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MEMO

TO: SP Energy Networks
DATE: 8 August 2014
FROM: NERA (Richard Druce and Peter Spittal)
SUBJECT: Ofgem's approach to totex modelling

1. Overview

This memo summarises our initial analysis of Ofgem's econometric totex models. As with its fast-track (FT) assessment, Ofgem has estimated two econometric totex models as a part of its assessment of cost efficiency. The alternative totex models are referred to as the "top-down" and the "bottom-up" models, which each receive an equal weight of 25% in Ofgem's aggregation of its various efficiency analyses (higher than the 12.5% weight each was assigned in the FT cost assessment). The weight assigned to the models in aggregating Ofgem's different analyses is arbitrary, although we note that the increase in weight assigned to the econometric totex models has marginally benefitted SPD, but slightly reduced SPMW's allowances.[1]

As in the FT assessment, both models seek to explain totex, using a "composite scale variable" (CSV) as the key explanatory factor. However, unlike the FT assessment, Ofgem has also included a time trend in each of its models in addition to the CSV. The two totex models differ only according to the definition of the CSV:

- the "bottom-up" model, uses a composite index of cost drivers from all of Ofgem's disaggregated activity models, weighted according to each activity's associated level of totex; and
- the "top-down" model, uses a composite index of two size cost variables (customer numbers and MEAV) with weights of 13% and 87%, respectively, estimated from a separate regression analysis. Ofgem used a different definition of top-down CSV in its FT expenditure assessment, which was made up of customer numbers, network length and units distributed, with each given equal weight. Ofgem has not provided justification for its change in variables included in the top-down CSV.

Ofgem has neither explained nor justified the process by which it selected either of these models. In particular, despite recognising the importance of an objective and transparent approach to model selection for its CAI regression, it has not provided detail about its decision on which variables to

[1] Had Ofgem used the same weighting of models as in its FT assessment, SPD's final allowance would have been £19m lower, at £1494m rather than the £1519m shown in Table 2.9 on page 13 of Ofgem's Draft Determination expenditure assessment annex. However, SPMW's assessment would have been £19m higher, at £1705m rather than £1686m. (We note also that the final allowance for SPMW of £1687m reported in Table 2.9 of Ofgem's expenditure assessment reflects a rounding error from £1686.48m.)

include in either of its CSVs, or why it decided to use a CSV rather than including relevant cost drivers separately.[2]

We have examined the robustness of Ofgem's totex econometric models, focussing on the impact of changes in its approach from the FT cost assessment. In particular, we have examined:

- whether Ofgem's change in approach to constructing its top-down CSV variable is statistically valid, and whether it has a material impact on allowances. We set out this analysis in Section 2;
- whether Ofgem's approach to controlling for trends in costs has a material impact on its modelled costs, as set out in Section 3;
- whether, by following a more objective approach to model selection (as we have used in our previous reports for SPEN), we are able to arrive at an econometric model with better statistical properties, and the impact of using such a model on allowances. We set out this analysis in Section 4; and
- whether econometric totex modelling, using high-level cost drivers, is limited in its ability to control for specific features of DNOs that drive variation in cost.

[2] In Appendix 9 of its Draft Determination expenditure assessment annex, it states that "As most of these [candidate] drivers are scale variables, we expect that there would be a significant degree of correlation between combinations of these. We have used a CSV throughout our slow track assessment to address this". However, it has not provided details of any regression analyses including the drivers in isolation, nor has it provided details of statistical tests that suggest that using a CSV is a better approach.

2. Ofgem's CSVs

Ofgem has used two econometric models, which seek to explain totex in terms of (1) a CSV and (2) a time trend. Following its FT assessment, Ofgem has revised the "top down" CSV that it uses in one of these models. We had criticised Ofgem's previous top down CSV measure on the basis that:

1. Ofgem's FT CSV variable arbitrarily constrained the model coefficients on the three size variables (customer numbers, network length and units delivered) to have the same coefficient; and
2. by including a single cost driver in its regression analysis (albeit a composite index), Ofgem failed to control for factors that may explain other keys aspects of the variation in DNO total expenditure.

