NERA ECONOMIC CONSULTING

Response to Ofgem's RIIO-ET2 and GT2 Draft Determination on Opex Cost Assessment

Prepared for National Grid and Scottish Power

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Our Assignment

NERA Economic Consulting (NERA) has been appointed by National Grid and SP Energy Networks (SPEN) to review the approach proposed by Ofgem for setting allowed levels of operating costs for the four Transmission Owners (TOs) – National Grid Electricity Transmission, National Grid Gas Transmission, Scottish Power Transmission and Scottish Hydro Electric Transmission – in the RIIO-T2 Draft Determination.

Ofgem's Approach to Setting Opex Allowances for RIIO-T2

In determining an efficient level of operating costs for the four TOs over the RIIO-T2 control period, Ofgem has made separate determinations of the efficient levels of Network Operating Costs (NOCs), Closely Associated Indirect (CAI) costs, and Business Support costs (BSCs). Across all these categories of opex, Ofgem has performed statistical calculations which involve the use of historical and forecast data on companies' costs, as well as a number of cost drivers, to estimate an "efficient" level of operating expenditure during the period from 2021/22-2025/26:

- For NOCs, Ofgem has set the level of allowances for each company by computing the ratio of each TO's expenditure in a number of different categories of expenditure to the associated volumes of work in each category of costs. It performs this calculation separately for the historical cost and volume data during the period 2014 to 2019 and for the forecast period from 2020 to 2026. It then sets NOCs allowances for the RIIO-T2 control period based on the lower of the two ratios, multiplied by its view on the forecast volumes for the T2 period. For some categories of cost, where volumes are not reported, it takes the minimum of (i) the average annual expenditure observed between 2014-19, and (ii) the average annual expenditure forecast in T2.
- For BSCs, Ofgem has set allowances based on the predicted values emerging from a regression model. This regression is estimated using data on the four TOs' costs and drivers over the historical period from 2014 to 2019. It then uses the regression equation to predict costs over the period to 2026 using its own view of forecast drivers. The driver used in Ofgem's favoured model for BSCs is a Composite Scale Variable (CSV), weighting together each TO's Modern Equivalent Asset Value (MEAV), their number of Full Time Equivalent employees (FTEs), and each TO's total expenditure ("totex"). The regression also includes a Gas Transport (GT) dummy to control for differences between ET and GT.
- For CAI costs, Ofgem has also set allowances using the predicted values from a regression model, which it also estimates using historical costs and driver data from 2014 to 2019. The drivers used in Ofgem's favoured CAI model are MEAV and each TO's capital expenditure ("capex").

Following its analyses of these models, Ofgem has chosen to "disallow" a significant portion of all four TOs' forecast opex over the T2 control period as Table 1 below shows.

Table 1: Operating Expenditure: TOs' T2 Submission vs. Ofgem's Allowance

	T2 Submission (£m)	Vol Adjustment (£m)	Cost Adjustment (£m)	Ofgem T2 Allowance (£m)	Difference (£m)
NGGT (TO)					
NOCs	199.9	n.a.	n.a.	190.4	9.5
BSC	163.4	n.a.	n.a.	157.8	5.6
CAI	156.5	n.a.	n.a.	69.7	86.8
NGET					
NOCs	972.2	348.3	74.9	549.0	
BSC	458.5		20.2	438.3	20.2
CAI	1050.9	231.8	195.3	623.8	427.1
SHET					
NOCs		72.4	45.2		
BSC	104.9		0.7	104.2	0.7
CAI	255.4	93.9		161.5	93.9
SPT					
NOCs	110.1	0	24.5	85.6	24.5
BSC	103.9		23.9	80	23.9
CAI	169.3	22.4	17.3	129.6	39.7

Source: Ofgem (9 July 2020), RIIO-2 Draft Determinations – National Grid Gas Transmission, National Grid Electricity Transmission, Scottish Hydro Electric Transmission, and Scottish Power Transmission.

As we explain in this report, Ofgem's statistical models are not sufficiently reliable to support its conclusions on the efficient levels of opex the TOs need to incur over the T2 control period, and to quantify how these allowances will need to adjust depending on the eventual scale of their capex programmes. Moreover, Ofgem's NOCs unit cost modelling has been conducted in a way that will set allowances systematically below the TOs' efficient costs. We discuss the reasons for these flaws and our suggested remedies below.

Ofgem has Set NOCs Allowances that will Systematically Understate TOs' Efficient Costs

As noted above, Ofgem has proposed NOCs allowances for the T2 period based on a unit cost benchmarking exercise. It computes – separately for each TO – the unit cost of each sub-category of NOCs costs (at the disaggregated level) observed historically over the T1 period to date (six year of data) and the average unit cost forecast in each company's business plan for the T2 control period. Ofgem calculates unit costs using the volumes within each sub-category of cost as a cost driver. For each TO, it then takes the minimum of the unit cost observed in T1 and the unit cost forecast for T2. The minimum of these unit costs defines its proposed allowed unit cost for the T2 period, which Ofgem multiplies by its own view of the forecast of volumes to set allowances. Where volumes are not reported, Ofgem takes the same approach with average annual expenditure instead of unit costs.

For areas of activity where companies forecast their unit costs will fall, Ofgem's approach will set lower allowed unit costs than achieved during T1, reflecting TOs' expected reduction in unit costs in the T2 period. However, where the TOs' have forecast rising unit costs, the unit costs allowed by Ofgem will be capped by the unit costs achieved during T1.

In reality, some unit costs will rise over time and others will fall, even if there is a tendency for unit costs to fall over time (in real terms, at least) due to the effects of technological progress and improvements in working practices. Such variation in unit costs may result from changes in the nature or location of the work being conducted for example.

As we have shown in this report, unit costs do vary over time – both upwards and downwards – and if that is for reasons beyond TOs' control and unrelated to efficiency, then Ofgem's approach will systematically disallow changes in efficient costs. The mechanism used to do this, i.e. taking the minimum unit cost achieved in T1 and forecast for T2, is entirely mechanistic and fails to analyse the reasons for changes in unit costs over time.

We have shown therefore that Ofgem's approach includes a downward bias and, when removing that bias, we find that both SPT's and NGET's T2 NOC allowances would be higher than allowed by Ofgem and/or submitted. It follows that there is no evidence to suggest that the TOs' NOCs expenditure projections are unreasonable.

Finally, we explained that Ofgem is probably double-counting the company's expected efficiency gains over T2 since TOs' forecast already include expected embedded efficiencies. To maintain consistency between the cost assessment and frontier shift elements of the price control, Ofgem should strip out the embedded productivity *before* comparing RIIO-1 and RIIO-2 costs, effectively setting allowances that assume no productivity growth. Only after setting these allowances should Ofgem apply an ongoing efficiency adjustment, whether that is based on its own view or companies' views of the scope for ongoing efficiency.

The Indirect Cost Models Do Not Provide a Reliable Basis for Forecasting Efficient Costs for the T2 Control Period

Ofgem's Comparative Benchmarking of Indirect Costs Relies on an Extremely Small Dataset

Ofgem has set allowances for indirect costs (both BSCs and CAI) using regressions, estimated using historical data for only 6 years of historical data. Ofgem also has only four cross-sectional observations. For this reason, at past price reviews, Ofgem has not conducted comparative benchmarking modelling to assess TOs' efficiency and set allowances for CAI and made some limited use of it for BSC.

To apply such techniques to set allowances, would have risked setting allowances using models which are extremely sensitive to changes in model specification, data error, differences between companies that are not explained by the available drivers, etc. For the reasons explained below, these modelling problems apply to the analysis Ofgem has performed to set T2 allowances for indirect opex.

Ofgem's decision to rely on comparative cost benchmarking for indirect opex is also inconsistent with its approach for NOCs which relies upon an assessment of individual TOs historical and forecast costs.

Alternative Regression Models that Pass Ofgem's Model Selection Criteria Show a Wide Range of Efficient Costs for the TOs

The four TOs are very different sizes. SPT and SHET operate 4,449 and 3,111 kilometers of network respectively. By contrast, NGET and NGGT operate respectively 14,915km and 7,660 kilometers of network respectively.

Given these differences in scale, how the regression modelling treats scale economies becomes a material determinant of how the degree to which predicted costs for individual companies over RIIO-T2. Ofgem assumes a Cobb-Douglas cost function in its models which imposes a single form of cost structure for all companies regardless of size. This assumption appears unlikely to be valid in reality. We have therefore considered different ways of controlling for alternative cost functions (relationships between cost drivers and costs), by testing linear models, quadratic terms as well as interaction terms.

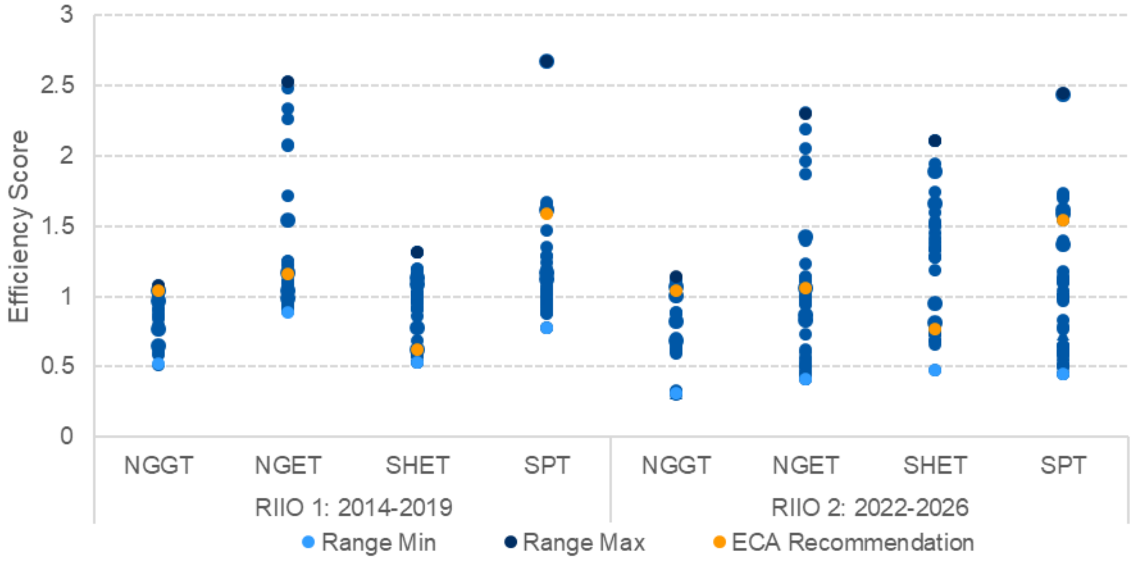
Through these sensitivities, we find that the modelled disallowance of the TOs' BSCs and CAI, defined by the difference between modelled costs and business plan forecasts, varies materially depending on these alternative approaches. Hence, due to the small sample size and the wide variation in the TOs' scale, there is a wide range of uncertainty around the degree to which the TOs' "efficient costs" vary from their business plan forecasts.

Ofgem has also considered only a very narrow range of cost drivers, which it appraises against a series of statistical tests. In fact, we have identified a number of other regression model specifications which could also provide a basis for explaining variation in the TOs' costs and predicting their costs over the T2 period. We considered a number of alternative modelling specifications, which all meet the model selection criteria set out by Ofgem and its advisors (ECA).

Like our sensitivities on alternative treatments of scale economies, these models show wide variation in the implied disallowances over the T2 control period. These sensitivities further illustrate the wide range of uncertainty around the degree to which the TOs' "efficient costs" over the T2 period vary from their business plan forecasts.

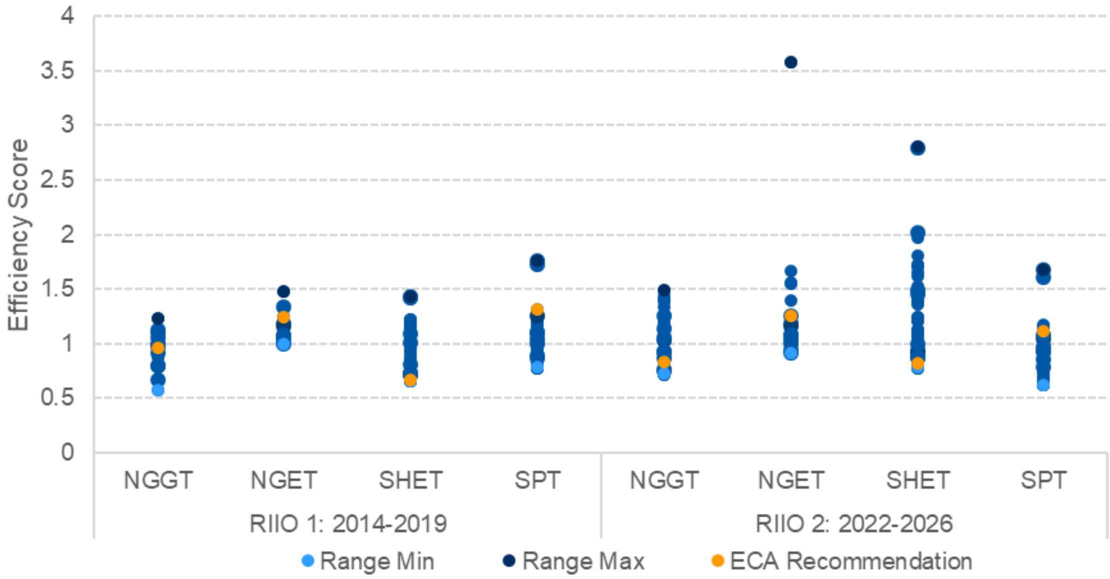
We illustrate the range of efficiency scores implied by our model specifications using alternative cost functions and cost drivers in Figure 1 for BSC and Figure 2 for CAI.

