties or sludge produced. Sludge produced (i.e. by the WWTW) is the more direct scale measure for bioresources as it measures how much sludge is required to be treated, so we consider it preferable to properties in explaining costs. We also note that the efficiency range across the industry narrows when sludge produced is controlled for, indicating a better model fit
- **sparsity driver -** Ofwat do not include any sparsity driver in their models. However, we consider it to be a key driver of bioresources costs because it determines infrastructure size and in waste there are significant decreases in unit cost for large WWTW and sludge treatment centres (STC). Also small STCs cannot support economic energy recovery or advanced energy recovery and therefore do not have the opportunity to recover costs versus other technologies in larger centres. Suitable drivers include sparsity measure, number of treatment works per property or load treated by works in size band 1-3. These drivers capture the transportation costs of importing sludge from many small WWTW
- **disposal cost driver -** Ofwat use % inter-siting by vehicle (tank and truck) which has little variation across the industry with the exception of United Utilities (due to their large sludge pipeline that transports sludge from upland towns to the Shell Green Incinerator). This is not an industry wide issue so we would not consider that the measure should be included in industry wide cost models for PR19. This driver may be partially under the influence of management control. Additionally, one model (OBR3) controls for the amount of inter-siting which might have some scale effect but also may introduce double counting effects
- **disposal route driver -** Ofwat control for % disposed to farmland in all the proposed bioresources models. As recycling to agriculture is the most cost effective disposal route this is a driver of costs. However, there is little variation across the industry with the exception of United Utilities so as the disposal cost driver we do not consider that the measure should be included in cost models for PR19. Additionally, we understand that this driver is considered "post-incineration" so does not capture differences in sludge treatment approach.

Given the absence of cost drivers to capture the impact of population sparsity on bioresources costs we do not consider any of the bioresources models appropriate for modelling at PR19. The other variables controlled for seem sensible from a cost assessment perspective, subject to the caveats on inter-siting above.

5.2 Sewage treatment models

Ofwat has proposed six sewage treatment models in their consultation. Our comments on these are as below:

- **scale driver -** Ofwat use load entering the WWTW or properties as the scale driver. Load captures trade effluent and therefore increased cost of treatment, so is the preferred scale driver to use and therefore should be included in the cost models for PR19
- **density / sparsity -** a key driver of treatment costs impacting upon the asset base, e.g. size of works. Ofwat use the percentage of load in small WWTWs (bands 1 to 3) in all its models which captures the higher costs associated with smaller works. However, the critical issue with regard to economies of scale in wastewater treatment is the very large differences in scale across works[7] and the much lower unit costs in very large works, which is not adequately captured using size bands 1 to 3[8]. As it stands, the models suggest that the unit treatment costs have constant returns to scale, bar an adjustment for size bands 1-3, so costs faced by companies as large as Thames Water or Severn Trent are equivalent to those of companies serving areas five times smaller
- **tightness of permits and associated treatment complexity** - the required treatment complexity is clearly a key driver of wastewater treatment costs, however, Ofwat only account for treatment complexity in four models, OSWT 3 to 6, so we consider models OSWT 1 and 2 are not robust. In addition, when accounting for complexity of treatment, Ofwat use % of ammonia <1mg/l which is the strictest Ammonia consent so the driver practically becomes a dummy for two companies (Thames Water & United Utilities). We consider this driver to be too restrictive to represent the costs incurred across the industry and support a broader measure to be included in cost models for PR19
- **% trade effluent -** captures the larger volume of load from non-residential customers. However, this may be double counted when load is used as a scale driver therefore model OSWT5 is not appropriate.

Given the constant returns to scale implied by the treatment models as well as the selection of drivers to control for tightness of permits we would not consider these models appropriate for cost assessment.

5.3 Bioresources plus models

Ofwat's choice of drivers for the seven bioresources plus models combine drivers used for within both bioresources and treatment models and therefore the comments above apply in these models as well.

- **scale driver** - as above, load is conceptually the better scale driver
- **sparsity -** is a key driver of both wastewater treatment and bioresources costs, impacting upon size of works. Percentage load in small WWTWs (size band 1 to 3) is included in Ofwat's models OBP 1 to 5 only, so we consider that models OBP6 and 7 omit a key driver and are not robust. As outlined above, percentage load treated in small WWTWs is not an adequate driver to capture costs, particularly in models with scale driver coefficients close to 1 (implying constant returns to scale)

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[7] From bands 1 to 6, with band 6 itself capturing a very broad range, including very large works.

[8] See our cost adjustment submission, South West Water Limited (2018), 'Cost adjustment claim: PR19 initial submission', 3 May.