Despite its modified approach, these criticisms still apply to Ofgem's top-down CSV variable. Ofgem's revised variable includes two size cost variables (customer numbers and MEAV) with weights estimated from separate regression analysis. In particular, Ofgem has estimated a regression of log totex on (1) an intercept, (2) the log of a "standardised" measure of log MEAV (in which Ofgem has (i) subtracted the average from each MEAV observation and (ii) divided by its standard deviation) and (3) the log of a "standardised" measure of log customer numbers. It uses the coefficient estimates for (2) and (3) to construct its weights for the CSV.[3]

However, following this initial regression, Ofgem has fixed the weights placed on each variable in the CSV in its subsequent regression (which has a different form to the regression it used to determine the weights), rather than allowing its econometric models determine (1) whether the variable does, in fact, have a statistically significant impact on costs, and (2) the relative size of the impact. In doing so, Ofgem has not allowed for the possibility that the coefficients will be different when (1) running a regression with the actual values of log MEAV and log customer numbers, rather than the "standardised" values used to derive the CSV weights, and (2) including a time trend in its specification.

In order to test the validity of Ofgem's approach, we estimated a regression of totex on a time trend and the two variables Ofgem includes in its top-down CSV (MEAV and customer numbers) separately.[4] We show the coefficients from this regression, along with the results of Ofgem's standard tests of model validity, in the second column of

[3] Ofgem sets out its approach to estimating the weights on its top-down CSV variable in more detail in Appendix 4 of its Draft Determination expenditure assessment annex.

[4] Following Ofgem's approach, here and in the remainder of the memo we have used the natural logarithm of all variables in our econometric analysis.

Table 2.1 (with the coefficients estimated from Ofgem's econometric model presented in the first column for comparison). We note that:

- when MEAV and customer numbers are included in an econometric model as separate cost drivers, the estimated coefficient on customer numbers is not statistically significant. We note that this is likely to be due to the high correlation between the two variables.[5] However, in cases where variables are highly correlated, a model using a composite index of both has little benefit over a model that simply includes one of the drivers (potentially alongside other cost drivers that have an economically meaningful and statistically significant influence on costs); and
- we have tested statistically whether the coefficient estimates conform to the weights assigned by Ofgem in constructing its top down CSV. We estimated the regression Ofgem has used to estimate the weights placed on MEAV and customer numbers (approximately 87% and 13%, respectively), and tested whether the coefficients from the regression including each of the variables as separate cost drivers conformed to these weights. We rejected the hypothesis that the estimated coefficients in our regression supported Ofgem's weighting of the variables in its CSV at the 1% significance level, which suggests that Ofgem's choice of weights is not justified in the model it has estimated.

Therefore, we conclude that Ofgem's top down CSV has little statistical justification. However, we note that the model performs similarly to Ofgem's specification against Ofgem's suite of diagnostic tests, and has a similar adjusted R-squared. Therefore, while this specification suggests that Ofgem's top-down CSV lacks statistical validity, we do not consider our alternative specification to represent a substantial improvement.

[5] The correlation coefficient between the log of MEAV and log of customer numbers is 0.94, where a coefficient of 1 indicates perfect correlation.

Table 2.1
Analysis of Ofgem's "Top Down" Totex Analysis

	Ofgem Specification – Top Down	*Separate MEAV and Customers*	*CSV as in FT Assessment*
"Top Down" CSV	0.81 *(0.00)*	-	-
Time Trend	-0.02 *(0.00)*	-0.02 *(0.00)*	-0.01 *(0.00)*
MEAV	-	0.76 *(0.00)*	-
Customers	-	0.05 *(0.64)*	-
"Top Down" CSV – as in FT Assessment	-	-	0.77 *(0.00)*
Constant	23.93 *(0.00)*	-7.43 *(0.00)*	19.02 *(0.00)*
Adjusted R-Squared	0.88	0.88	0.85
Reset Test	✓ 0.51	✓ 0.49	✓ 0.84
Test for Heteroskedasticity	✗ 0.02	✗ 0.04	✗ 0.00
Test for Normality of Errors	✓ 0.08	✓ 0.12	✓ 0.07

Note: p-values in parentheses.