Figure 1: Efficiency Scores for BSC Across a Range of Models that Pass ECA's own Model Selection Criteria



Source: NERA analysis.

Figure 2: Efficiency Scores for CAI Across a Range of Models that Pass ECA's own Model Selection Criteria



Source: NERA analysis. Note: We illustrate the efficiency score for NGGT implied by ECA's modelled and prior to Ofgem's adjustment.

Statistical Evidence Shows that Ofgem's Modelling is Mis-specified

While the modelling Ofgem has conducted is highly sensitive to different choices of drivers and changes in the way scale economies are specified we have also shown that the models relied upon by Ofgem to set allowances also suffer from a number of statistical problems. These problems undermine the robustness of Ofgem's modelling as a means of predicting efficient costs for the T2 control period.

- First, Ofgem has pooled data on all four TOs into a single model, encompassing both NGGT (the gas TO) and the three electricity TOs. Ofgem is therefore making an assumption that the differences between the indirect costs incurred by these different types of business using fundamentally different technologies can be adequately controlled for using a simple statistical model. It has failed adequately to test this hypothesis. Our own statistical tests show that the gas and electricity TOs do not have comparable cost structures, indicating that Ofgem's models are mis-specified. For instance, when running Ofgem's preferred CAI model on ET only the regression coefficient on Capex is no longer significant (MEAV only at 5 per cent significance level). Likewise, for BSC we find that an interaction terms between the GT dummy and the cost drivers are also statistically significant. This suggests that Ofgem may be failing to capture differences in the relationship between BSC and its choice of drivers between ET and GT.
- The model Ofgem has used to set allowances fails the "Ramsey RESET" test, an important test for model mis-specification. Despite statements from ECA and Ofgem's academic advisor (Andrew Smith), this is an important test for model mis-specification. Its failure identifies that there are non-linearities in the relationships between costs and Ofgem's selected drivers for which the model fails to account. The consequence of this failure is that the modelled coefficients could be biased, and the modelled costs for individual TOs may be materially over or under stated.
- Ofgem also uses "panel" data to estimate regression equations, containing observations on multiple (four) companies over multiple (six) years. With panel data, a number of alternative regression techniques are available, not just the standard "Ordinary Least Squares" approach used by Ofgem. Standard econometric tests can inform the choice between these alternative statistical approaches. While the choice between these alternatives may not be clear-cut in small samples, standard statistical tests indicate that a "random effects" or "fixed effects" estimator may be more robust than OLS. Ofgem has ignored the results of these tests for its chosen regression models and retained a standard OLS approach. Failure to account for the panel structure of the data suggests that Ofgem's estimate of modelled costs may be over- or under-estimating individual TOs' inefficiency because it conflates efficiency with company-specific effects. Running these alternative models shows a wide range of sensitivity to modelled costs over the T2 period, which further undermines the reliability of Ofgem's conclusion to disallow some portion of the TOs' indirect opex forecasts.

Ofgem's Models Use Endogenous Cost Drivers, Creating Statistical Bias and Preventing them From Identifying Efficient Levels of TOs' Costs

Another flaw in Ofgem's models is the "endogenous" nature of cost drivers it has used to explain variation in costs. For instance, Ofgem has used (amongst other drivers) totex and the number of FTE employees to explain indirect costs. These are endogenous and may both influence and be influenced by the dependent variable in Ofgem's regressions.

A well-known feature of OLS regression estimators is that, when applied with endogenous cost drivers, they generate biased coefficient estimates. Ofgem's use of endogenous cost drivers will result in biased coefficients, and inaccurate estimates of TOs' modelled costs over the T2 control period.

Put differently, a major reason for Ofgem using comparative benchmarking to compare companies' costs is to set allowances that reflect "efficient" costs, and do not include any inefficiency. Under Ofgem's approach, companies could increase expenditure or employ more staff to perform functions that are not required to meet the needs of customers, and the inclusion of the totex and FTE drivers would provide additional allowances as a result. Their inclusion therefore injects bias into the statistical modelling, and undermines the model's usefulness as a way of identifying efficient costs.

Ofgem's Opex Escalator May Fail to Compensate TOs for Efficient Changes in Indirect Costs

Ofgem has included an uncertainty mechanism in its price control that would adjust the CAI allowances upwards if TOs increase their expenditure during the T2 control period ("Opex Escalator"). To calibrate this mechanism, Ofgem has used the coefficient on the capex driver from its CAI regression. For the reasons set out above, this estimated coefficient is extremely unreliable, given the various statistical problems we have identified with the regression model. Moreover, Ofgem's approach ignores the effect of higher capex on CAI that is captured via the coefficient on MEAV in the CAI regression, and ignores how changes in capex also affect BSCs.

In fact, our analysis suggests this coefficient on capex is towards the top end of the range of credible estimates. If this coefficient is a high-end estimate, it suggests that Ofgem may have set the portion of indirect cost allowances which do not vary with capex at a level which is too low.

Conclusions

Ofgem's Assessment of the TOs' Indirect Costs is Extremely Unreliable; its Proposal to Disallow Large Portions of TOs' CAI and BSC is Flawed

For the reasons set out above, we find that Ofgem's comparative benchmarking models and its unit cost benchmarking of NOCs do not constitute a reliable basis of evidence upon which it draws conclusions on the TOs' efficient costs over the RIIO-T2 control period.

Indeed, ECA (Ofgem's economic advisors supporting the indirect cost benchmarking for RIIO-T2) seem to share our concerns that this modelling is not reliable. For example, with regards to its CAI regression model ECA states the following:[1]

> "we include a discussion of each network's results, which require further scrutiny. We consider the model appropriate for forming the basis of an efficiency challenge, but further investigation (outside of the modelling process) is needed by Ofgem before it takes its decision on where to set the allowances, particularly for NGET and SHET".

Ofgem's proposal to disallow large amounts of TOs' opex is therefore unreliable. In fact, Ofgem has no substantive evidence that the levels of expenditure currently proposed by the TOs includes any element of inefficiency.

A more reliable approach to setting opex allowances would be to set allowances based on current levels of indirect costs for each company, with indexation over time for inflation,

[1] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p. xii.

RPEs, ongoing productivity and (if appropriate) changes in NOCs and capex due to changing workload requirements.

We Recommend Ofgem Changes its Approach to Forecasting TOs' NOCs

Instead of its current approach to setting allowed levels of NOCs for the T2 control period, we recommend that Ofgem adopts a more balanced approach to assessing the TOs' business plan forecasts of NOCs. Adopting a more balanced cost assessment approach would account for the fact that some unit costs will fall and others will rise, avoiding any systematic downward bias. Our alternative analysis shows that SPT and NGET's business plan forecasts do not propose inefficient levels of expenditure for the T2 control period.

1. Introduction

On 9 July 2020, Ofgem published its Draft Determination (DD) for the electricity transmission (ET) sector price control (RIIO-ET2) for the three Transmission Owners (TOs) in Great Britain (NGET, SPT and SHET) and for the gas transmission (GT) sector price control (RIIO-GT2) for the gas transmission operator (NGGT).[2] Both price control periods will run from 1 April 2021 to 31 March 2026.

In this context, NERA Economic Consulting (NERA) has been commissioned by National Grid and SP Energy Networks (SPEN) to review Ofgem's DD and the accompanying papers prepared for Ofgem by its consultants. This report reviews and responds to the key elements of Ofgem's and its consultants' methodology to cost benchmarking and setting baseline allowances for operating expenditure (opex) for electricity and gas TOs.

The remainder of this report is structured as follows:

- Chapter 2 describes Ofgem's approach to setting the efficient level of opex allowances for TOs in its RIIO-T2 DD;
- Chapter 3 reviews Ofgem's proposed methods for identifying TOs' efficient level of network operating costs over RIIO-T2 and proposes remedies to the identified flaws;
- Chapter 4 reviews Ofgem's proposed methods for identifying TOs' efficient level of indirect costs over RIIO-T2 and proposes remedies to the identified flaws; and
- Chapter 5 concludes with our overall assessment of Ofgem's opex cost assessment.

This report should be read alongside an accompanying NERA report which reviews Ofgem's proposed approach and allowances in the DD for Real Price Effects (RPEs) and ongoing productivity improvements.

[2] National Grid Electricity Transmission (NGET) owns, manages and operates the electricity transmission in England and Wales, SP Transmission (SPT) in southern Scotland, and Scottish Hydro Electric Transmission (SHET) in Northern Scotland. National Grid Gas Transmission (NGGT) instead owns, manages and operates the National Transmission System (NTS) in Great Britain and is the sole gas transmission owner (TO) and system operator (SO) in Great Britain.

2. Ofgem's Approach to Setting Efficient Operating Expenditure at RIIO-T2

In determining the efficient level of operating costs for the four TOs over the RIIO-T2 control period, Ofgem has made separate determinations of the efficient levels of Network Operating Costs (NOCs), Closely Associated Indirect (CAI) costs, and Business Support costs (BSCs). We describe Ofgem's methodology for setting allowances for these categories of costs during RIIO-T2 below, along with the outcomes of the cost assessment process for NGGT, NGET and SPT.

2.1. Ofgem's Assessment of Network Operating Costs

2.1.1. Electricity transmission

In the electricity transmission sector, NOCs comprise expenditure on faults, inspections, repairs and maintenance, vegetation management, operational protection measures and IT capex, and legal and safety. In its DD for RIIO-T2, Ofgem's cost assessment appraises each individual network company's historical costs over the first six years of RIIO-T1 against the company's forecast costs for RIIO-T2 at the disaggregated level for each sub-category of cost listed above.[3]

As described in the DD, depending on the availability of cost and volume data, Ofgem has relied on one of the following approaches to identify the efficient level of NOCs for each electricity TO over RIIO-ET2:[4]

- **Unit cost approach**: Ofgem relies on this approach if cost and volume data are available for both the RIIO-T1 and T2 price control periods. Under this approach, for each sub-category of costs, Ofgem sets the proposed allowance by taking the lower of the RIIO-T1 unit cost and T2 unit cost and multiplying the selected unit cost by the proposed RIIO-T2 volumes for that sub-category of cost.
- **Average annual cost approach**: Ofgem applies this alternative approach for cost sub-categories where network companies did not provide volume data in either the RIIO-T1 or T2 period. Under this approach Ofgem sets the proposed allowance for each cost sub-category by taking the lower of the "average annual cost" over RIIO-T1 and T2 and providing this average annual cost for each year of RIIO-T2. The "average annual cost" is obtained by dividing total cost over the number of years over the relevant period (6 years for T1 and 5 years for T2).

As noted by Ofgem, for some sub-categories of NOCs the above general approach is not applicable because, for example, "a network company is proposing works in the RIIO-T2 period without either an historical equivalent or comparator in the RIIO-T1 period".[5] In these instances, Ofgem relied upon a bespoke cost assessment of the company's Engineering Justification Papers (EJPs).

[3] Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para.3.41.

[4] Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para.3.42.

[5] Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para.3.43.

Table 2.1 and Table 2.2 show SPT's and NGET's NOCs submission and Ofgem's proposed allowance in the DD following its cost assessment process.

For SPT, Ofgem states that it has applied its general approach for all cost categories except for operational protection measures and IT capex, which has been reviewed separately "due to its bespoke nature".[6] However, as we explain in Section 3.1 below, Ofgem's stated approach is not consistent with its calculations in the modelling files where it appears that Ofgem used a unit cost approach also for Operational Protection Measures and IT Capex. Overall, Ofgem's approach leads it to conclude that £24.5 million out of £110.1 million submitted by SPT is "inefficient" cost and therefore should not be allowed in the baseline opex allowance.

