



Private & Confidential
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Ofwat
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29 August 2014

Dear Sonia,

PwC review of Northumbrian Water's doubtful debt cost models

Under the terms of Service Order SER/0379, you asked PricewaterhouseCoopers LLP ("us") to carry out a review of the econometric analysis undertaken on behalf of Northumbrian Water ("NES") by Oxford Economic Research Associates Ltd ("Oxera"). This analysis was used to support a doubtful debt cost adjustment submitted in NES's Retail Business Plan for Asset Management Period Six ("AMP6") which covers the period from 2015/16 to 2019/20.

In their December 2013 submission, NES's proposed bad debt adjustment was not supported by any econometric modelling. NES subsequently submitted a model in June 2014 to corroborate their earlier analysis. We advised Ofwat on the robustness of this modelling. This letter describes the comments provided by us to Ofwat.

Analysis submitted, June 2014

NES submitted econometric modelling to support their original bad debt adjustment claim in June 2014. This included analysis by Oxera that used a cross industry panel model to produce an estimate of the adjustment based on deprivation and bill levels.

The original adjustment (from December 2013) had been based on a simple comparison of deprivation levels in NES's region with the industry average. The percentage difference was combined with NES's current doubtful debt costs to estimate an adjustment of £3.2m per annum. NES subsequently revised the requested adjustment to £5.8m per annum in June 2014 following modelling results produced by Oxera which we describe below¹.

In their analysis for NES, Oxera presented three cross industry panel data models they had previously developed as part of the Dŵr Cymru assessment. One model was based on income deprivation, one on multiple deprivation and one on unemployment². These models were not the final versions submitted by Dŵr Cymru which were based on using a different historic data set developed by Experian.

These models were used to estimate an adjustment value of between £5.1m and £6.5m per annum in 2012/13 (in 2012/13 prices) by comparing the fitted estimate for NES with the

¹ Both values are in nominal prices.

² These were the 14 May 2014 versions of the models, as described in PwC's letter to Ofwat and in "Points of clarification – Note prepared for Dŵr Cymru Water", Oxera, 14 May 2014.

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equivalent value if they had industry average bills and deprivation or unemployment. The mid-point of this estimate was taken as the basis for the amended £5.8m adjustment claim.

The models were also used to produce forecasts for total doubtful debt costs at NES (i.e. equivalent to the ACTS level plus the adjustment). The average of the Oxera models provided an estimated doubtful debt cost of £68m over AMP6 (in 2010/11 prices), which compares to the £68m requested in NES's business plan (when also expressed in 2010/11 prices). The equivalent value estimated from the PwC model which used unemployment as a driver of doubtful debt costs was £79m over AMP6³.

Comments and results from statistical tests

We considered that the cross industry panel approach adopted provided helpful corroboration to the original analysis. However we do note several issues with the specific models provided.

The models did not perform as well on statistical tests as did earlier versions of the Oxera modelling, for example those produced for South West Water, and the final model used by Dŵr Cymru (full test results are given in the Annex). In particular, the models failed tests on the statistical properties of residuals, and the Sargan-Hansen test showed that a fixed effects approach should have been used rather than the random effects approach. The implications of the tests on residuals are that outliers may be an issue with these models, which can be controlled for using alternative regressors (e.g. a quantile regressor). This would result in different coefficients and estimates from the models. The Sargan-Hansen test implied that the results of a random effects model will be biased.

Another issue with the approach was the circularity of the forecasting methodology. Some of the model coefficients were estimated using forecast data on doubtful debt from companies' business plans. This is not a standard econometric approach (it is standard to estimate coefficients based on modelling historic data alone), and this approach introduced additional modelling error through the uncertainty inherent in the forecasts and circularity in the estimates generated.

In addition, Oxera used different models to derive the estimated the 2012/13 adjustment value and to estimate forecasts for total doubtful debt. The former used a model with time dummies, whilst for the latter they replaced the time dummies with a time trend⁴. We considered this approach to be unnecessary and not consistent with standard practice. The preferred model which used time dummies could simply have been used to generate forecasts without altering the specification.

Given the issues above we also reviewed the results of alternative modelling approaches for further corroboration of the adjustment value. As described above, the PwC model which used

³ For more details of the model see "PwC review of South West Water's doubtful debt cost models" PwC, 29 April 2014.

⁴ A time dummy is a variable used to explain anomalous patterns in individual years whilst a time trend is used to capture consistent patterns which escalate over time.



unemployment as a driver of doubtful debt costs independently predicted a slightly higher value for total doubtful debt costs in AMP6 (i.e. the ACTS cost plus the adjustment value)⁵.