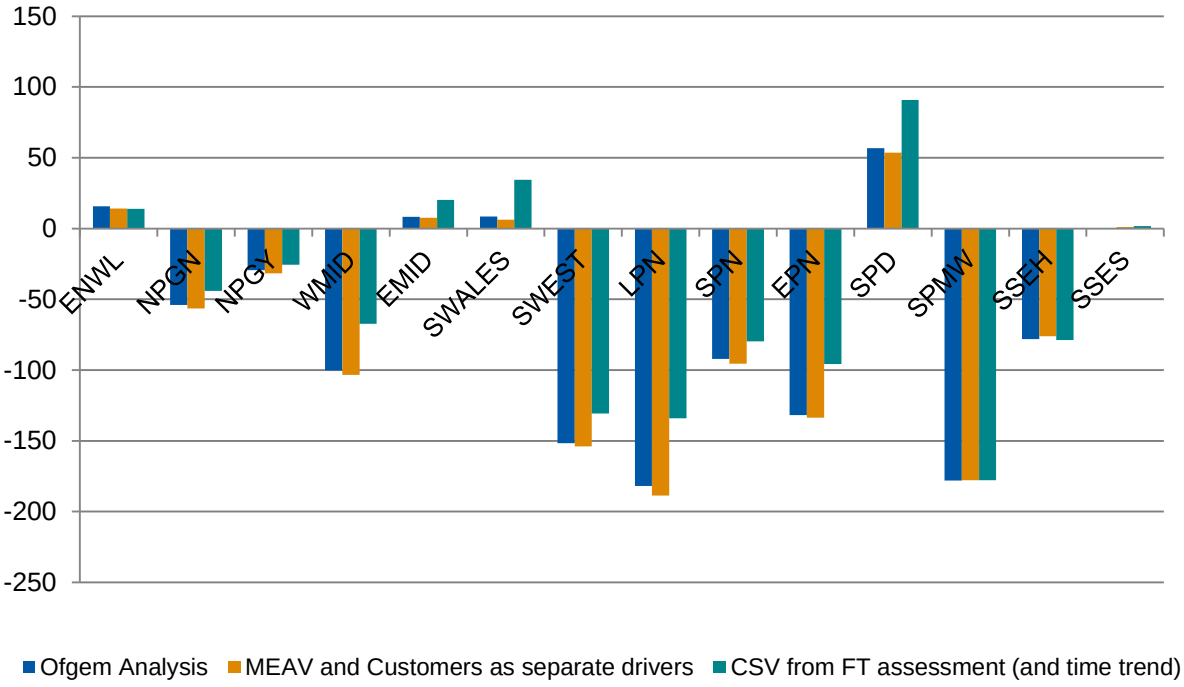
We also examined the impact of Ofgem's change of definition of CSV relative to its FT cost assessment (which, as we have set out in previous reports for SPEN, we consider to be equally arbitrary and lacking in statistical justification). The final column of Table 2.1 shows the coefficient estimates from a regression in same form of Ofgem's current top-down totex model, but with Ofgem's FT CSV (recalculated using the standard-track dataset) substituted for Ofgem's revised top-down CSV. The coefficient estimates, and the performance of the model against Ofgem's diagnostic tests, are similar to the current Ofgem specification, with the standard-track top-down CSV.

Figure 2.1 shows the difference between DNOs' submitted costs and Ofgem's modelled costs for each of the models presented in Table 2.1. These efficiency gaps correspond to the figures presented in column (a) of Table 2.5 of Ofgem's Draft Determination expenditure assessment annex. In particular, the bars in the chart show:

- the impact of each analysis on Ofgem's view of efficient costs, based on each of its three models (the two totex models and its disaggregated models), aggregated with weights of 25% on each of the totex models and 50% on the disaggregated model, and following its adjustment to the upper quartile; but
- before applying adjustments for either RPEs or smart grids, or the IQI mechanism.

Therefore, the chart represents the impact of changes to Ofgem's top-down totex model (with 25% weight), holding all other aspects of Ofgem's analysis constant (with 75% weight).

Figure 2.1
Impact of CSV Sensitivity Regressions on Allowances



We note that the impact of each of our two analyses is relatively small, although reverting to the top-down CSV variable Ofgem used in its FT assessment increases SPD's allowance by £34.2m relative to Ofgem's standard-track assessment.

3. Ofgem's Use of a Time Trend

In its standard-track assessment, Ofgem has included a time trend in each of its totex regression models as it has estimated its models using data covering DCPR5 and forecasts for RIIO-ED1, rather than just historical data as in its FT assessment. However, its approach to controlling for time variation its totex models is different to its CAI regression, in which it uses a dummy variable to indicate the period covered by DCPR5. Neither approach is "best" on theoretical grounds, but the most appropriate is an empirical question.

Table 3.1 and Table 3.2 show three estimated coefficients from three regressions examining the impact of Ofgem's choice of method of controlling for time variation, for the bottom-up and top-down totex regressions respectively:

1. The coefficients estimated from Ofgem's standard-track models (provided for comparison);
2. Coefficients from Ofgem's models estimated without a time trend; and
3. Coefficients from regressions estimated using a DCPR5 dummy instead of a linear time trend.