Table 2.1: Ofgem's Assessment of SPT's Network Operating Costs for RIIO-T2

Sub-category	SPT Submission (£m)	Work/volume reduction (£m)	Cost reduction (£m)	Ofgem Allowances (£m)
Faults	19.8	0.0	7.5	12.3
Inspections	7.4	0.0	1.9	5.5
Repairs and Maintenance	48.6	0.0	6.8	41.8
Vegetation Management	2.0	0.0	0.6	1.4
Operational Protection Measures and IT Capex	11.7	0.0	0.0	11.7
Legal and Safety	20.5	0.0	7.6	12.9
Total	**110.1**	**0.0**	**24.5**	**85.6**

Source: Ofgem[7]

For NGET Ofgem makes no cost reductions, except for legal and safety where it disallows a portion of costs, noting that it is "proposing to allow £69.805m of "other" costs within this cost category, subject to NGET providing further justification for these costs".[8] In its DD, Ofgem also disallows about £350 million, which it describes as "work/volume" reduction. [✂]

6 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Scottish Power Transmission, para. 3.82.

7 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Scottish Power Transmission, p.62, Table 35.

8 Ofgem (9 July 2020), RIIO-2 Draft Determinations – National Grid Electricity Transmission, para. 3.89.

Table 2.2: Ofgem's Assessment of NGET's Network Operating Costs for RIIO-T2

Sub-category	NGET Submission (£m)	Work/volume reduction (£m)	Cost reduction (£m)	Ofgem Allowances (£m)
Faults	1.0	0.0	0.0	1.0
Inspections	94.0	0.0	0.0	94.0
Repairs and Maintenance	415.9	206.9	0.0	209.0
Vegetation Management	29.6	0.0	0.0	29.6
Operational Protection Measures and IT Capex	186.9	124.8	0.0	62.1
Legal and Safety	244.8	16.6	74.9	153.3
Total	**972.2**	**348.3**	**74.9**	**549.0**

Source: Ofgem[9]

2.1.2. Gas transmission

In the gas transmission sector, NOCs comprise both the TO direct expenditure incurred on an "an ongoing basis relating to NGGT's field-based workforce delivering its asset steward responsibilities" as well as SO direct opex expenditure incurred to operate the network on a day-to-day basis.[10]

Ofgem's assessment uses a "historical trend model for both the TO and SO to forecast RIIO-T2 costs".[11] Unlike the electricity transmission sector, Ofgem has not relied on a disaggregated analysis of each cost category "due to changes in the way some of these [NOCs] costs have been categorised across RIIO-T1 and RIIO-T2".[12] It has therefore used historical actual total direct opex data to set RIIO-GT2 costs.

In its DD for NGGT, Ofgem proposes to allow £379.65 million against NGGT's submission of £389.51m (for both TO and SO functions), implying therefore a disallowance of c. £10 million of NGGT's proposed NOCs over RIIO-T2.[13] As we discuss in Section 3.4 below Ofgem's fails to provide robust supporting evidence for disallowing this portion of NOCs.

Table 2.3: [✂]

2.2. Ofgem's Assessment of Indirect Operating Expenditure

2.2.1. Ofgem and ECA's model selection process

In its DD, Ofgem has relied on comparative cost benchmarking to estimate gas and electricity transmission operators' efficient levels of BSC and CAI, except for IT&T costs which Ofgem assessed as part of separate expert review (along with non-operational capex).[14] The benchmarking models were developed by Ofgem's advisors, ECA.

9 Ofgem (9 July 2020), RIIO-2 Draft Determinations – National Grid Electricity Transmission, p. 69.

10 Ofgem (9 July 2020), RIIO-2 Draft Determinations - Gas Transmission Annex, para. 3.44.

11 Ofgem (9 July 2020), RIIO-2 Draft Determinations - Gas Transmission Annex, para. 3.45.

12 Ofgem (9 July 2020), RIIO-2 Draft Determinations - Gas Transmission Annex, para. 3.45.

13 Ofgem (9 July 2020), RIIO-2 Draft Determinations - Gas Transmission Annex, p. 29, Table 5.

14 Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para. 3.47.

Ofgem and ECA performed a joint assessment of indirect opex in the ET and GT sectors, which they justify on the basis of "the commonality of their sub-categories" of cost.[15] Ofgem however excluded from the joint benchmarking NGGT (SO) "given its different business nature". Ofgem considered broadening the dataset further to include the electricity distribution networks, but excluded them on grounds that it would "require significant data normalisations to ensure costs were being compared on a like-for-like basis".[16]

ECA's benchmarking analysis followed a separate process of model selection for BSC and CAI, drawing conclusions regarding the recommended benchmarking models for use at RIIO-T2. The models explored by ECA vary in the choice of cost drivers used to explain variation in costs across network operators, in the choice of estimator, and the sample used for estimation (i.e. with or without gas transmission). For BSC, ECA explored eight econometric models and for CAI it explored seven econometric models.[17]

Ofgem adopts ECA's preferred econometric model to set both BSC and CAI allowances. ECA assesses its preferred model using a two-phase approach.[18]

In Phase I, for its eight proposed BSC econometric models and seven CAI econometric models, ECA uses four "high importance" criteria and two "medium importance" criteria to select its preferred model, and discount alternative models, to advance to Phase II assessment.[19] We summarise these criteria in Table 2.4 below.

[15] Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para. 3.45.

[16] Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para. 3.45.

[17] See Table 2.10 and Table 2.11 below for an overview of all ECA's models.

[18] Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para. 3.49.

[19] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 42.

Table 2.4: ECA's Phase I Model Selection Criteria

Criterion	"Importance"	Application of Criterion
F-test for joint significance of model coefficients	High	ECA prefers models where explanatory variables are jointly statistically significant as indicated by an F-test for statistical significance.
Goodness of model fit (Adjusted R squared)	High	ECA prefers models with a higher adjusted R squared statistic.
Estimated coefficients are of sign, magnitude and statistical significance that matches economic logic	High	ECA dismisses models where the coefficient estimated on the cost drivers are negative (as the cost driver increases, costs fall) or greater than one (implying diseconomies of scale i.e. costs rise more than proportionately than the cost driver). ECA prefers model where coefficients are individually statistically significant as estimated through a t-test.
Estimates are plausible	High	ECA prefers models where modelled costs conform to its expectations over actual costs
Sensitivity of coefficients to the addition of a time trend or removal of a year of data	Medium	ECA prefers models where coefficient estimates are robust to "minor changes to specification and dataset"
Hausman test for fixed effects	Medium	ECA uses the Hausman test to assess its assumption of random effects against fixed effects. However, ECA prioritises the economic plausibility and statistical significance of its model results as determined through the criteria above.

Source: ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 42.

Having performed its Phase I assessment, ECA chooses a single "preferred" econometric model to advance to its Phase II assessment.

In its Phase II assessment, ECA uses one "medium importance" criterion and five "low importance" criteria and tests to evaluate its Phase I preferred model.[20] We summarise ECA's use of Phase II criteria in Table 2.5 below.

[20] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 63.

Table 2.5: ECA's Phase II Model Selection Criteria

Criterion	"Importance"	Application of Criterion
Statistical significance of coefficients robust to use of "robust standard errors"	Low	ECA prefers models where the statistical significance of its explanatory variables is maintained when it uses standard errors that are robust to forms of heteroskedasticity.
VIFs are below 10	Medium	ECA uses the Variable Inflation Factor (VIF) to test for multicollinearity. It rejects models where correlation between explanatory variables is 0.9 or above.
Breusch-Pagan text	Low	ECA uses the Breusch-Pagan test to inform whether the use of random effects instead of pooled OLS will "improve the model"
RESET test	Low	ECA uses the RESET test to identify non-linearities in its model specification.
White test	Low	ECA uses the White test to identify heteroskedasticity in its model
Jarque-Bera test	Low	ECA uses the Jarque-Bera test its assumption that the residuals of its model are normally distributed and therefore it may apply t- and F-tests for statistical significance.

Source: ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 63.

For both its BSC and CAI preferred models, ECA does not change its preferred model from the Phase I assessment as a result of its Phase II assessment of the model.

Therefore, from the range of models tested, ECA and Ofgem selects one preferred model for CAI and one preferred model for BSC to set TOs' allowances. The models have the following features:

- Both models use a Pooled OLS (POLS) estimators "given their relative simplicity, transparency, and favourable small sample properties".[21]
- Both models use aggregate BSC and CAI cost respectively ("top-down" approach) "to reduce potential distortion from differences in cost allocations and to reduce the risk of inadvertently 'cherry picking' results".[22]

[21] Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para. 3.48.

[22] Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para.3.48.

- Both models are estimated using historical data only over the RIIO-T1 period (2014-2019) "to avoid undue dependency on network company view".[23]
- The BSC model uses a Composite Scale Variable (CSV) and Gas Transport (GT) dummy as cost drivers in the regression model. The CSV incorporates three cost drivers: MEAV, Full Time Employees (FTEs), and Totex.
- The CAI model uses MEAV and Total Capex as cost drivers and (unlike BSC) does not include any dummy variable to control for differences between ET and GT.

2.2.2. Deriving allowances from the Ofgem/ECA regression models

Ofgem sets allowances for CAI and BSC by using forecasts of the relevant cost drivers and the estimated regression coefficients to forecast costs for each company during the RIIO-T2 period. Hence, it identifies as "inefficiency" (and hence disallows) any difference between the modelled prediction of costs for the T2 period, and companies' business plan forecasts.

The ratio between Ofgem's modelled forecast of costs for the T2 period and companies' business plan forecasts, i.e. the efficiency score for each company, is provided in Table 2.7 below for CAI and BSC separately. As the table shows, Ofgem finds that SHET appears efficient in both regression models as the model predicts higher costs than its business plan, while SPT and NGET appear inefficient in both regression models, and NGGT appears efficient in the CAI model but inefficient in the BSC model.

Table 2.6: Ofgem's Efficiency Scores for the BSC and CAI Models for RIIO-T2

Network	BSC	CAI
NGGT	1.04	0.84
NGET	1.06	1.25
SHET	0.77	0.82
SPT	1.54	1.11

Source: Ofgem[24]

The outcomes of Ofgem's and ECA's modelling of CAI and BSC for SPT, NGET and NGGT (TO and SO) are set out Table 2.7 below. As the tables show, Ofgem makes both "cost" reductions as a result of its cost efficiency assessment, and "work/volume" reductions which reflect Ofgem's adjustments to companies submitted views on underlying cost drivers (e.g., capex programmes).

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23 Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para.3.50.

24 BSSCAICostAssessment_File.xlsx (Excel), sheet "Cal_EfficiencyCAI" (cells AN28:AO31) and "Cal_EfficiencyBSS" (cells AN52:AO55).

Table 2.7: Ofgem's Assessment of BSC and CAI Costs for RIIO-T2

Network	Submission (£m)	Work/volume reduction (£m)	Cost reduction (£m)	Ofgem Allowances (£m)	Implied Efficiency Gap
Business Support Costs					
NGGT (TO)	163.36	5.55		157.81	1.04
NGGT (SO)	113.96	3.88		110.08	1.04
NGET	458.5		20.2	438.3	1.05
SHET	104.9		0.7	104.2	1.01
SPT	103.9		23.9	80	1.30
Closely Associated Indirects					
NGGT (TO)	156.49	86.79		69.70	2.25
NGGT (SO)	48.93	1.02		47.91	1.02
NGET	1050.9	231.8	195.3	623.8	1.68
SHET	255.4	93.9		161.5	1.58
SPT	169.3	22.4	17.3	129.6	1.31

Note: Implied efficiency gap calculated as ratio of a company's submitted costs over Ofgem's allowance. These differ from the efficiency scores in Table 2.3 because including Ofgem's volume adjustments to the modelled costs and IT&T costs which have been assessed separately.
Source: Ofgem[25]

2.2.3. NERA's replication of Ofgem's BSC and CAI benchmarking models

Based on our review of ECA's report and supporting modelling files provided by Ofgem we have identified inconsistencies between the results provided in the report and the supporting modelling files. As Table 2.8 and Table 2.9 below show, we find that ECA reports different regression results (coefficients and other statistics) and efficiency scores for its "preferred" CAI and BSC models in the report and the Excel output files.

From our review of the RIIO-T2 DD and modelling files, we understand that Ofgem has relied upon the results provided in the Excel file to set the baseline allowances.

[25] Ofgem (9 July 2020), RIIO-2 Draft Determinations – National Grid Electricity Transmission, p.70, Tables 31 and 32; Ofgem (9 July 2020), RIIO-2 Draft Determinations – Scottish Power Transmission, p. 63-64, Tables 36 and 37; RIIO-2 Draft Determinations – Scottish Hydro Electric Transmission, p. 48, Tables 28 and 29; Ofgem (9 July 2020), RIIO-2 Draft Determinations – National Grid Gas Transmission, p. 143.