We also reviewed the adjustment values for NES derived from the final Oxera panel data models submitted by South West Water and Dŵr Cymru⁶. These models were broadly similar to those NES submitted but had superior performance on the statistical tests. In particular they passed tests on the normality of residuals and the Sargan-Hansen test. The average adjustment value suggested by these models was slightly higher than £5.1 and £6.5m per annum range reported in Oxera's latest modelling.

Summary

On balance, we considered that the additional cross-checks provided by NES gave further corroboration for the adjustment value they requested. Whilst there were some specific issues with the panel models chosen, we note that they provided consistent estimates to PwC modelling and the previous analysis by Oxera for other companies. Overall we considered that in terms of the econometric analysis alone, NES's quality of evidence was broadly commensurate to that submitted by South West Water and Dŵr Cymru Water.

Yours Sincerely

PricewaterhouseCoopers LLP

⁵ For more details see "PwC review of South West Water's doubtful debt cost models" PwC, 29 April 2014.

⁶ These values were taken from the modelling files previously submitted by Oxera to Ofwat.



Annex – results of statistical tests conducted by PwC

Summary of statistical test results – Oxera models, June 2014 (test values given in parentheses)

Test	Oxera model 1 Index of Multiple Deprivation	Oxera model 2 Income domain	Oxera model 3 Unemployment
Ramsey RESET test for model specification	Failed using fitted value of dependent variable (0.0000)	Failed using fitted value of dependent variable (0.0001)	Passed using fitted value of dependent variable (0.2662)
	Passed using fitted value of independent variables (0.0841)	Passed using fitted value of independent variables (0.1444)	Passed using fitted value of independent variables (0.0939)
Linktest model specification test	Passed (0.878)	Passed (0.313)	Passed (0.094)
Breusch-Pagan test for heteroskedasticity	Failed (0.0067)	Failed (0.0049)	Failed (0.0007)
Shapiro-Wilk test for normality of residuals	Failed (0.00011)	Failed (0.0000)	Failed (0.0000)
White test for residual normality after Panel regression	Failed (0.0446)	Failed (0.0152)	Failed (0.0005)
Breusch-Pagan test on the validity of a random effects or pooled OLS approach	RE preferred to OLS (0.0000)	RE preferred to OLS (0.0000)	RE preferred to OLS (0.0000)
Sargan-Hansen test – on the validity of a random effects or fixed effects approach	FE preferred to RE (0.0040)	FE preferred to RE (0.0051)	FE preferred to RE (0.0457)

A model specification test (Ramsey RESET) had mixed results, with part fails on model 1 and 2 and a pass on model 3. The results of this test cannot be relied upon as they are not valid when heteroskedasticity tests are failed (as is the case in these models). Nevertheless, if taken at face value for models 1 and 2, the results suggest the models may have the wrong functional form (e.g. it may be the case that it should not be linear). This can also be indicative of omitted variables.



A different model specification test (Linktest) was passed, which contradicted the result of the Ramsey RESET test for model 1 and model 27. In circumstances where specification tests are contradictory, it is often recommended to seek an alternative specification.

We performed tests on whether the statistical properties of model residuals (i.e. the difference between the actual and modelled values) were consistent with those expected under a given modelling approach. The models all failed the White test for normality of the residuals and the Shapiro-Wilk test. This suggests that some other estimator beside the ones used may have been more suitable (e.g. a robust or quantile regression approach).

A further test on the statistical properties of residuals (heteroskedasticity) was also failed for both models. This was controlled for by the use of robust standard errors in the regressions.

There is a standard test for panel data models only (the Breusch-Pagan test) to identify whether a random effects model is more appropriate than an Ordinary Least Squares (OLS) model. This test confirmed that the random effects approach was preferable to the OLS approach.

Further tests can be used to assess whether a fixed effect panel approach is preferable to a random effects panel approach. Under heteroskedasticity (which tests show was present in all models), it is necessary to use the Sargan-Hansen test to determine whether a random effects or fixed effects model is more appropriate⁸. The Sargan-Hansen test showed that the fixed effects approach should have been used for these models. However, the random effects approach was actually applied which have led to bias in the coefficients.

This letter has been prepared only for Ofwat and solely for the purpose and on the terms agreed with Ofwat under Service Order SER/0379 dated 29 July 2013. We accept no liability (including for negligence) to anyone else in connection with this note, and it may not be provided to anyone else without our prior written consent.

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⁷ The Linktest can provide different results to the Ramsey RESET test as it uses a different method to test model specification. However, its results are also not valid under heteroskedasticity.

⁸ The Hausman test is also used for this purpose but the results of this test are not reliable when heteroskedasticity is present.