In both cases, the three models perform similarly although, as expected, the specification that does not control for trends in costs over time at all has a marginally lower adjusted R-squared.

Table 3.1
Coefficient Estimates for Bottom Up Time Trend Sensitivity Regressions

	Ofgem Specification – Bottom Up	*No Time Trend*	*DCPR5 Dummy*
"Bottom Up" CSV	0.85 *(0.00)*	0.84 *(0.00)*	0.85 *(0.00)*
Time Trend	-0.01 *(0.00)*	-	-
DCPR5 Dummy	-	-	0.09 *(0.00)*
Constant	28.44 *(0.00)*	0.83 *(0.10)*	0.77 *(0.01)*
Adjusted R-Squared	0.89	0.84	0.88
Reset Test	✓ 0.47	✓ 0.32	✓ 0.48
Test for Heteroskedasticity	✗ 0.01	✗ 0.02	✓ 0.07
Test for Normality of Errors	✓ 0.11	✓ 0.11	✓ 0.12

Note: p-values in parentheses.

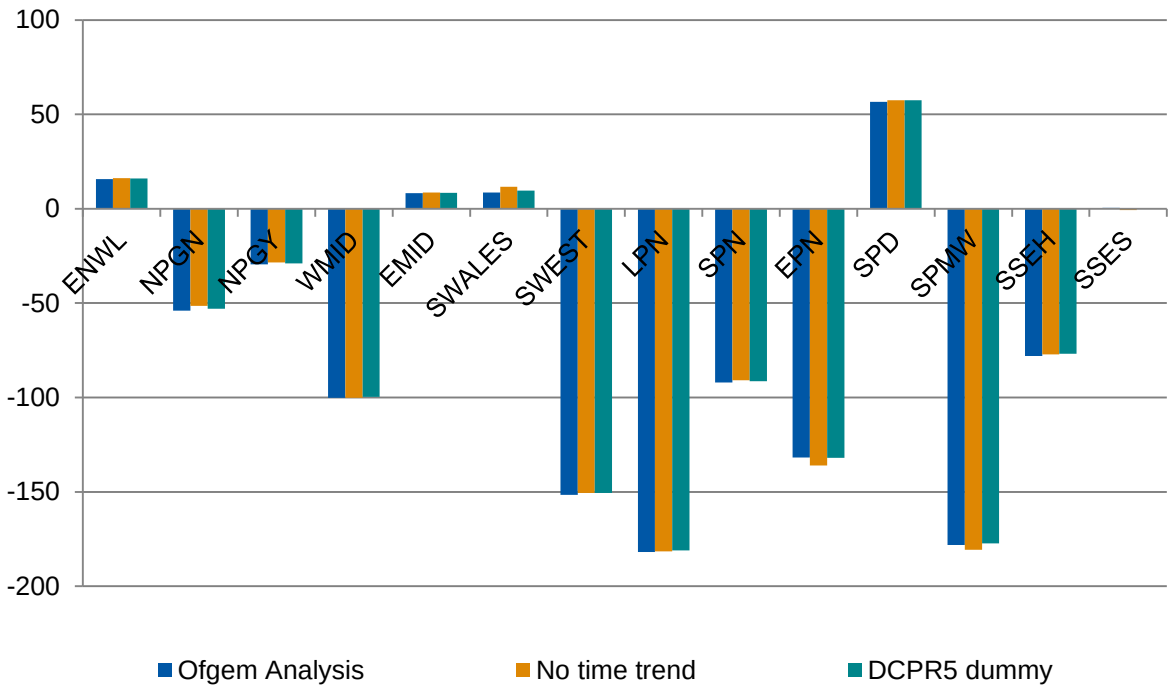
Table 3.2
Coefficient Estimates for Top Down Time Trend Sensitivity Regressions

	Ofgem Specification – Top Down	*No Time Trend*	*DCPR5 Dummy*
"Top Down" CSV	0.81 *(0.00)*	0.80 *(0.00)*	0.81 *(0.00)*
Time Trend	-0.02 *(0.00)*	-	-
DCPR5 Dummy	-	-	0.10 *(0.00)*
Constant	23.93 *(0.00)*	-7.27 *(0.00)*	-7.44 *(0.00)*
Adjusted R-Squared	0.88	0.84	0.87
Reset Test	✓ 0.51	✓ 0.32	✓ 0.49
Test for Heteroskedasticity	✗ 0.02	✗ 0.02	✗ 0.04
Test for Normality of Errors	✓ 0.08	✓ 0.11	✓ 0.12

Note: p-values in parentheses.