Table 2.8: BSC and CAI Regression Results: ECA Report vs. Supporting Modelling Files

	BSC Model 7 (CSV + GT Dummy)		CAI Model 4 (MEAV + Capex)	
	ECA Report (Table 11)	ECA Excel Files	ECA Report (Table 16)	ECA Excel Files
CSV	0.800***	0.801		
GT Dummy	-0.314***	-0.314		
MEAV			0.198**	0.231
Capex			0.735***	0.754
Constant	3.210***	3.212	-2.093***	-2.435
Observations	24	24	24	24
Adj R-squared	0.774	0.795(1)	0.786	0.785(1)

*Note: *** p<0.01, ** p<0.05, * p<0.1. (1) We assume the R-squared provided in the Excel files are not adjusted.*
Source: ECA[26] and Ofgem[27]

Table 2.9: BSC and CAI Efficiency Scores: ECA Report vs. Supporting Modelling Files

	BSC Model 7 (CSV + GT Dummy)				CAI Model 4 (MEAV + Capex)			
	ECA Report (Table 12)		ECA Excel Files		ECA Report (Table 17)		ECA Excel Files	
	RIIO-1	RIIO-2	RIIO-1	RIIO-2	RIIO-1	RIIO-2	RIIO-1	RIIO-2
NGGT	1.14	1.05	1.04	1.04	0.93	0.91	0.96	0.84
NGET	1.01	1.05	1.16	1.06	1.20	1.42	1.24	1.25
SHET	0.59	0.78	0.62	0.77	0.65	0.87	0.67	0.82
SPT	1.56	1.53	1.58	1.54	1.33	1.13	1.31	1.11

Source: ECA[28] and Ofgem[29]

We have also replicated ECA's CAI and BSC cost benchmarking models on the basis of information provided in the DD, in ECA's report and in the supporting modelling files provided by Ofgem. Our results are:

- Consistent with what is reported in the Excel files for ECA's preferred models (Model 7 for BSC and Model 4 for CAI), and therefore different from what is reported in the ECA report both in terms of regression outputs and efficiency scores.
- Different from the results reported in the ECA report for all other regression models tested by ECA. Neither Ofgem nor ECA provided Excel results for the other regression models tested in the report. We have therefore been unable to cross-check consistency of the results between the report and the modelling files that ECA supposedly used.

[26] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Table 11 and Table 16.

[27] "BSSCAICostAssessment_File.xlsx" (Excel), sheet "Inp_Regress", and "BSC_network_regs.xml" (Excel) and "CAI_network_regs.xml" (Excel).

[28] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Table 12 and Table 17.

[29] "BSSCAICostAssessment_File" (Excel), "Cal_EfficiencyCAI" sheet (cells AN28:AO31) for CAI and "Cal_EfficiencyBSS" sheet (cells AN51:AO55) for BSC.

Table 2.10 and Table 2.11 below compare the regressions results reported in the ECA report for all the BSC and CAI models and our replication of the models. As the tables show, we find different values for the regression coefficients for most BSC models and all CAI models.

Table 2.12 and Table 2.13 below compare the efficiency scores reported in the ECA report (where available) for all the BSC and CAI models and the resulting efficiency scores from our replication of the models. Red values indicate that our modelling worsens the efficiency score of a company relative to ECA's results. Green instead indicates that our modelling improves the efficiency score of a network company relative to ECA's results. Reflecting the different underlying coefficients, we find different efficiency scores for most BSC models and all CAI models.

We also note that in replicating the ECA cost benchmarking, the do-files do not allow for a quick and accessible run of all the regression models tested by ECA in its report and output the associated efficiency scores. We also find that the Stata ".do files" are incomplete and inconsistent with the ECA report:

- ECA uses a time trend variable in model 3 for CAI and models 4 and 6 for BSC. However, this variable is not defined in the respective Stata ".do files". It is therefore not possible to replicate the models without editing the files, suggesting that ECA must have relied upon another version of the ".do files".
- Table 11 of the ECA report suggests that Model 6 for BSC uses MEAV as a cost driver along with a GT dummy and time trend. However, the Stata code suggests that Model 6 uses CSV as cost driver along with a GT dummy and time trend. We assume, based on our replication of the model, that the header of the table is incorrect.

The above inconsistencies casts doubt regarding the conclusions ECA has drawn from its report and Ofgem's reliance on its results for setting the efficient level of BSC and CAI costs. However, given that we find consistent results with those reported in the Excel files for ECA's preferred BSC and CAI models, the analysis presented in the remainder of this report relies on our replication of ECA's models and the data provided in the supporting modelling files.

Table 2.10: BSC Regression Results: ECA Report vs. NERA Replication

	Model 1 (MEAV)		Model 2 (MEAV + Time)		Model 3 (CSV)		Model 4 (CSV + Time)		Model 5 (MEAV+GT)		Model 6 (CSV+ GT+Time)		Model 7 (CSV+GT)		Model 8 (MEAV-ET only)	
	ECA	NERA	ECA	NERA	ECA	NERA	ECA	NERA	ECA	NERA	ECA	NERA	ECA	NERA	ECA	NERA
CSV					0.754***	0.755***	0.748***	0.748***			0.793***	0.793***	0.800***	0.801***		
GT Dummy									-0.504***	-0.504***	-0.308***	-0.309***	-0.314***	-0.314***		
MEAV	0.729***	0.729***	0.722***	0.722***					0.825***	0.825***					0.825***	0.825***
Time trend			0.063	0.063			0.061	0.061			0.059	0.059				
Constant	-3.726***	-3.726***	-3.883***	-3.883***	3.127***	3.129***	2.913***	2.915***	-4.495***	-4.495***	3.000***	3.002***	3.210***	3.212***	-4.490***	-4.490***
Obs	24	24	24	24	24	24	24	24	24	24	24	24	24	24	18	18
Adj R2	0.681	0.681	0.684	0.684	0.761	0.762	0.766	0.767	0.725	0.724	0.779	0.781	0.774	0.776	0.730	0.730

*Note: *** p<0.01, ** p<0.05, * p<0.1.*
Source: Table 11 of ECA's report and NERA analysis of Ofgem's supporting modelling files.

Table 2.11: CAI Regression Results: ECA Report vs. NERA Replication

	Model 1 (MEAV)		Model 2 (Total Capex)		Model 3 (Total Capex + Time)		Model 4 (Total Capex + MEAV POLS)		Model 5 (Total Capex + MEAV RE)		Model 6 (Total Capex + MEAV + FE)		Model 7 (Total Capex FE)	
	ECA	NERA	ECA	NERA	ECA	NERA	ECA	NERA	ECA	NERA	ECA	NERA	ECA	NERA
Total Capex			0.860***	0.886***	0.862***	0.886***	0.735***	0.754***	0.415***	0.378***	0.381***	0.346***	0.395***	0.363***
MEAV	0.424**	0.416***					0.198**	0.231***	0.044	0.026	-0.247	-0.216		
Time trend					-0.014	0.003								
Constant	0.100	0.160	-0.978**	-1.046*	-0.939*	-1.056*	-2.093***	-2.435***	1.212	1.63		4.061		1.955***
Obs	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Adj R2	0.340	0.325	0.728	0.677	0.716	0.662	0.786	0.764	0.531	0.7327	0.595	0.493	0.488	0.5

*Note: *** p<0.01, ** p<0.05, * p<0.1. The reported R2 for model 6 refers to the overall R2.*
Source: Table 16 of ECA's report and NERA analysis of Ofgem's / ECA's supporting modelling files.

Table 2.12: BSC Efficiency Scores Results: ECA Report vs. NERA Replication

	Model 1 (MEAV)		Model 2 (MEAV + Time)		Model 3 (CSV)		Model 4 (CSV + Time)		Model 5 (MEAV+GT)		Model 6 (CSV+ GT+Time)		Model 7 (CSV+GT)		Model 8 (MEAV-ET only)	
	RIIO-1	RIIO-2	RIIO-1	RIIO-2	RIIO-1	RIIO-2	RIIO-1	RIIO-2	RIIO-1	RIIO-2	RIIO-1	RIIO-2	RIIO-1	RIIO-2	RIIO-1	RIIO-2
ECA																
NGGT					0.82	0.86							1.01	1.05		
NGET					1.32	1.22							1.14	1.05		
SHET					0.61	0.82							0.59	0.78		
SPT					1.60	1.60							1.56	1.53		
NERA																
NGGT	0.77	0.82	0.72	0.51	0.84	0.85	0.79	0.54	1.04	1.11	0.97	0.66	1.04	1.04	0.63	0.67
NGET	1.55	1.42	1.44	0.89	1.33	1.22	1.25	0.78	1.22	1.12	1.09	0.68	1.16	1.06	1.22	1.12
SHET	0.63	0.82	0.57	0.51	0.66	0.82	0.60	0.52	0.58	0.74	0.57	0.49	0.62	0.77	0.58	0.74
SPT	1.61	1.59	1.47	0.98	1.62	1.59	1.48	1.00	1.60	1.55	1.45	0.98	1.58	1.54	1.60	1.55

Source: Table 12 of ECA's report and NERA analysis of Ofgem's / ECA's supporting modelling files.

Table 2.13: CAI Efficiency Scores Results: ECA Report vs. NERA Replication

	Model 1 (MEAV)		Model 2 (Total Capex)		Model 3 (Total Capex + Time)		Model 4 (Total Capex + MEAV POLS)		Model 5 (Total Capex + MEAV RE)		Model 6 (Total Capex + MEAV + FE)		Model 7 (Total Capex FE)	
	RIIO-1	RIIO-2	RIIO-1	RIIO-2	RIIO-1	RIIO-2	RIIO-1	RIIO-2	RIIO-1	RIIO-2	RIIO-1	RIIO-2	RIIO-1	RIIO-2
ECA														
NGGT			1.15	1.08			0.93	0.91	0.87	0.98			1.01	1.15
NGET			1.32	1.61			1.20	1.42	1.97	2.25			1.00	1.14
SHET			0.57	0.82			0.65	0.87	0.61	0.85			0.99	1.41
SPT			1.07	0.99			1.33	1.13	0.98	0.80			1.01	0.83
NERA														
NGGT	0.53	0.70	1.23	1.00	1.23	0.98	0.96	0.84	0.89	0.96	1.04	1.15	0.90	0.98
NGET	2.00	2.08	1.43	1.45	1.42	1.42	1.24	1.25	2.21	2.30	3.00	3.16	2.31	2.41
SHET	0.78	0.97	0.59	0.75	0.59	0.74	0.67	0.82	0.63	0.83	0.56	0.78	0.62	0.82
SPT	1.25	0.93	1.02	0.93	1.02	0.91	1.31	1.11	0.89	0.75	0.65	0.57	0.86	0.72

Source: Table 15 and 17 of ECA's report and NERA analysis of Ofgem's / ECA's supporting modelling files.

2.3. Ofgem's Approach to Setting Opex Allowances

Having identified the efficient level of cost for each company as we describe in Sections 2.1 and 2.2, Ofgem makes two adjustments to calculate allowances for each company over the T2 period (discussed below):

- application of its own views of ongoing achievable efficiency; and
- application of its forecast of Real Price Effects (RPEs).

2.3.1. Ongoing efficiency

Ofgem relies on evidence from its consultant, CEPA to set an ongoing efficiency target for the TOs' operating costs. CEPA suggests a reference range of 0.7 to 1.4 per cent per annum. Ofgem selects an efficiency target at the top of CEPA's range of 1.4 per cent for opex allowances. Ofgem also includes in its target an assumption regarding the additional productivity gains from past investments network companies have made in innovation projects in RIIO-T1.

Before applying its ongoing efficiency target, Ofgem removes the ongoing efficiency targets proposed by companies in their business plans. Ofgem applies the efficiency challenge as a compounding annual reduction to the baseline revenue allowances throughout the RIIO-T2 regulatory period.[30]

2.3.2. RPEs

Ofgem relies on evidence from its consultant, CEPA to forecast RPEs for the T2 control period. Ofgem applies its forecast of RPEs for each cost category based on company-specific cost structures for each TO.[31] In its DD, Ofgem uses the cost structures submitted by companies in their business plans. Ofgem explains that in its FD it will update the cost structure to reflect its final views of company cost allowances.

Ofgem has also proposed to use an ex-post true up based on outturn CPIH and relevant input price indices, based on any differences between outturn and forecast RPEs. Ofgem's ex-post adjustments will be conducted as part of its Annual Iteration Process.

