Anglian Water

7A. COMMENTS ON OFWAT'S APPLICATION OF WHOLESALE WATER COST ASSESSMENT MODELLING IN ITS PR19 DRAFT DETERMINATIONS

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A Comment on Misspecification and Systematic Bias in Ofwat's PR19 Draft Determination Integrated Wholesale Water and Wastewater Models

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Comments on Systematic Bias in Ofwat's Wholesale Water Modelling, and Comparison to Alternative Robust Models

1. Various Issues, model misspecifications and omitted variables bias identified by Saal & Nieswand (March 2019) remain unaddressed by Ofwat

Saal & Nieswand (March 2019) report for Anglian Water demonstrated a series of issues, model misspecifications and omitted variables issues across the range of Ofwat's IAP modelling. These issues entirely remain and have not been addressed, let alone acknowledged, by Ofwat, which continues to employ the same model variables, and even persists in modelling water costs ***in the absence of using water as a variable*** in any of its models. Moreover, this is despite its decision to change the definition of modelled botex considerably, thereby moving modelled "costs" even further from any economically valid definition of costs**.**

It must therefore be emphasised that the concerns with regard to the suitability of Ofwat's wholesale water modelling for regulatory cost assessment raised in Saal & Nieswand (March 2019) remain almost entirely unaddressed, or even acknowledged by Ofwat.[1]

2. Given Ofwat's inappropriate modelling framework, it is more likely that Ofwat's random effects control for unmodelled and legitimate cost drivers rather than capturing differences in cost efficiency.

Saal & Nieswand (March 2019, Comment #15) highlighted the need to further explore potential concerns with Ofwat's approach to applying random effects, correctly focussing on Ofwat's rigid adherence to a modelling framework that resulted in mis/underspecified models that were demonstrated to suffer from issues such as omitted variables bias. They therefore suggested that Ofwat's use of random effects would results in unmodelled factors influencing company costs being wrongly interpreted as inefficiency. Upon further reflection, it is important to more strongly emphasise that Ofwat's approach is likely in result in larger positive (negative) random effects for firms that face legitimately more (less) challenging operating environments that are not adequately controlled for by Ofwat. Thus, Ofwat's dual reliance on random effects, and strict adherence to its flawed modelling framework, is highly likely to result in biased efficiency assessment.

Stated most simply, in the absence of appropriate control variables for legitimate heterogeneity in operating environments, it is more likely that Ofwat's random effects capture unmodelled cost drivers rather than differences in cost efficiency.

[1] We note and briefly comment on those changes Ofwat has made to its wholesale wastewater modelling below.

3. Ofwat's use of a time invariant random effect estimated for 2012-18 when assessing cost efficiency for 2014-18 is methodologically incorrect and will result in bias in its backward-looking assessment of efficient costs

Upon further reflection, we also raise a further concern with regard to Ofwat's application of random effects models. That is, Ofwat uses random effects for the 2012 to 2018 period despite actually assessing costs in the 2014-2018 period. This is inappropriate on both methodological and regulatory grounds, as the estimated random effect which determines estimated cost efficiency is not defined for the relevant cost assessment period. Stated differently, because a single random effect is estimated for each company and forms the basis of its overall two-part annual residual, and hence measured cost performance, 2014-2018 cost assessment will be biased if estimated with a random effect derived using 2012-2018 data.

This implies an important methodological bias in Ofwat's backward-looking assessment of efficient costs.

4. Ofwat's failure to control for statistically significant differences over time in the cost environment faced by regulated firms causes bias in both its backward-looking and forward-looking cost assessment, while empirical assessment of this issue suggest that its integrated wholesale water models are not statistically robust

In addition, Saal & Nieswand (March 2019, Comment #15) noted that Ofwat fails to control for what we have now demonstrated to be statistically significant differences across time, and therefore: "not only assumes that no technical changes has occurred, but also assumes that changing economic and regulatory conditions, including the profound change in (regulatory models and) cost accounting that occurred after 2015, has no effect on firms and/or the data." Saal & Nieswand (March 2019) also noted that there was "… also a lack of an adequate justification as to why time controls are not required , and how this omission influences the appropriateness of Ofwat's models and the appropriateness of how it applies these models in its subsequent assessment steps."