- **treatment complexity -** is a key driver of cost as treatment is 72% of the bioresources plus cost base. However, only models OBP6 and 7 control for treatment complexity, via % biological load treated by WWTWs with ammonia consents for <1mg/l, so we do not consider models 1-6 to be robust. As above, we also consider that this driver is not suitable for across the industry and should take the form of a broader consent definition
- **disposal route driver** - as above, recycling to agriculture is most cost effective disposal outlet However, the values across the industry are relatively similar so this driver should not be used in cost models for PR19**.**

Given the above we do not consider any of these models suitable for the whole industry.

5.4 Sewage collection models

Ofwat has proposed six sewage treatment models in their consultation. Our comments on these are as below:

- **scale driver** - Ofwat use properties or waste volume as the scale driver. We consider that properties is the most relevant measure of scale in sewage collection, as a larger number of properties requires a larger and more complex sewage collection network. The sewer network is built for storm capabilities so most infrastructure is able to handle more waste volume without a significant impact. While waste volume does impact upon pumping costs, we consider that the impact of large customers, not picked up by number of properties, is better considered through testing the significance of the percentage of trade effluent as an additional driver. Additionally, some large trade loads are direct to the WWTW.
- **density driver** - Ofwat uses density in models OSCW 1 and 2 to model sewerage collection costs. With regards to the network, this is aligned with expectations as there are increased costs associated with operating in densely populated urbanised areas
- **sparsity and associated complexity of network / pumping requirements -** Ofwat include the number of pumping stations per length of sewers in models OSCW3 to 5, and the log of this driver in OSCW1. We consider that pumping is an essential cost driver to consider and, therefore, that model OSCW2 is not robust. In our submission, we used pumping station capacity per sewer in all our network plus models, as we consider that this better reflects the additional pumping costs. Pumping capacity scales directly to the amount of work that can be done (at maximum capacity), whereas the number of pumping stations weights pumping stations of all sizes equally. Additionally, as Ofwat note in their consultation response, capacity performs better statistically
- **maintenance drivers -** Ofwat include % mains replaced or renewed post 2001 or % gravity sewers rehabilitated post 2001 as ‘additional drivers of maintenance costs’. We do not consider that the latter is a relevant cost driver as it is a small element of maintenance costs and companies have very small amounts of gravity sewers replaced as a proportion of total sewers. In addition, this driver has a small variation across the industry and therefore should not be included in cost models for PR19. Given the high coefficient on % gravity sewer rehabilitated, and that this variable fails tests of statistical significance, we do not consider that this variable should be included in sewage collection models.

All five models considered have an inappropriate driver or an unrealistically high and statistically insignificant coefficient on the % of gravity sewers rehabilitated. Therefore, we consider that none of the sewage collection models, as presented, are appropriate for cost assessment at PR19.

5.5 Network plus models

Ofwat has provided ten network plus models for consultation. We provide thoughts on these below:

- **scale driver** - Ofwat use various measures for scale. At the network plus level, we consider that properties is the most appropriate scale driver, as it captures both the impact of scale of treatment and the complexity of the wastewater collection network
- **treatment complexity -** is omitted from eight of Ofwat's ten network plus models (models ONPW1 to 8). As treatment accounts for 57% of network plus costs, we do not consider that any of these models are robust. Treatment complexity is only included in models ONPW 9 and 10, where treatment complexity is defined as % of ammonia <1mg/l. With regards to this definition see our comments above under the wastewater treatment models on the reasons why we do not consider it to be suitable for the cost models
- **density / sparsity** - density is controlled for by Ofwat through properties per sewer in models ONPWW1 to 4 and has a positive sign. The sewer network is expensive to construct, so sparse networks are generally set up in small catchment areas. With regards to the network, there are increased costs associated with operating in densely populated urbanised areas, while in treatment and sludge there are reduced costs as a result of having larger treatment works serving densely populated areas. Based on our modelling, we find that sparsity more than offsets any density effect.[9] Unlike sewage collection, Ofwat has included no asset based variables, including those driven by sparsity/topography, such as the complexity of the wastewater network, pumping capacity or CSOs. Similarly, unlike all of Ofwat's sewage treatment and wholesale wastewater models, Ofwat has not taken any account of the impact of economies of scale from large treatment works, which is driven by density[10]
- **maintenance -** Ofwat include percentage of length of sewer laid post 2001. We believe that other drivers might better capture the need for maintenance as sparse networks increase asset complexity and therefore maintenance costs. As well, as described above, larger assets have lower unit costs to run. In some of our models we also included the number of CSOs per sewer km, as CSOs require screen cleaning and maintenance, and are also associated with higher storage and maintenance requirements.

Overall, we consider that Ofwat's network plus models are too simple to provide any insights into relative efficiency, as any efficiency estimate will be conflated with regional characteristics not adequately controlled for.