2.3.3. Uncertainty mechanisms

Ofgem determines companies' baseline totex allowances through its cost assessment and adjustment process that we describe above. However, Ofgem links a proportion of the baseline totex allowance for each company to uncertainty mechanisms (UMs) that allow Ofgem to adjust companies' allowances throughout the price control period. Ofgem proposes that "approximately 50% of baseline Totex across gas distribution and transmission sectors will be linked to uncertainty mechanisms and [Price Control Deliverables]".[32]

Ofgem uses four main types of UMs:[33]

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30 Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para 3.61.

31 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 5.22.

32 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 5.8.

33 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 7.4.

- Volume drivers, which Ofgem uses to "adjust allowances in line with actual volumes where the volume of certain types of work that will be required over the price control is uncertain";
- Re-openers: to allow Ofgem to decide within the price control period to adjust allowances;
- Pass-through mechanisms: which Ofgem uses to "adjust allowance for costs incurred by the network companies that they have limited control over"; and
- Indexation: which Ofgem uses to "adjust allowance for costs that network companies have very limited control". RPEs are an example of an indexation UM.

The majority of Ofgem's proposed UMs are re-opener mechanisms. Ofgem applies both cross-sector UMs (across sectors and companies) and sector-specific UMs (differ across sectors but common between companies within the sector). It also approves some bespoke UMs suggested by companies in their business plan submissions that relate to specific uncertainties that companies face. Ofgem rejected bespoke UMs suggested by companies when it considered they did not satisfy Ofgem's criteria for approval. Ofgem proposes to allow 15 bespoke UMs in RIIO-2, one for GD, three for ET, and 11 for GT.

2.3.4. Opex escalators

2.3.4.1. Electricity transmission

Ofgem's DD proposes an "opex escalator" indexation UM for all ET companies. Ofgem intends that the opex escalator for ET will adjust companies' CAI and NOC allowances for changes to outturn capex allowances that occur during the T2 period due to UMs.

As we explain above, Ofgem sets baseline CAIs and NOCs using regression modelling. The regression cost drivers are capex and MEAV. However, those cost drivers are subject to their own UMs throughout RIIO-2. Therefore, Ofgem proposes the opex escalator to adjust CAIs and NOCs for changes to outturn capex allowances that occur during RIIO-ET2 through UMs. More specifically, Ofgem proposes a 0.754 per cent uplift to CAI for each 1 per cent uplift in capex, and will adjust NOCs by 0.5 per cent of the uplift to RAV resulting from project delivery.[34]

Ofgem determines the 0.754 uplift on CAI allowances by using the coefficient on the capex cost driver in its POLS regression.[35] Ofgem determines the 0.5 per cent uplift to NOCs based on "the analysis of historical data to establish the relationship of NOCs to the RAV, which is equivalent to 0.5% of the uplift to RAV resulting from the project delivery, where the uplift is given, post energisation of the asset, as efficient incurred cost multiplied by the regulatory capitalisation rate".[36]

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34 The uplift to RAV is calculated as efficiently incurred cost multiplied by the regulatory capitalisation rate. See: Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, p. 80.

35 Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para 4.65.

36 Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para 4.66.

2.3.4.2. Gas transmission

Ofgem proposes an "opex escalator" indexation UM for NGGT. Ofgem states that the purpose of the opex escalator for NGGT is to adjust NGGT's CAI opex allowance for changes to outturn capex allowance which come about through UMs.[37]

Similar to the opex escalator for ET, Ofgem sets total baseline CAI for NGGT using cost drivers including total baseline capex. Total baseline capex allowances may vary during RIIO-T2 due to UMs or mechanisms linking capex funding with project outputs. Ofgem proposes to apply a 0.754 per cent uplift to NGGT's CAI allowances for each 1 per cent uplift in capex allowances.

Ofgem determines the 0.754 per cent uplift on CAI allowances by using the coefficient on the capex cost driver in its POLS regression.[38]

2.3.5. Totex Incentive Mechanism

Ofgem applies two final incentive mechanisms to companies at RIIO-2: the Totex Incentive Mechanism (TIM) and the Business Plan Incentive Mechanisms (BPIM).

The TIM is an incentive rate that dictates how companies share actual cost overspends and underspends relative to totex allowances with their customers. Ofgem states that the TIM is "designed to encourage network companies to improve efficiency in delivery" whilst also providing "some protection to companies from overspends".[39]

Ofgem calculates a bespoke incentive rate for each network company and sector. To calculate the incentive rate, Ofgem utilises a "confidence metric" which it determines by calculating the ratio of "high-confidence" baseline costs to totex.[40]

Ofgem categorises companies' baseline costs to determine "high-confidence" baseline costs which it states "are those costs for which we have a high level of confidence in our ability to independently set a cost allowance".[41] Ofgem also states that high-confidence baseline costs would incorporate costs where Ofgem could use information to set cost allowances that is independent of cost forecasts provided by companies in their business plans. In particular:

- Ofgem categorises all costs that are determined through econometric modelling and econometric benchmarks as high-confidence costs.[42]

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37 Ofgem (9 July 2020), RIIO-2 Draft Determinations - Gas Transmission Annex, para 4.39.

38 Ofgem (9 July 2020), RIIO-2 Draft Determinations - Gas Transmission Annex, para 4.40.

39 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 10.2.

40 Ofgem calculates the incentive rate as follows:

*Incentive rate (%) = [50% * confidence metric] + [15% * (1-confidence metric)] where:*

confidence metric = [aggregate efficient cost benchmark for high confidence costs] / [overall totex allowance]

For ET – SPT it proposes a TIM incentive rate of 39.1 per cent and for GT – NGGT it proposes an incentive rate of 36.6 per cent.

Source: Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 10.5.

41 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, p. 119.

42 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 10.17.

- Ofgem categorises costs as high-confidence when it has "a high degree of confidence that the activity needs to, or will, be undertaken during the RIIO-2 price control period" and it has "a high degree of confidence in our ability to estimate efficient costs of delivering that activity".[43]
- Ofgem may treat costs as high-confidence costs if it attaches a PCD and has confidence in its ability to estimate efficient costs associated with the PCD.[44]

Ofgem excludes costs associated with UMs in its assessment of "high-confidence" costs.

2.3.6. Business Plan Incentive Mechanism

Ofgem applies penalties and rewards to companies based on its assessment of their business plans. Ofgem applies rewards when it perceives that a company's business plan "represents genuine additional value for money to customers compared to business-as-usual and provides information that helps [Ofgem] to set a better price control".[45] Ofgem penalises companies when it perceives their business plans do not present value for money to customers and are inefficient or of lower quality.[46]

Ofgem assesses and applies rewards and penalties through the BPIM across four stages of assessment:

- **Stage 1:** Ofgem assesses each business plan against its minimum requirements for business plans, which pertain to its standards for example on cost-benefit analyses, engineering justifications etc. When it assesses that a company's business plan has not met its minimum requirements, it may apply a penalty of 0.5 per cent of allowed totex to the company's allowances.
- **Stage 2:** Ofgem issues rewards based on each company's Consumer Value Proposition (CVP). Ofgem reviews the level of justification provided in the business plans for each company proposal in the CVP. When Ofgem determines that the CVP delivers additional value for money to customers, it issues a reward based on multiplying the net consumer value by the company's efficiency incentive rate.[47] If companies are unable to provide a robust methodology to calculate the monetised value of activities within their CVPs, Ofgem may not determine a reward.[48] Companies that receive a reward for their proposals are subject to reporting requirements throughout the price control to update Ofgem on the outcome and delivery of the proposal, and are also subject to a claw-back mechanism of the reward for non-delivery of the proposal.[49] Companies must propose performance metrics to be assessed on the delivery of their proposals.
- **Stage 3:** Ofgem issues penalties based on a subset of "low-confidence costs" as it determines using the method we describe above. Ofgem applies a penalty of 10 per cent

[43] Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 10.20.

[44] Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 10.22.

[45] Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 10.26.

[46] Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 10.26.

[47] Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 10.58.

[48] Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 10.60.

[49] Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, p. 133.

of the value of any poorly justified, low confidence costs that are removed by Ofgem from companies' business plans.[50] Ofgem calculates the total lower confidence costs removed by Ofgem from business plans as the difference between company cost forecasts in the business plan and its efficient baseline allowances.[51] Ofgem assesses the subset of poorly justified, lower confidence costs to which it applies a penalty by taking into account company cost forecasts as well as its own forecasts of costs to undertaking that activity. All "high-confidence costs", as it determines using the method we describe above, are not subject to a penalty at Stage 3 of the BPIM.

- **Stage 4:** Ofgem issues rewards for "high-confidence costs" which it determines using the methods we describe above. Ofgem sets baseline allowances for high-confidence costs using the lower of the company forecast and the efficient cost benchmark. Ofgem applies a reward for companies if its aggregated costs across "high-confidence" cost categories are greater than the aggregate costs of the efficient cost benchmark across those categories.[52] Ofgem calculates the reward by applying the company-specific sharing factor to the positive difference.[53]

Overall penalties and rewards for each company across stages of assessment in the BPIM are subject to a cap and collar of plus and minus 2 per cent of totex allowances.[54]

We summarise the penalties and rewards that Ofgem applies to NGGT, NGET, and SPT in Table 2.14 below.

Table 2.14: BPIM Rewards and Penalties at DDs for NGGT, NGET, and SPT

(£m)	Total Stage 3 Penalty	Stage 3 Penalty for NOCs	Stage 3 Penalty for BSC/CAIs	Stage 4 Rewards
NGGT	18.6	0	0	0
NGET	79.6	7.49	0	0
SPT	16.6	0	0	0

Source: Ofgem's Company Specific Annexes.

50 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 10.88.

51 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 10.91.

52 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 10.98.

53 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 10.99.

54 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, Table 15.

3. Assessment of Ofgem's Approach to Setting Efficient Network Operating Costs at RIIO-T2

In this chapter we review Ofgem's approach to assessing TOs' NOCs allowances for RIIO-T2. As we describe below, we identify conceptual flaws and inconsistencies in Ofgem's methodology across the TOs which suggests Ofgem has systematically understated TOs' efficient costs for the T2 control period. We discuss the reasons for these flaws and our suggested remedies in the remainder of this chapter.

3.1. Ofgem Fails to Justify Using Different Approaches to Appraising NOCs across Electricity TOs or Sub-Categories of Cost

As described in Section 2.1.1 above, Ofgem states it has set RIIO-T2 NOCs allowances for electricity TOs using a "unit cost" and "average annual cost" approach. Ofgem also states that where this "general" approach could not be applied, it relied upon an assessment of companies' submitted engineering evidence.

However, a detailed review of Ofgem's supporting modelling files for NGET and SPT suggests that it has not consistently applied its stated approach:

- For SPT Ofgem states that it has appraised all cost sub-categories using a "comparison of SPT's proposed rates with their historically incurred RIIO-ET1 rates" except for Operational Protection Measures and IT Capex which has been reviewed separately "due to its bespoke nature".[55] However, a review of the modelling files suggests that it has also used the lower of the T1 and T2 unit costs also for this sub-category of NOCs.[56] In fact, for all categories of SPT's NOCs, Ofgem has set NOCs allowances using a comparison between historical and forecast costs using either its unit cost or average annual cost approach. As we explain below, this method is flawed and is likely to materially understate SPT's efficient costs. We also understand from SPT that it has submitted detailed explanations, setting out the reasons why its NOCs are changing between the T1 and T2 control periods, which Ofgem has not considered in the DD.[57]
- For SPT, we find that for some categories of NOCs Ofgem has applied neither of the approaches mentioned in the DD report. For example, for some sub-categories of costs for which T1 volume data is not available, Ofgem has allowed T2 costs as submitted, neither applying an average unit cost approach nor relying upon expert review.[58] Ofgem has failed to provide an explanation for allowing T2 submitted costs for these sub-categories of cost and not allowing submitted costs for other categories where volume data is not available.
- For NGET, [✂]

The differences in approach listed above suggests that Ofgem has not used a consistent approach, and has not documented its approach accurately. The lack of a coherent approach

55 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Scottish Power Transmission, para.3.82.

56 NERA review of "RIIO-ET2_SPT_NOCs_Model_DD" (Excel), sheet "SPT_Op_Prot_Meas_&_IT_Capex".

57 [✂]

58 [✂]

to assessing NOCs across TOs illustrates the subjectivity associated with Ofgem's approach in its DD and undermines the credibility of the regulatory framework as a mechanism for remunerating efficiently incurred costs.

Also, notwithstanding that Ofgem deviates from its stated approach in practice, its DD approach of relying exclusively on one cost assessment approach (unit cost analysis or expert review) contradicts its own statements during the RIIO-2 consultation phase that it would rely on a "toolkit" of methodologies to appraise TOs' business plans and set baseline cost allowances.[59] Ofgem's failure to demonstrate that it has validated its cost assessment results against other methods further undermines the credibility and robustness of the cost assessment process.