As Ofwat has not in any way acknowledged or addressed this issue, it therefore continues to ignore very considerable changes in the underlying cost, regulatory and accounting environment faced by water companies and, stated frankly, appears to deliberately ignore the considerable change from moderately declining unit wholesale water botex until 2016, which was followed by sharp increases in unit water botex.

This results in potential bias in Ofwat's cost assessment for two reasons.

Firstly, failure to account for significant temporal changes in the underlying cost environment will result in biased models that cannot capture differences in companies' responses to such changes and may also result in biased parameter estimation and model selection. **That is, not modelling the actual cost environment faced by all firms and falsely assuming it is static will lead to biased backward-looking cost assessment.**

Secondly, the absence of time controls, coupled with the use of 2012-2018 data, will create a further bias in projection of costs. That is, a properly specified model that controls for time can be employed to project costs forward from current cost conditions. **In contrast, Ofwat's approach effectively projects costs forward from the average cost conditions for the 2012-18 period, even though they can be statistically demonstrated to have changed during that period (and also within the 2014-18 period).**

As demonstrated in the below table, the two above issues alone contribute to significant demonstrable downward bias in Ofwat's own models' assessment of efficient integrated wholesale water botex. Thus, while Ofwat's 2012-18 models predict botex of £1125.4m for Anglian Water, estimating the same models for the 2014-18 period and controlling for changes in the cost environment faced by all firms in the model yields an estimate of £1278.9m for the 2021-25 AMP7 period.

2014-18 Modelled Costs, Upper Quartile Analysis, and 2021-25 Projected Costs									
	Botex	**M11218**	**M21218**	**M11418**	**M21418**	**M1D1218**	**M2D1218**	**M1D1418**	**M2D1418**
Anglian Water's Actual and Predicted Botex Summed Values 2014-2018	1,168.8	1,163.6	1,227.7	1,152.5	1,226.7	1,149.5	1,201.8	1,189.7	1,239.7
Upper Quartile Ratio (Actual Botex/Predicted Botex)		0.910	0.899	0.937	0.918	0.911	0.915	0.908	0.927
Anglian Water Ratio (Actual Botex/Predicted Botex)		1.004	0.952	1.014	0.953	1.017	0.973	0.982	0.943
ANH Ratio/Upper Quartile Ratio		1.104	1.059	1.083	1.037	1.117	1.063	1.082	1.017
		M11218	**M21218**	**M11418**	**M21418**	**M1D1218**	**M2D1218**	**M1D1418**	**M2D1418**
Upper Quartile Corrected Summed Predicted Botex for 2021-25 (after assuming -1.1 percent annual Continuing Efficiency Improvement Assumption)		1,094.9	1,156.0	1,114.8	1,181.5	1,190.3	1,254.8	1,236.6	1,321.1
		Model Averages by Model Type and Regression Estimation Period							
		Ofwat no time dummies 2012-2018		**Ofwat no time dummies 2014-2018**		**Ofwat time dummies 2012-2018**		**Ofwat time dummies 2014-2018**	
Average Model		1125.4		1148.1		1222.5		1278.9	

Moreover, Ofwat's integrated wholesale water models are not empirically robust to estimation in the 2014-18 cost efficiency assessment period when we appropriately control for statistically significant changes in the cost environment faced by firms. Thus, in WW1 Ofwat's systematically biased (see point 5 below) ln (booster stations/length of mains) control variable is only statistically significant at 10 percent when the model is estimated for 2014-18 without time controls, and this variable is not statistically significant at even the 20 percent level in both WW1 and WW2 when time controls are allowed for. As an estimated regulatory model should be robust when estimated for the actual period of cost efficiency assessment, more than sufficient degrees of freedom exist for appropriate estimation[2] and solid theoretical arguments (see above) suggest econometric and regulatory bias via Ofwat's reliance on 2012-18 data to assess 2014-18 costs, these results alone cast considerable doubt on the robustness of Ofwat's cost assessment methods for PR19 .