5.6 Wholesale wastewater models

Ofwat has provided eight wholesale wastewater models for consultation. These principally draw from Ofwat's network plus models so many of the comments above still apply. We provide further thoughts on these below:

- **scale driver –** Ofwat's models use the number of properties or load. As in network plus, we consider properties to be the most appropriate scale driver
- **density / sparsity driver -** density is controlled for by Ofwat, in models OWWW 3 to 8, through properties per sewer and has a positive sign. In addition, sparsity is controlled for in

[9] See our cost adjustment submission, South West Water Limited (2018), 'Cost adjustment claim: PR19 initial submission', 3 May.

[10] See our cost adjustment submission, South West Water Limited (2018), 'Cost adjustment claim: PR19 initial submission', 3 May.

all models through the percentage of load in WWTW bands 1-3. As discussed above, there are clear economies of scale in larger treatment works, so we consider the inclusion of the WWTW bands to be helpful, but we do not consider that it fully captures the economies of scale impact across the very large size range of treatment works11. Our view on the use of density measures is as described above for the sewage collection and network plus models. We would additionally add that in our modelling, we have found that when sparsity and density measures are controlled for directly, we have not found a "u-shape" as in clean water, instead finding that sparsity dominates at the aggregate level, as it affects a larger proportion of the cost base: treatment and bioresources. These two areas account for 65% of aggregate costs

- **sparsity / topography impacts upon pumping requirements -** in Ofwat's models, the number of pumping stations per length of sewers is controlled for only in model OWWW 2. We believe that this is a key driver and therefore that the other models are not robust
- **complexity of treatment drivers -** as stated above, we believe complexity of treatment to be very important and that it should be accounted for in all models. However, only models OWWW3 and 5 include load from trade effluent, which does not take into account permits
- **disposal route drivers -** we do not consider disposal route to be suitable for the cost models as values across the industry are similar
- **maintenance drivers -** we suggest more encompassing drivers should be included for maintenance including CSOs.

Overall, we consider that none of Ofwat's wholesale wastewater models capture the impact of treatment complexity or adequately consider the issue of economies of scale in treatment. Therefore, none of the wholesale wastewater models, as presented, are appropriate for cost assessment at PR19.

5.7 Enhancement expenditure models

Ofwat has provided three first time sewerage cost models and four sewerage growth models for consultation. We provide further thoughts on these below:

- **wide efficiency range -** model OE6 to 12 predict very high maximum efficiency which distorts the upper quartile benchmark
- **first time sewerage drivers -** Ofwat's models use a combination of S101a schemes, the connectable properties served by these schemes and the average number of connectable properties per scheme, which we consider to be acceptable drivers for these schemes
- **sewerage growth drivers -** Ofwat's models use either a resident population or non/resident properties, as well as two models which include a load per WWTW driver, which we consider to be acceptable drivers.

[11] See our cost adjustment submission, South West Water Limited (2018), 'Cost adjustment claim: PR19 initial submission', 3 May.

6. Retail model response

Our general comments on Ofwat's retail service models are provided below.

6.1 Bad debt (doubtful debt plus debt management costs) models

There are three key issues that need to be captured in models of bad debt costs:

- **scale –** we expect doubtful debt costs to increase with company size, with economies of scale present in debt management expenditure12
- **deprivation –** areas with higher levels of deprivation are likely to have higher default rates than more prosperous areas13
- **bill size –** higher bills lead to larger doubtful debt costs when customers default.

Ofwat has provided six bad debt models for review as part of the model consultation. We present our thoughts on these areas, by cost driver, below:

- **scale –** in Ofwat's models a constant returns to scale assumption is imposed in three of the six bad debt models, which use bad debt per household as a dependent variable without controlling for customer numbers separately (ORDC1, 2 and 5). We consider that this assumption fails to capture the economies of scale present in debt management
- **deprivation –** Ofwat uses three different measures of deprivation: the percentage of households defaulting (Equifax); credit risk score (Equifax); and the proportion of the population experiencing income deprivation (Office of National Statistics (ONS)). All of these deprivation drivers seem appropriate measures to capture the impact of deprivation on the propensity to default on water bills. We support corroborating the validity of different deprivation drivers using alternating variable in models with all other controls held constant, as Ofwat has done both in the model results presented in the consultation as well as using other models not presented[14]. We would consider that measures of deprivation that differ significantly from the ONS income deprivation measure to require robust justification
- **bill levels –** Ofwat controls for bill levels across all six bad debt models in the consultation. We consider this driver to be adequately captured across all models submitted
- **averaging drivers -** given the large changes to the retail services efficiency following benchmarking at PR14 (noted by Ofwat in the model consultation) we do not consider it appropriate to supress the impact of more recent years by averaging across all variables to reduce the model to a cross section over the period as done in model ORDC6.