3.2. Ofgem's Unit Cost Approach Will Tend to Understate TOs' Efficient Costs

3.2.1. The asymmetry of Ofgem's approach will tend to set NOCs allowances below the TOs' efficient costs

As noted above, for SPT and some areas of NGET's NOCs, Ofgem has relied on a unit cost assessment of each TO's costs to estimate the efficient level of expenditure over the T2 control period. For areas of activity where companies forecast their unit costs will fall, Ofgem's approach will set lower allowed unit costs than achieved during T1, reflecting TOs' expected reduction in unit costs in the T2 period. However, where the TOs' have forecast rising unit costs, the unit costs allowed by Ofgem will be capped by the unit costs achieved during T1.

By relying on this approach to set NOCs allowances, Ofgem is therefore making two assumptions: (1) that TOs' unit costs should be strictly decreasing over time and that any increase should be deemed "inefficient", and (2) that historical and forecast costs are comparable and that past trends are a reliable indicator of future unit cost trends.

However, in reality some unit costs will rise over time and others will fall, even if there is a tendency for unit costs to fall over time (in real terms, at least) due to the effects of technological progress and improvements in working practices. Such variation in unit costs may result from changes in the nature or location of the work being conducted, for example.

If unit costs do vary over time – both upwards and downwards – for reasons beyond TOs' control and unrelated to efficiency, Ofgem's approach will systematically disallow changes in efficient costs. The mechanism Ofgem has used to do this, i.e. taking the minimum of the unit cost achieved in T1 and forecast for T2, is entirely mechanistic and fails to analyse the reasons for changes in unit costs over time.

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[59] For example, in its December 2019 Sector Methodology Decision document for the ET sector Ofgem states: "We have decided to confirm the approach to TO cost assessment set out in our December consultation. Namely, that we will adopt a range of techniques, underpinned by use of historical cost data, as appropriate, in determining our view of efficient costs." Source: Ofgem (24 May 2019), RIIO-2 Sector Specific Methodology Decision - Electricity Transmission, para 5.11.

Likewise, in its June 2019 document Ofgem stated: "As noted in this chapter, we are not consulting further on the cost assessment techniques we will use to assess transmission network expenditure. Our three primary workstreams will be (i) needs case assessment, (ii) Network Asset Risk Metric (NARM) and (iii) cost assessment, maintaining our toolkit approach". Source: Ofgem (28 June 2019), RIIO-2 tools for cost assessment, para.5.32.

The risk of Ofgem's approach failing to capture variation in TOs' efficient unit costs over time is not just a theoretical concern. A closer assessment of SPT's and NGET's unit costs over time (described below) suggests Ofgem's approach is likely to materially understate their efficient NOCs over the T2 control period.

3.2.2. The risk of data error increases the risk that Ofgem's approach understates the TOs' efficient NOCs

Ofgem's unit cost approach relies on an extremely short, and often incomplete and volatile, time series of cost and volumes data for each sub-category of costs. As a result, Ofgem may have proposed allowances based on only a few (if not one single) year of data which is unlikely to reflect accurately the TOs' future costs over the T2 control period. The paucity and volatility of data means that Ofgem will systematically conflate "efficiency" in unit costs with other factors explaining changes in efficient costs.

Also, we understand from information provided by National Grid and SPT, that Ofgem's cost and volume disaggregation for the purpose of assessing NOCs at T2 required a retrospective analysis of T1 cost/volume data to map them onto T2 reporting templates. Such a retrospective review of data always requires a degree of subjective interpretation of the associated cost/volume reporting guidelines, which may reduce the accuracy of T1 data and undermine the comparability of T1 unit cost with T2 costs

3.2.3. [✂]

[✂]

Figure 3.1: [✂]

Figure 3.2: [✂]

3.2.4. [✂]

[✂]

Figure 3.3: [✂]

Figure 3.4: [✂]

3.2.5. The problems with Ofgem's unit cost modelling are exacerbated in those cost categories where it uses an annual average cost approach

As noted in Section 2.1.1 above, for categories of cost where volume data in either the RIIO-T1 or T2 period is not available, Ofgem has applied an "average annual cost" approach instead of its "unit cost" analysis. Under this approach Ofgem sets the proposed allowance for each cost category by taking the lower of the "average annual cost" over T1 and T2 and multiplying the selected average annualised costs by 5 (i.e. for the 5 years of T2). Ofgem obtains the "average annual cost" by dividing total cost over the 6 historical years for which it has data by 6.

A detailed review of Ofgem's NOCs modelling files suggests:

- For SPT, [✂]
- For NGET, [✂]

Like its unit cost approach discussed above, Ofgem's "average annual cost" makes no effort to disentangle any supposed inefficiency in companies' cost forecasts from changes in expenditure requirements for other reasons.

Ofgem's approach also results in the same downward bias in allowances as for the categories of expenditure covered by its unit cost modelling. By setting NOCs allowances based on annual average T2 costs for cost categories with falling expenditure and based on T1 costs when they are rising, Ofgem's approach means its forecast NOCs for T2 are biased downwards for both SPT and NGET.

Indeed, Ofgem's "average annual cost" approach is even more limited than Ofgem's unit cost analysis. For the cost categories covered by its unit cost modelling, Ofgem controls for differences over time in the volume of workload when making costs forecasts. Ofgem's "average annual cost" approach cannot achieve this, so its cost forecasts are even more unreliable than in the cost categories covered by unit cost analysis.

These flaws in Ofgem's approach are especially serious, considering the volatility of costs over time in the categories to which this method is applied. For instance, Figure 3.5 and Figure 3.6 below show (respectively for NGET and SPT) annual expenditure over time for two sub-categories of cost where Ofgem has applied its average annual cost approach. As the figures show, in both instances Ofgem's mechanistic approach of taking the minimum of the annualised cost results in a material reduction in T2 allowances relative to TOs' submitted costs, without any consideration of the reasons why the TOs had forecast rising costs.

Figure 3.5: [✂]

Figure 3.6: [✂]

Also, as we explain in Section 3.5 below, for areas where Ofgem's approach uses T2 annual average costs to set the T2 allowances Ofgem is probably double-counting expected efficiency gains over T2 that are already built into TOs' business plan.

3.3. Less Biased Cost Forecasting Methods Suggest SPT's and NGET's NOCs Projections are Efficient

To assess the extent to which Ofgem's methodology leads to a biased assessment of companies' NOCs, we undertook two cross-checks to examine how Ofgem's modelled allowances would change if it utilised a different approach to calculate allowances. For clarity, we do not propose that Ofgem should utilise the methods we use in our cross-checks to set allowances.

Our review of Ofgem's unit cost and annual average cost approaches suggests that its approach includes an inherent downward bias in the TOs' T2 NOCs allowances.

While we have not performed any more detailed assessment of the costs the TOs expect to incur over the T2 period, our two cross-checks to Ofgem's approach assess whether SPT's and NGET's business plan NOCs forecasts are reasonable. Both these cross-checks remove the bias in Ofgem's approach that comes through the use of the minimum of T1 and T2 unit costs or annual average costs:

- We have considered one cross-check which uses the average of the T1 actual and T2 forecast unit costs, multiplied by T2 forecast volumes ("Cross-Check 1"). This check would increase the time series on which Ofgem relies upon to set allowances and remove the inherent downward bias which stems from taking the "minimum" over the T1 and T2 periods. For cost categories in which Ofgem uses average annual costs, we take a consistent approach, forecasting average annual costs for T2 based on the average of average annual expenditures in T2 and T1.
- We consider another cross-check in which we use T1 unit costs multiplied by T2 forecast volumes ("Cross-Check 2"). This check would be consistent with its indirect cost assessment which relies on historical data on cost to set allowances and cross-checks the resulting values with forecast data. For cost categories in which Ofgem uses average annual costs, we take a consistent approach, forecasting average annual costs for T2 based on the average of average annual expenditures in T1.

[✂]

Table 3.1: [✂]

[✂]

Table 3.2: [✂]

Our cross-checks maintain Ofgem's approach to setting allowances based on simple analyses of unit costs multiplied by volumes, but removes the bias that comes from using the minimum of T1 and T2 unit costs or annual average costs. Addressing that bias alone, our analysis demonstrates that companies' submissions are not unreasonable, and pending any different form of analysis that suggests otherwise, they should be allowed in full. We do not propose that Ofgem should utilise our cross-check methodologies to set allowances but seek to agree with companies as to how to complete a full cost assessment and technical review of details and trends in each line item of costs.

3.4. [✂]

[✂]

3.5. Ofgem's Fails to Consider the Extent of Ongoing Efficiency Embedded in TOs' Business Plans

As noted above, Ofgem also fails to account for the level of ongoing efficiency which is already embedded into companies' business plans.

As described in Section 2.1.1, when setting allowances using its unit or average annual cost approach, Ofgem sets NOCs allowances by assessing each company's unit or annual average cost by NOC sub-category. Ofgem then compares average costs for the first six years of RIIO-1 to proposed costs during RIIO-2 and sets allowances based on the lower of these. We refer to these allowances as "pre-adjusted", in that the ongoing efficiency adjustment applies after this step.

We understand from modelling files provided by National Grid that Ofgem has not removed embedded productivity from NOCs before performing this assessment. As a result:

- Where allowances are based on RIIO-2 proposed costs (because they are lower than costs in the first six years of RIIO-1), then the pre-adjusted cost allowance already includes the effects of productivity improvement, *whether or not this is explicitly identified by companies*; and
- Where allowances are based on RIIO-1 actual costs (because the effect of other cost drivers during RIIO-2 outweighs ongoing efficiency), then the pre-adjusted cost allowance does not include the effects of productivity.

Therefore, the pre-adjusted NOC allowance likely partially includes the effects of ongoing efficiency embedded into companies' business plans. In order to maintain consistency between the cost assessment and frontier shift elements of the price control, Ofgem should strip out the embedded productivity *before* comparing RIIO-1 and RIIO-2 costs, effectively setting allowances that assume no productivity growth. Only after setting these allowances should Ofgem apply an ongoing efficiency adjustment, whether that is based on its own view or companies' views of the scope for ongoing efficiency.

3.6. Conclusion

In this chapter we have identified conceptual flaws and inconsistencies in Ofgem's methodology across the TOs which suggests Ofgem has systematically understated TOs' efficient costs for the T2 control period.

We noted that Ofgem has used an inconsistent approach to appraising electricity TOs' costs and has failed to provide an accurate description of its approach. Likewise, for NGGT, Ofgem has failed to provide the supporting analysis to its NOCs assessment, which prevents proper scrutiny from third parties. Together, this lack of transparency illustrates the subjectivity of Ofgem's NOCs assessment process for TOs and undermines the credibility of the regulatory framework as a mechanism for remunerating efficiently incurred costs.

We also explained that Ofgem's unit cost approach which it uses to appraise electricity TOs' NOCs hinges on the assumption that efficient unit costs of NOCs should only ever decrease and that historical trends in costs are a good predictor of future trends. However, we have shown that NGET's and SPT's unit costs vary materially – both upwards and downwards – over time and this may be for reasons beyond TOs' control and unrelated to efficiency. It follows, that Ofgem's mechanistic approach of taking the minimum of T1 and T2 unit cost will systematically disallow upward changes in efficient costs.

As set out above, we have considered two cross-checks to Ofgem's approach which remove the bias in Ofgem's approach that comes through the use of the minimum of T1 and T2 unit costs or annual average. In both instances we find that allowances which are markedly higher than SPT's and NGET's business plan NOCs forecast and therefore is no evidence to suggest that the TOs' NOCs expenditure projections are unreasonable. Therefore, pending any different form of analysis that suggests otherwise, they should be allowed in full in the final determination.

Finally, as we explained, we find that for areas where Ofgem's approach uses T2 unit costs to set the T2 allowances Ofgem is probably double-counting the company's expected efficiency gains over T2 since TOs' forecast already include expected embedded efficiencies. To maintain consistency between the cost assessment and frontier shift elements of the price control, Ofgem should strip out the embedded productivity *before* comparing RIIO-1 and RIIO-2 costs, effectively setting allowances that assume no productivity growth. Only after setting these allowances should Ofgem apply an ongoing efficiency adjustment, whether that is based on its own view or companies' views of the scope for ongoing efficiency.

4. Assessment of Ofgem's Approach to Setting CAI and BSC Allowances

In this chapter we review Ofgem and ECA's approach to comparative benchmarking of transmission owners' indirect opex at RIIO-2 consisting of both BSCs and CAI. As we describe below, we identify material flaws in Ofgem's methodology which undermine its ability to robustly estimate the efficient level of indirect opex for electricity and gas TOs in Great Britain over the RIIO-T2 price control period.