5. It can be unequivocally demonstrated that Ofwat's integrated wholesale water models are systematically biased because of Ofwat's effective imposition of an inappropriate parameter restriction. Moreover, making simple incremental changes to this model, and building from the suggestions made to Ofwat by Saal & Nieswand (March 2019), provides alternative models that are substantially more robust for regulatory cost assessment than Ofwat's own models

Despite the many issues illustrated in Ofwat's modelling wholesale water modelling by Saal & Nieswand (March 2019), Ofwat has persisted in retaining its models and reiterated its confidence in the use of its ln(boosters/mains variable) and density based models as being the best available model available with which to estimate wholesale water costs. We have therefore closely reviewed this model again, and have identified incontrovertible theoretical and statistical evidence that Ofwat's integrated wholesale water models rely on a specification which not only imposes an inappropriate negative relationship between modelled botex and length of mains, but also results in Ofwat's properties scale variable becoming entirely statistically insignificant (even at the 20 percent level) when this inappropriate parameter restriction is relaxed. **Thus, we unequivocally argue that Ofwat's integrated wholesale water models suffer from systematic bias.**

Given this, we have built from the suggestions of Saal & Nieswand (March 2019), and demonstrated how appropriate adjustments of Ofwat's integrated models to allow for upstream and downstream outputs, specification of effective water as an incentive compatible measure of water volumes net of leakage and alternative control variables result in estimates that we believe are conceptually, statistically, and theoretically substantially more robust for regulatory cost assessment than Ofwat's models.

As demonstrated in the below table, providing a model that does not suffer from the systematic bias present in Ofwat's models and appropriately estimating the model for the 2014-18 period with the time dummies necessary to accurately predict costs in the AMP07 period, suggests predicted botex of £1406.8m for Anglian Water.

[2] Any claim by Ofwat that the inclusion of time controls is inappropriate or spurious should be set against the 0.00 significance tests for inclusion of such time controls, and the fact that even when the sample is appropriately restricted to cover the 2014-18 period and time controls are allowed for, the remaining 78 degrees freedom in the model is more than adequate in normal and regulatory econometric practice.

	Botex	E1L1418	E2L1418	ELAN1418	E1LD1418	E2LD1418	ELAND1418
Anglian Water's Actual and Predicted Botex Summed Values 2014-2018	1,168.8	1,333.0	1,415.6	1,336.3	1,352.1	1,403.7	1,360.0
Upper Quartile Ratio (Actual Botex/Predicted Botex)		0.917	0.951	0.932	0.922	0.934	0.925
Anglian Water Ratio (Actual Botex/Predicted Botex)		0.877	0.826	0.875	0.864	0.833	0.859
ANH Ratio/Upper Quartile Ratio		0.956	0.868	0.938	0.938	0.891	0.929
		E1L1418	E2L1418	ELAN1418	E1LD1418	E2LD1418	ELAND1418
Upper Quartile Corrected Summed Predicted Botex for 2021-25 (after assuming -1.1 percent annual Continuing Efficiency Improvement Assumption)		1,210.9	1,353.0	1,250.8	1,371.6	1,454.2	1,394.6
		Model Averages With and Without Time Dummies					
		no time dummies			With time dummies		All Models
		2014-2018			2014-2018		2014-2018
	Average Model	1271.6			1406.8		1339.2

6. Application of a standard academic approach to controlling for differences in population dispersion via a simple translog model that allows for cost interactions between network length and delivered output provides an additional alternative and more robust integrated wholesale water model than those used by Ofwat. Moreover, as Ofwat's density variables are not significant in this model, this model also demonstrates that Ofwat has not properly triangulated its models via the use of alternative modelling approaches.