[12] Debt management, although relating to bad debt repayments, shares characteristics with customer service opex, as it relies on engagement and contact with customers to enable customers in debt to pay their bills. See for example Ofwat's research and recommendations on debt management costs, https://www.ofwat.gov.uk/regulated-companies/vulnerability/debt-management-and-other-retail-costs-research-and-recommendations/. As such we would expect debt management to also benefit from economies

[13] A key driver for the rate of customer defaults is the level of deprivation present in a company area, with more deprived customers less able to keep up with regular utility bills, including those for water and wastewater services. As such we would expect both the level of such defaults (doubtful debt) and the costs required to minimise and manage these costs (debt management) to increase with deprivation levels.

[14] Consultation, page 80. Other deprivation drivers considered include unemployment rate and the number of mortgage repossessions.

Overall, we would consider models ORDC3 and 4 to be the most appropriate of the models consulted on by Ofwat, and that they are a good starting point for cost assessment for PR19. These models would need to be robust to further examination with the revised data, and with the addition of the 2017/18 data.

6.2 Total operating costs less bad debt models

There are three key issues that need to be captured in models of total operating costs less bad debt:

- **scale –** we expect operating costs less bad debt to increase with company size, subject to economies of scale in customer service and other opex
- **scope –** dual service customers incur more costs to serve than water-only or wastewater-only customers
- **metering –** metered customers incur additional costs to serve through meter reading expenditure.

Ofwat has provided four total operating costs less bad debt models for review as part of the model consultation. We present our thoughts on these areas, by cost driver, below:

- **scale –** in Ofwat's models a constant returns to scale assumption is imposed in two of the four total operating expenditure less bad debt models, which use expenditure per household as a dependent variable without controlling for customer numbers separately (OROC1 and 2). We consider that this assumption fails to capture the economies of scale present in customer services and other opex
- **scope –** Ofwat controls for the proportion of dual customers across all four total operating costs less bad debt models. We therefore consider this driver to be adequately captured across all models submitted
- **meter penetration –** Ofwat control for the proportion of metered customers in two of the four total operating expenditure less bad debt models. The models which do not control for this factor (OROC1 and 3) omit an important driver of retail expenditure.

Overall, we would consider model OROC4 to be the most appropriate of the models consulted on by Ofwat, and that it is a good starting point for cost assessment for PR19. This model would need to be robust to further examination with the revised data and with the addition of the 2017/18 data. Other models submitted for consultation do not adequately capture all costs in retail.

6.3 Total operating cost models

As total operating costs cover both the retail bad debt and totex less bad debt models, an ideal model would capture all of the factors explained above. We acknowledge that accommodating all of these factors is challenging within a single model, but we do not consider that a valid argument for using models with omitted variables given the option to model different areas separately.

Ofwat has provided four total operating models for review as part of the model consultation. We present our thoughts on these areas, by cost driver, below:

- **scale** – in Ofwat's models a constant returns to scale assumption is imposed in three of the four total operating expenditure less bad debt models, which use expenditure per household as a dependent variable without controlling for customer numbers separately (ORTC1 to 3). We consider that this assumption fails to capture the economies of scale present in customer services, other opex and debt management. We note that the customer numbers variable tests statistically significant in model ORTC4

- **scope/bill size** – we note that there is significant collinearity between measures of dual service customers and bill size. Given the constraints of developing total operating costs models which capture all of the requisite drivers we would consider a model controlling for only one of these a reasonable compromise. However, we would consider it important to verify that there were not substantial differences in outcomes between the two drivers
- **deprivation –** we note that a measure of deprivation, the percentage of households defaulting (Equifax), is only included as a driver in two of the four models (ORTC3 and 4). We would consider deprivation to be a key factor to include in total operating cost models. We note that the deprivation driver is significant in only one of the two specifications considered, ORTC4. Finally, we would suggest that models could be more robust by considering different measures of deprivation, to avoid the possibility of model misspecification
- **meter penetration –** Ofwat control for the proportion of metered customers in three of the four total operating expenditure less bad debt models. The model which does not control for this factor (ORTC2) omits an important driver of retail expenditure.

Overall, we would consider model ORTC4 to be the most appropriate of the models consulted on by Ofwat. Other models submitted for consultation do not adequately capture all costs in retail. We would like to see that this specification is robust to alternate measures of deprivation and that the relationship between bill size, dual customers and costs was being robustly captured before supporting the use of this model for cost assessment at PR19. If this is not possible, we would support triangulating across appropriate models from the two areas of the retail value chain: bad debt and operating costs less bad debt.