4.1. Ofgem's Use of Unreliable Regression Models Contradicts its Own Statements and Ignores ECA's Guidance

4.1.1. Ofgem's "Methodology Decision" stated it would retain the T1 approach, which acknowledged the differences between TOs

As described in Section 2.2 above, Ofgem has set allowances for indirect costs (both BSCs and CAI) using regressions, estimated using historical data for only 6 years. Ofgem also has only four cross-sectional observations covering the ET and GT sectors. For this reason, at past price reviews, Ofgem has not conducted comparative benchmarking modelling to set TOs' CAI allowances and made only a limited use of it to set BSC allowances. It instead relied on expert judgement for CAI and a toolkit of approaches for BSC, including expert judgment and external comparators.[60]

Ofgem's use of comparative benchmarking of indirect costs without applying alternative techniques to cross check its results therefore contradicts with its earlier statements in December 2018 and May 2019 that its intent was to "adapt the RIIO-ET1 cost assessment process, as appropriate, rather than establish a new approach for RIIO-ET2".[61] Ofgem's consultants also note this material change in approach to forecasting indirect costs:[62]

> "…our modelling approach for CAIs (transmission only) differs from that of RIIO-T1, as we took an aggregated top-down approach compared to relying on a bottom-up combination of trend analysis and expert review for RIIO-T1."

At past reviews, Ofgem's limited use of comparative benchmarking to set the TOs' allowed costs has reflected the limited amount of data to allow identification of efficient costs for the TOs, which is compounded by the substantive differences between them. The two Scottish TOs are markedly smaller than NGET, and NGGT transports gas, so operates a fundamentally different business. Ofgem notes some of these difficulties in the RIIO-T2 DD:[63]

> "The difficulties with transmission cost assessment are well documented: there are only a few companies to compare, and they vary significantly in size and scale. Forward-looking Business Plans are specific to each region, though there is a degree of interdependence through boundary transfer flows between adjacent regions. Lack

60 See for instance: Ofgem (17 December 2012), RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas, para 6.30 for CAI and para 1.3 – 1.6 of Appendix 3 for BSC.

61 Ofgem (24 May 2019), RIIO-2 Sector Specific Methodology Decision -Electricity Transmission, para.5.1.

62 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 69.

63 Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para.3.11.

of cost comparability with other national and international regulatory regimes means that the availability of useful datasets is limited".

4.1.2. ECA also cautioned Ofgem against using these models without further scrutiny; further scrutiny shows they are not reliable

ECA also acknowledges these difficulties of comparing costs between the TOs using regression-based modelling to set allowances, stating:[64]

> "Our approach was more in-line with the regression approach for CAIs in RIIO-ED1, but the robustness of a regression-only approach may be limited by a smaller sample size. Hence, we recommend that some of the results of the CAI model need further scrutiny before they are used to set allowances".

Similar, for BSC, even though ECA argues that its preferred model is an improvement on other models that it assesses, it still cautions that its final model results may require "further scrutiny".[65]

Ofgem's reliance solely on comparative cost benchmarking models to forecast CAI and BSC is therefore inconsistent with its own statements earlier in the T2 process that it would not "establish a new approach for RIIO-ET2". Its use of the ECA regression models directly also seems to ignore the cautionary advice that ECA itself offers on the use of the regressions to set allowances.

The inconsistency of Ofgem's approach with its own statement in the T2 Sector Specific Methodology Decision and its failure to heed ECA's warnings about the reliability of its modelling represent, not only failure of Ofgem's process, but have a material impact on allowances.

As we demonstrate below, Ofgem places far more weight on the results of the regression models than warranted by their statistical robustness. We show in Section 4.2 that the model used by Ofgem has an extremely poor fit, with some TOs appearing to be outliers. In Section 4.3 we show statistical evidence that the modelling is mis-specified. Reflecting the poor performance of Ofgem's model against these robustness checks, we also show in Section 4.4 that its modelling results are not robust to alternative specifications of the model that perform no less well against Ofgem's stated model selection criteria.

4.2. Ofgem's Models Have Poor Statistical Fit

4.2.1. ECA highlights two particular examples of outliers affecting its analysis

In making its Draft Determination for RIIO-T2, Ofgem and its consultants (ECA and Professor Andrew Smith) have elaborated on the overarching principles to conducting model selection set out in Ofgem's "RIIO-2 tools for cost assessment" paper[66] to define statistical robustness tests for the RIIO-T2 Draft Determination, as we explain in Section 2.2.1 above.

[64] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 69.

[65] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 58.

[66] Ofgem (28 June 2019), RIIO-2 tools for cost assessment, para 2.40-2.46.

However, it is striking that ECA's formal statistical tests predominantly focus on the reliability of the estimated coefficients, making little attempt to assess whether the overarching fit of the regression model adequately and reliably explains variation in the TOs' efficient costs, and whether there are outliers.

In fact, the discussion in the ECA report reveals that the model performs poorly at explaining differences between the TOs. For instance, with reference to Ofgem's preferred BSC regression model, ECA notes that:[67]

> "The high dispersion of implied efficiency scores gave pause about the regression approach, despite the models having apparently strong statistical fits."

ECA also identifies particular evidence that differences between the TOs are not well-explained by the models. It notes that the inclusion of a GT dummy variable "improved the statistical fit" of its preferred model.[68] ECA also notes that "Outlier results remain, particularly for SPT, for which we have considered several sensitivity checks to confirm the model's general robustness".[69]

Neither Ofgem nor ECA give significant further consideration to whether the differences between GT and ET mean their indirect costs are driven by different cost functions. If there are not comparable, comparing their costs in a single econometric model could lead to statistical bias and inaccuracy, as we discuss further in Section 4.3.1.

4.2.2. ECA's modelling cannot be robustly used to compare the efficiency of SHET and SPT's BSC costs

Regarding the question of whether SPT is an outlier, ECA asserts that SPT is an "inefficient outlier" in its preferred model and hypothesises that SPT is found to be inefficient because:[70]

> "SPT, as the smallest network, is judged as inefficient due to the presence of fixed costs, but we note that our use of a regression model, with a significantly positive intercept term, should partly address the fixed costs issue"

In evaluating ECA's preferred model, Ofgem asserts that "SPT remains an inefficient outlier in [its] modelling",[71] but that "use of a regression model, with a significantly positive intercept term, should address this issue".[72]

ECA's statement that the inclusion of an intercept term should "partially" address the issue seems to be ignored by Ofgem. The omission of this word is not simply a difference in drafting, but fails to mention an important caveat that ECA attaches to its analysis. In addition, both ECA and Ofgem are likely incorrect to state that the intercept term in their model corrects for fixed costs as we explain further in Section 4.4.1.

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67 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 58.

68 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 58.

69 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. xii

70 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 55.

71 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Scottish Power Transmission, para 3.86.

72 Emphasis added. Ofgem (9 July 2020), RIIO-2 Draft Determinations – Scottish Power Transmission, para 3.86.

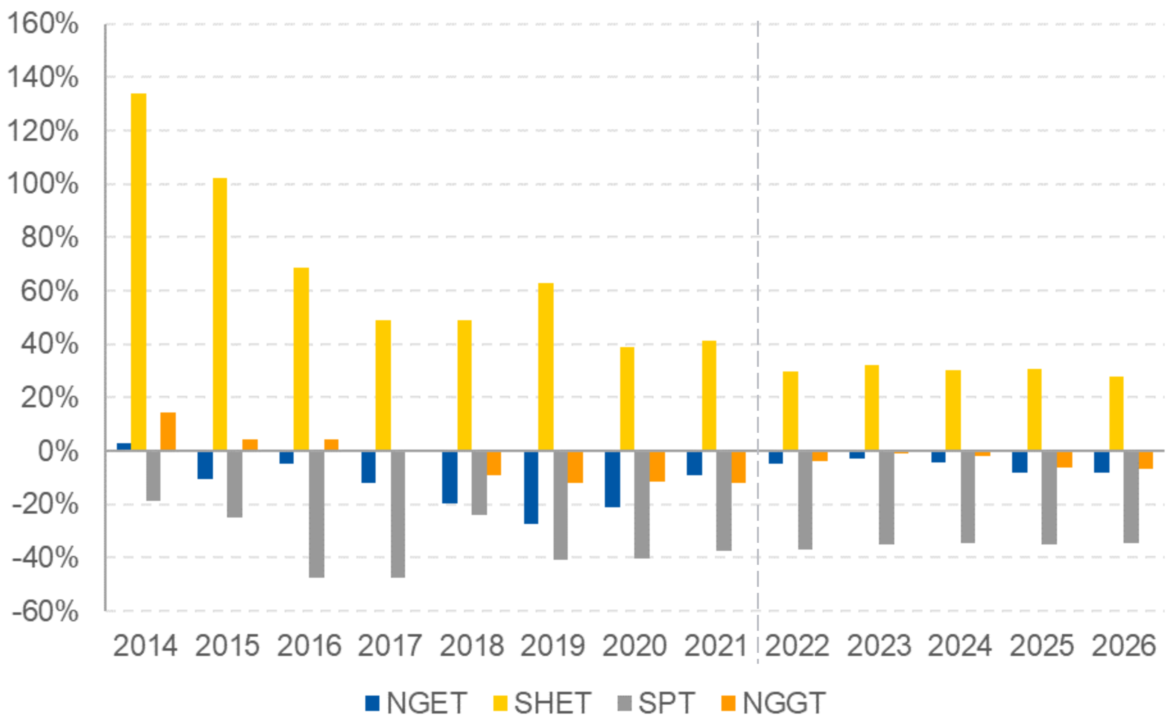
In fact, SPT and SSEH are materially smaller companies than NGGT and NGET. Including a constant term in the BSC regression may account for the fact that some BSCs are fixed, irrespective of the size of the TO. However, ECA's modelling assumes that any further differences in TOs' BSCs can be controlled for by its CSV, and its asserts that if SPT has higher costs than predicted by a model that controls for its CSV, it must be an *inefficient* outlier.

In fact, while SPT may be an outlier, Ofgem's evidence that it is an outlier due to its inefficiency relies on an assumption that a statistical model, which for the reasons we set out below is deeply flawed, explains reliably differences between companies' efficient costs.

In fact, the only inference that can be drawn reliably from ECA's modelling is that, given the model specification ECA and Ofgem have selected, both SHET and SPT are outliers, and that the modelling performs very poorly at explaining differences between their costs.

Figure 4.1 below shows the difference between Ofgem's modelled BSC costs and companies' historically incurred BSC costs in RIIO-1 and forecast costs in RIIO-2. SHET's modelled BSC costs are 130 per cent lower than predicted by the model in 2014, and remain 40 per cent higher than the model predicts at the end of T1. SPT's modelled costs are around 40 per cent higher than predicted by the model for much of the modelling horizon.

Figure 4.1: Difference Between Modelled and Actual/Forecast BSC Costs as a Percentage of Actual/Forecast BSC Costs



Source: NERA analysis of Ofgem's Cost Assessment File

It is highly implausible that these differences in modelled efficiency for SPT and SSEH represent genuine differences in the operational performance of these companies. It is far more likely that ECA and Ofgem's simplistic assumption that differences between their BSCs are explained by a simple CSV is not reliable.

Moreover, even if ECA's model can pass some statistical tests designed to test the reliability of modelled regression coefficients, the resulting differences between modelled and actual costs are too wide to consider the model provides a credible basis for forecasting how individual TOs' costs will evolve in the future.