While Anglian Water persisted in applying the Bristol Water CMA PR14 Appeal models in its business plan assessment, we had already voiced our concerns with these models to Anglian Water in the review I and my colleagues carried out of Anglian Water's September 2017 initial water industry cost modelling report. Similarly, in our various reports for Anglian Water, and our cost assessment consultation response, we have voiced significant concerns with regard to the rigid modelling approach employed by Ofwat, and the fact that it appears to have effectively been designed to eliminate any potential to capture cost interactions between the upstream and downstream activities of an integrated water company.

We have therefore developed an alternative model, using a standard academic approach to control for differences in population density and dispersion in network industries, which is an interactive translog model including upstream volumes (effective water) and downstream network activities (mains length) , as well as a set of appropriate control variables. **As Ofwat's density variables can be shown to be statistically insignificant in these models, they also demonstrate that Ofwat's density specification is not a unique solution to modelling costs while controlling for geography and other spatial characteristics**. Moreover, as the below tables demonstrate, these models suggest a considerably higher estimate of Anglian Water's 2021-25 botex than that obtained from Ofwat's systematically biased models.

2014-18 Modelled Costs, Upper Quartile Analysis, and 2021-25 Projected Costs						
	botex	**Rs2D1218**	**Rs2D1418**			
Anglian Water's Actual and Predicted Botex Summed Values 2014-2018	1,168.8	1,298.4	1,335.5			
Upper Quartile Ratio (Actual Botex/Predicted Botex)		0.925	0.931			
Anglian Water Ratio (Actual Botex/Predicted Botex)		0.900	0.875			
ANH Ratio/Upper Quartile Ratio		0.973	0.941			
		Rs2D1218	**Rs2D1418**			
Upper Quartile Corrected Summed Predicted Botex for 2021-25 (after assuming -1.1 percent annual Continuing Efficiency Improvement Assumption)		1316.9	1367.2			

7. **The preferred specifications of the methodologically, conceptually, and empirically superior and more robust models we summarize here suggest that Anglian Water's efficient integrated wholesale water botex for the 2021-25 period is in the range of £1367.2m to £1406.2m, thereby demonstrating the considerable bias in Ofwat's wholesale water cost assessment**

8. **While beyond the scope of this review to address, appropriate consideration and modelling of complex cost interactions between upstream and downstream activities, as well as consideration of how water scarcity, leakage control, and water demand management influence the cost of water provision, is absent from Ofwat's modelling. As economic regulation should allow companies to address public interest concerns about increasing water scarcity via an approach that minimises the whole system costs of water provision, we strongly recommend that Ofwat should adopt a whole system modelling approach for PR24.**

9. **Focussing on PR19, we emphasise the strong potential downward bias in Ofwat's assessment of Anglian's wholesale water costs because its modelling approach does not in fact consider the cost of water provision. We therefore emphasise that Ofwat's exclusion of water volumes from its models is inconsistent with the need for a company to meet water demand while minimising whole system costs in the face of water scarcity. In contrast, the alternative models presented here use Effective Water as an incentive-compatible output proxy that allows for the implications of water scarcity. However, it must be emphasised that this approach is only a first step towards moving Ofwat's modelling approach towards a whole system cost assessment perspective.**

Comments on Ofwat's Wholesale Wastewater Modelling

1. As with its Water Modelling the issues identified by Saal & Nieswand (March 2019) remain unaddressed by Ofwat's Wastewater Modelling

As with its wholesale water modelling, Ofwat has continued to adhere to its rigid and flawed modelling framework for wastewater, and has largely used the same explanatory variables despite its above noted change to the definition of botex. The one exception to this is the moderate change to Ofwat's bioresource modelling, which now addresses the fact that sludge transportation costs are associated with the size of treatment works, in address to Anglian's concerns. However, while the addition of this variable is perhaps an improvement, the revised bioresource models continue to rely primarily on marginally statistically significant "density" variables and continue to have remarkably low overall explanatory power.