Figure 3.1, which is calculated equivalently to Figure 2.1 above,[6] shows the impact of these sensitivity regressions on DNOs' efficiency gaps. Final allowances are not sensitive to Ofgem's use of a time trend, or the exact method by which it controls for variation in costs over time.

Figure 3.1
Impact of Time Trend Sensitivity Regressions on Allowances



[6] That is, it shows the impact of each analysis on Ofgem's view of efficient costs, based on each of its three models (the two totex models and its disaggregated models), aggregated with weights of 25% on each of the totex models and 50% on the disaggregated model, and following its adjustment to the upper quartile, but before applying adjustments for either RPEs or smart grids, or the IQI mechanism.

4. Ofgem's Approach to Model Selection

As discussed in Section 1, above, Ofgem has not explained or justified the process by which it selected either of its totex models, despite recognising the importance of an objective and transparent approach to model selection for its CAI regression. It has not explained how it decided which variables to include in either of its CSVs, or why it decided not to include relevant cost drivers separately and allowing their relative weight to be determined by its regression analysis.[7]

We have developed an alternative econometric model of totex. In contrast to Ofgem's approach, however, we do not impose weights on a pre-selected set of cost drivers; Ofgem's assumed weightings constrain the regression coefficients in a way that is either arbitrary (for its bottom-up CSV) or cannot be justified statistically (for its top-down CSV, as discussed in Section 2 above).

Instead, we have followed the model selection procedure that we have developed in previous reports for SPEN, by testing statistically whether variables we highlight as potentially relevant cost drivers for totex have a statistically significant influence on costs, and whether the estimated models conform with economic theory. Following our previous approach, we identified that the following variables may be potentially relevant in explaining variation in costs:

- MEAV, customers, network length, area and (top-down) CSV all of which are measures of network size. We include these on the basis that larger DNOs are likely to incur higher costs; and
- the Gini index, a measure of the density and dispersion of customers, which tends to increase the size of the network required to serve customers, and thus increase costs.[8]

Through our model selection procedure, we have "tested-down" from this initial set of potentially relevant cost drivers to identify a model with robust statistical properties, and coefficients that conform to predictions from economic and/or engineering theory.

We present the model that resulted from this process as the "NERA Model" in Table 4.1. All cost drivers in the NERA Model are statistically significant at the 1% level, and have coefficients in line with expectations:

- MEAV has a positive coefficient, suggesting larger DNOs incur higher levels of cost; and

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[7] In Appendix 9 of its Draft Determination expenditure assessment annex, it states that "As most of these [candidate] drivers are scale variables, we expect that there would be a significant degree of correlation between combinations of these. We have used a CSV throughout our slow track assessment to address this". However, it has not provided details of any regression analyses including the drivers in isolation, nor has it provided details of statistical tests that suggest that using a CSV is a better approach.

[8] In our previous reports, we have also included density as an alternative measure of the density and dispersion of customers, but this variable is not included in Ofgem's standard-track dataset.

- the time trend has a negative coefficient, suggesting that DNOs' costs have generally fallen over time (and are forecast to fall further in RIIO-ED1).

Table 4.1
Regression Coefficients for NERA Totex Model

	Ofgem Specification – Top Down	*Ofgem Specification – Bottom Up*	*NERA Model*
"Top Down" CSV	0.81 *(0.00)*	-	-
"Bottom Up" CSV		0.85 *(0.00)*	-
Time Trend	-0.02 *(0.00)*	-0.01 *(0.00)*	-0.02 *(0.00)*
MEAV	-	-	0.83 *(0.00)*
Constant	23.93 *(0.00)*	28.44 *(0.00)*	23.92 *(0.00)*
Adjusted R-Squared	0.88	0.89	0.88
Reset Test	✓ 0.51	✓ 0.47	✓ 0.21
Test for Heteroskedasticity	✗ 0.02	✗ 0.01	✗ 0.02
Test for Normality of Errors	✓ 0.08	✓ 0.11	✓ 0.08