Moreover, Ofwat's arguments (in its Draft Determination cost efficiency technical appendix) for not employing nonindigenous sludge treatment as an alternative control variable are spurious, and in fact contrary to its arguments for allowing the size of treatment works via either a share variable or via a properties per works variable as both would also be "in the control" of companies. However, the size of treatment works, and the resulting need for nonindigenous treatment of sludge (and hence its transportation), are not the result of casual managerial discretion as Ofwat assumes, but are instead the result of relevant population dispersion patterns at a level of disaggregation well below that captured by Ofwat's density measures (see below).

2. Ofwat continues to fail to provide an integrated wholesale wastewater model despite the fact that Saal & Nieswand (2019) demonstrated this was feasible while adhering to Ofwat's modelling framework, and that various other models better able to capture cost interactions between upstream and downstream activities, such as those employed by Anglian Water in its business plan, have been presented to Ofwat as part of the PR19 process

We particularly emphasise that Ofwat continues to fail to provide an integrated wastewater model, with which to triangulate its disaggregated models, despite that fact that Saal & Nieswand (2019) readily demonstrated the feasibility of doing this while staying within Ofwat's modelling framework. Moreover, Ofwat continues to ignore the complex cost trade-offs between transportation, sewage treatment and sludge treatment costs, as determined by complex geographic and topographical factors (and not managerial discretion as Ofwat appears to assume) that our modelling for Anglian Water identified as key to modelling integrated wastewater modelling, which we emphasise was not only highlighted in Anglian Water's own cost modelling reports, but also indicated in our previous commentary on Ofwat's modelling included in Anglian Water's IAP response (Saal, Nieswand and Arocena, 2019 ; Saal & Nieswand, 2019; Anglian Water 2018).

“ Thus, in sum, we believe that Ofwat’s failure to provide an integrated wholesale waste water model, coupled with the overall relatively low quality of its disaggregated models, has resulted in Ofwat employing a set of models that does not yet meet what we believe to be appropriate standards for use in regulatory cost assessment” (Saal, & Nieswand, pp. 48-9).

3. Ofwat’s wastewater models are particularly illustrative of its reliance on random effects modelling, as an inappropriate approach to regulatory cost assessment, which is likely to confuse unmodelled heterogeneity in the factors influencing firms costs with cost efficiency.

This point is demonstrated in the below tables, which illustrate that Ofwat’s wastewater models consistently fail Ramsey Reset tests when estimated with OLS, regardless of the estimation period employed, thereby suggesting under-specification of its models. Moreover, the high number of statistically insignificant parameters in its models when estimated with OLS, as illustrated in the second table, further demonstrates that its models are not particularly robust.

In contrast, Ofwat’s random effects models generally do not fail Ramsey Reset tests. Moreover, its random effects coefficients are generally statistically significant when estimated with 2012-18 data (see table presented with Comment 4 below). However, one cannot escape the conclusion that Ofwat’s random effect models effectively camouflage what are in fact underspecified models.

Given this evidence, it is my considered opinion that the time invariant random effects resulting from Ofwat’s models are much more likely to be consistent with a control for unmodelled heterogeneity rather than the assumption made by Ofwat, which is that they are consistent with interpretation as indicators of cost inefficiency.

		OLS Ramsey Reset Test Signficance Level							
Estimation Period	Time Dummies	**SWC1**	**SWC2**	**SWT1**	**SWT2**	**BR1**	**BR1**	**BRP1**	**BRP2**
2012-2018	**no**	0.22	0.22	0.01	0.00	0.23	0.00	0.00	0.00
2012-2018	yes	0.21	0.31	0.02	0.00	0.10	0.00	0.00	0.00
2014-2018	**no**	0.10	0.19	0.01	0.00	0.10	0.01	0.01	0.00
2014-2018	yes	0.26	0.39	0.02	0.00	0.09	0.03	0.01	0.00
		Random Effect Ramsey Reset Test Signficance Level							
Estimation Period	Time Dummies	**SWC1**	**SWC2**	**SWT1**	**SWT2**	**BR1**	**BR1**	**BRP1**	**BRP2**
2012-2018	**no**	0.54	0.62	0.48	0.57	0.76	0.14	0.21	0.30
2012-2018	yes	0.55	0.51	0.20	0.04	0.36	0.05	0.30	0.50
2014-2018	**no**	0.93	0.90	0.64	0.73	0.33	0.36	0.23	0.25
2014-2018	yes	0.91	0.90	0.31	0.31	0.34	0.39	0.38	0.54

		OLS _Proportion of Paramters not signficant at 10% (excuding constant and time controls)							
Estimation Period	Time Dummies	SWC1	SWC2	SWT1	SWT2	BR1	BR1	BRP1	BRP2
2012-2018	**no**	0.33	0.33	0.33	0.67	0.00	0.00	0.00	0.00
2012-2018	yes	0.33	0.33	0.33	0.67	0.00	0.00	0.33	0.33
2014-2018	**no**	0.33	0.33	0.67	0.67	0.33	0.50	0.33	0.67
2014-2018	yes	0.33	0.33	0.67	0.67	0.33	0.50	0.33	0.67

4. While Ofwat's reliance on random effects effectively camouflages the mis/under specification of its models when estimated inappropriately with 2012-18 data, even its random effects models are not statistically robust when estimated with 2014-18 data.

As argued above with regard to Ofwat's water modelling, consistent cost assessment for costs in the 2014-18 period with a time invariant random effect requires the use of a random effect specified for 2014-18 period. However, as the below table illustrates, Ofwat's models cannot be considered statistically robust when they are appropriately estimated for the 2014-18 period.

		RE Proportion of Paramters not signficant at 10% (excuding constant and time controls)							
Estimation Period	Time Dummies	SWC1	SWC2	SWT1	SWT2	BR1	BR1	BRP1	BRP2
2012-2018	**no**	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00
2012-2018	yes	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00
2014-2018	**no**	0.33	0.33	0.00	0.67	0.33	0.00	0.33	0.67
2014-2018	yes	0.33	0.33	0.33	0.33	0.33	0.00	0.33	0.33

In contrast, while not reported here, it can be confirmed that the alternative integrated models consistent with Ofwat's modelling framework suggested by Saal & Nieswand (2019) remain statistically robust when estimated with 2014-18 data, thereby illustrating that it is inappropriate model specification, and not the reduced sample period, that causes the loss of parameter significance in Ofwat's models

5. As with its water modelling, failure to employ a random effect consistent with its 2014-18 cost efficiency assessment period and controls for statistically significant differences over time in the cost environment faced by regulated firms causes significant downward bias in Ofwat's assessment of Anglian Water's 2021-25 botex plus

We firstly note that given time constraints, but in contrast to our above water models which model botex, we have simply modified Ofwat's codes and rerun its models using its new Botex plus definition for wastewater. Nevertheless, after making upper quartile corrections, and allowing for the -1.1 percent annual continuing cost efficiency assumed by Ofwat for AMP7, Ofwat's wastewater models suffer from a similar bias to that we observed for its water models.

		Model Averages by Model Type and Regression Estimation Period							
Estimation Period	Time Dummies	**Sewage Collection**	bias	**Sewage Treatment**	bias	**Bio-Resources**	bias	**Bio-Resources Plus**	bias
2012-2018	**no**	721.8		824.2		299.0		1106.3	
2014-2018	yes	748.1	-26.3	866.8	-42.7	317.0	-18.0	1160.0	-53.8