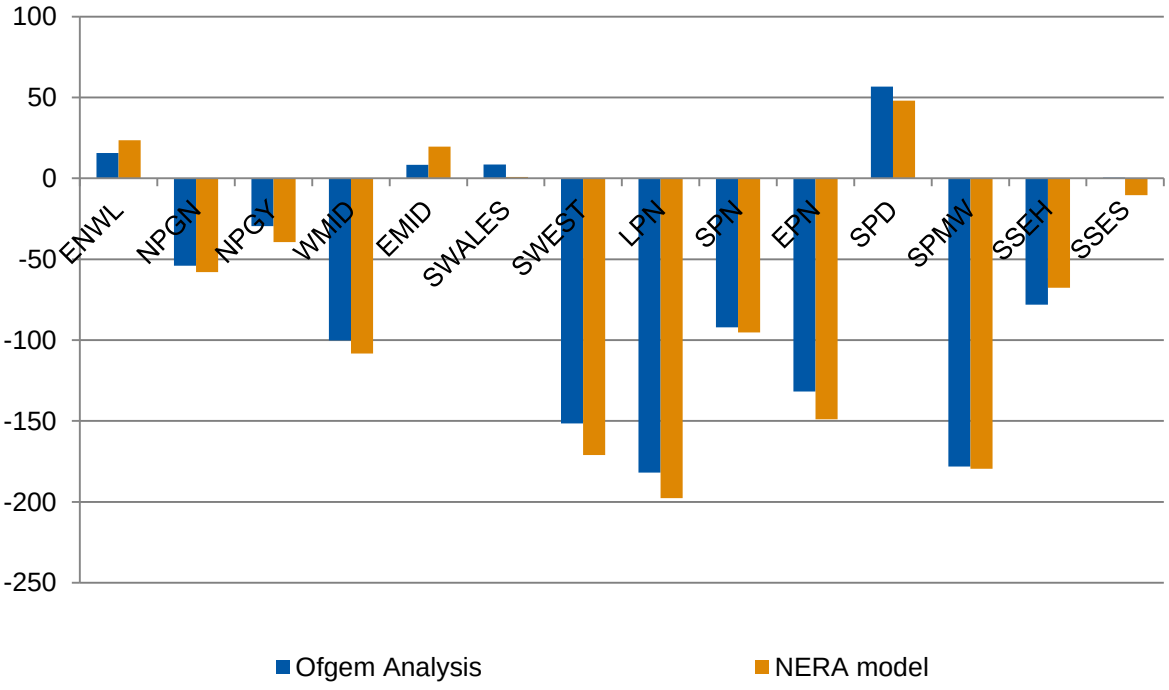
Note: p-values in parentheses.

The NERA model performs similarly to the Ofgem specifications against Ofgem's diagnostic tests, and has a similar adjusted R-squared. This is not surprising, as the model that resulted from our model selection procedure is very similar to the Ofgem models.

Figure 4.1, which is calculated equivalently to the figures above, shows the impact of the NERA Model on DNOs' efficiency gaps. However, in contrast with the charts above, we have calculated the efficiency gap using the NERA Model in place of both of Ofgem's totex models, rather than just its top-down model. Therefore, the NERA model is given a 50% weight in calculating final allowances.

We note that SPEN performs less well with NERA's model relative to Ofgem's model. However, as we discuss above, we believe that econometric totex benchmarking using high-level cost drivers is severely limited, as it is not able to control for specific factors that drive differences in costs between DNOs.

Figure 4.1
Impact of NERA Model on Allowances



5. Conclusions

In this memo, we have tested the robustness of Ofgem's econometric totex results to changes in its assumptions and model specification. In general, we have found that estimated allowances are not sensitive to these sensitivity analyses.

However, Ofgem has recognised in its disaggregated cost assessments that there are differences between DNOs that cannot be controlled for in comparative (statistical) benchmarking, and has made qualitative adjustments to account for these. For example, Ofgem made qualitative adjustments to its disaggregated costs assessment for SPD and SPMW in reinforcements and asset replacement.[9] It is impossible control for such factors using high-level econometric models of totex.

In Section 4, we applied an objective model selection procedure to identify an econometric model for totex with good statistical properties. However, even through this process, we were unable to significantly improve on Ofgem's model. We believe that this reflects a general limitation of Ofgem's totex analysis, in that it is unable to control for DNO-specific factors that drive variation in costs, but do not represent inefficiency.

[9] Ofgem sets out the results of its disaggregated efficiency assessment, along with qualitative adjustments, in Appendix 1 of its Draft Determination expenditure assessment annex.