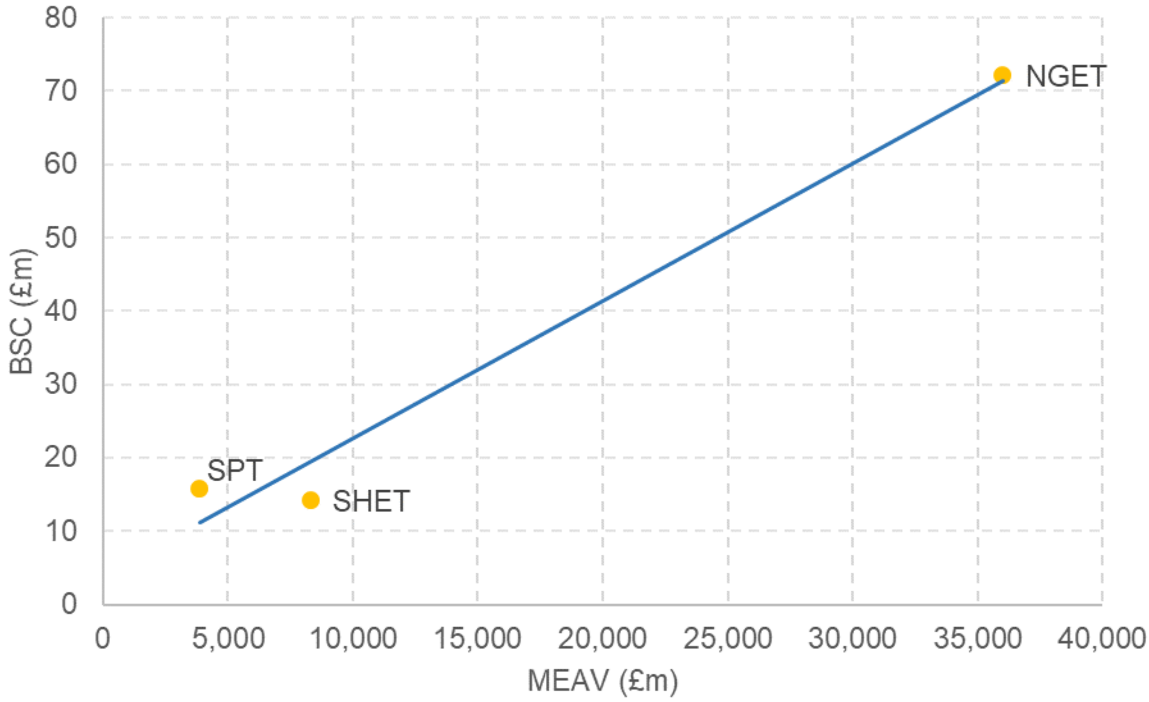
In fact, SPT and SSEH have BSCs which are almost identical. SPT predicts expenditure of £15.8 million per annum on average over the T2 period, while SHET predicts £14.2 million per annum on average. Despite this negligible difference in SPT and SHET's costs, the average value of Ofgem's CSV for SPT is three times smaller than the CSV for SHET over T2.

A simple interpretation of these numbers leads to the conclusion that SHET and SPT are similar companies of a similar size, both incur similar levels of BSC, which are at approximately the minimum level of fixed BSCs incurred by any TO of any size, and Ofgem's CSV does not provide a meaningful basis for comparing their BSCs. This would be consistent with ECA's hypothesis that "BSCs reflect a mix of both semi-variable and 'fixed' costs that will increase by step changes in response to both size / volume and the complexity of an organisation".[73]

The result Ofgem obtains, in terms of modelled efficiency gaps is, in fact, heavily skewed by the regression equation having to explain the difference between the costs of two very big companies (NGGT and NGET) and two small ones (SHET and SPT), as illustrated Figure 4.2, the slope of the regression line is determined entirely by the level of National Grid's BSCs. The regression model does not capture the point at which any TO of any size (measured by a MEAV) would start to incur BSCs above the minimum (and very similar) levels of expenditure incurred by SHET and SPT.

[73] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.29-30.

Figure 4.2: Ofgem's Modelled BSC vs. Average T2 MEAV and Line of Best Fit



Note: NGGT removed because Ofgem uses a GT dummy. Source: NERA Analysis of Ofgem's Cost Assessment File.

The regression model therefore provides no material evidence on the degree to which SHET and SPT's BSCs are efficient.

4.2.3. Ofgem's regression modelling cannot robustly compare National Grid's costs with the Scottish TOs' costs

For similar reasons, the regression line is effectively constrained to go through middle of the National Grid data points shown in Figure 4.2.

To illustrate this point, we ran a sensitivity on Ofgem's CAI and BSC models in which we added £20 million to NGET and NGGT's BSCs and CAI costs, and re-estimated Ofgem's econometric models in order to estimate the resulting modelled costs across all companies. We illustrate our results for BSCs and CAI costs in Table 4.1 and Table 4.2 below respectively.

In both the case of modelled BSCs and CAI costs, Ofgem's modelled costs rise roughly 1:1 with the £20m increase in submitted costs for NGET and NGGT. Our analysis suggests that Ofgem's modelled costs are driven almost entirely by differences in National Grid's scale relative to that of the Scottish TOs More specifically, the slope of Ofgem's regression line which it uses to model costs seems to be entirely driven by the scale of National Grid relative to the Scottish TOs.

Table 4.1: Difference in Ofgem's Modelled BSCs When £20m Is Added to NGGT and NGET's Submitted BSCs Across T1 and T2

Units: (£m)	**2022**	**2023**	**2024**	**2025**	**2026**	**Average Across T2**
NGGT	21.89	22.85	22.88	22.53	22.51	**22.53**
NGET	17.77	18.34	18.17	17.96	18.01	**18.05**
SHET	1.29	1.42	1.42	1.44	1.35	**1.38**
SPT	-0.04	-0.01	-0.01	-0.03	-0.03	**-0.03**

Source: NERA Analysis.

Table 4.2: Difference in Ofgem's Modelled CAI Costs When £20m Is Added to NGGT and NGET's Submitted CAI Costs Across T1 and T2

Units: (£m)	**2022**	**2023**	**2024**	**2025**	**2026**	**Average Across T2**
NGGT	19.98	19.28	19.47	19.81	19.81	**19.67**
NGET	18.20	18.01	22.22	24.23	24.15	**21.36**
SHET	3.40	0.31	2.62	3.17	6.93	**3.29**
SPT	0.65	0.32	1.81	3.22	3.57	**1.91**

Source: NERA Analysis.

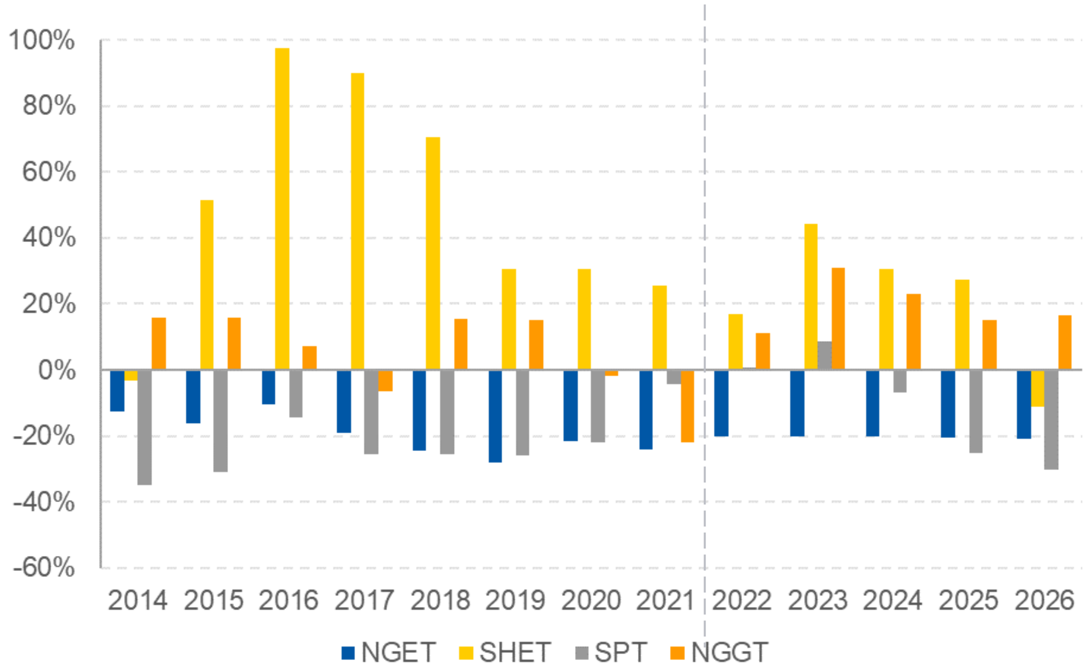
Therefore, the limited data available to Ofgem and ECA mean that its regression model cannot provide any evidence on the degree to which National Grid is efficient, or otherwise.

4.2.4. Ofgem's CAI modelling is also not able to control for differences between the TOs' costs

ECA raises similar concerns "about the dispersion of the implied efficiency scores, particularly for NGET and SHET"[74] in its CAI regressions. Similar to Figure 4.1 for BSCs, Figure 4.3 shows the differences between Ofgem's modelled CAI costs and companies' historical and forecast CAI costs for RIIO-1 and RIIO-2. Just as we explain above for BSCs, the unexplained differences between actual/forecasts and those predicted by this model are wider than can credibly be ascribed to differences in the TOs' relative efficiency.

[74] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 66.

Figure 4.3: Difference Between Modelled and Actual/Forecast CAI Costs as a Percentage of Actual/Forecast CAI Costs



Source: NERA analysis of Ofgem's Cost Assessment File

ECA seems to agree with this assessment, stating that "there is concern that the high efficiency score results for RIIO-1, ranging from 0.57 to 0.64, are unrealistic".[75] However, ECA's response to this "concern" fails to address it. It states that:[76]

> "given MEAV appears to be a robust and reasonable cost driver to include in the model, and the Total Capex ratio is a crude / simplistic model, this contradiction is not necessarily an issue".

While this statement explains why ECA thinks the simplistic nature of its capex-only POLS model may make it unsittable for modelling, and that it considers MEAV to be a "robust and reasonable cost driver", it does not address the wide dispersion of apparent efficiency gaps. This extremely poor fit of the regression model means it is likely there are other important drivers for which ECA has not controlled, the assumed functional relationship is wrong, there is not sufficient data to reliably estimate relationships (even for models that include "robust and reasonable" cost drivers, or (more likely) all of these problems apply.

Indeed, apparently contradicting this conclusion, ECA also admits that because of "the small sample size, the regression result could change significantly if the inputs change".[77] Therefore, using Ofgem's own criteria for model assessment, its model is not robust because it is not stable to "changes in, for example, the data sample or precise model specification".[78]

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75 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 67.

76 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 67-68.

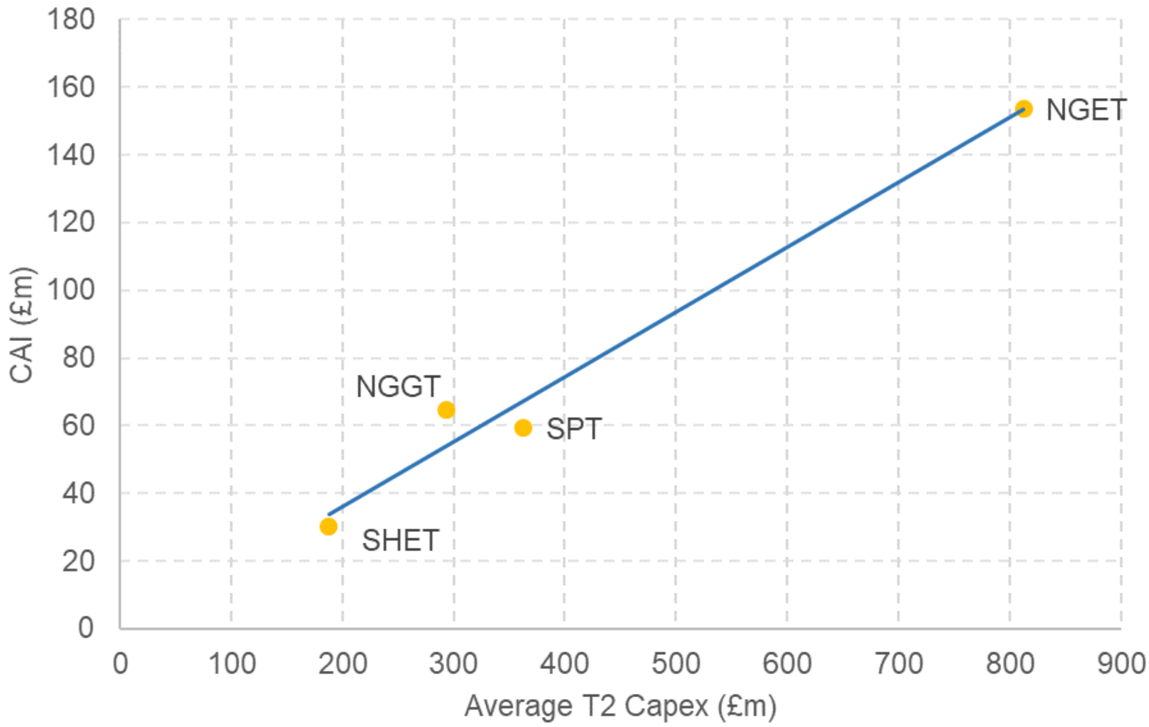
77 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 67.

78 Ofgem (28 June 2019), RIIO-2 tools for cost assessment, para 2.46.

Moreover, ECA states that whilst its model may be used as a "*basis* for challenging NGET", further "technical review" may be needed of NGET's MEAV, capex, and CAI submissions.[79] Ofgem, to our knowledge, does not provide evidence of further technical review in NGET's company annex.

Similarly to BSC, it is likely that the slope of Ofgem's regression line to explain CAI costs is determined almost entirely by the size of National Grid, and particularly NGET, relative to the Scottish TOs. We plot Ofgem's model CAI cost allowances against average capex and MEAV across T2 for companies in Figure 4.4 and Figure 4.5 below respectively.

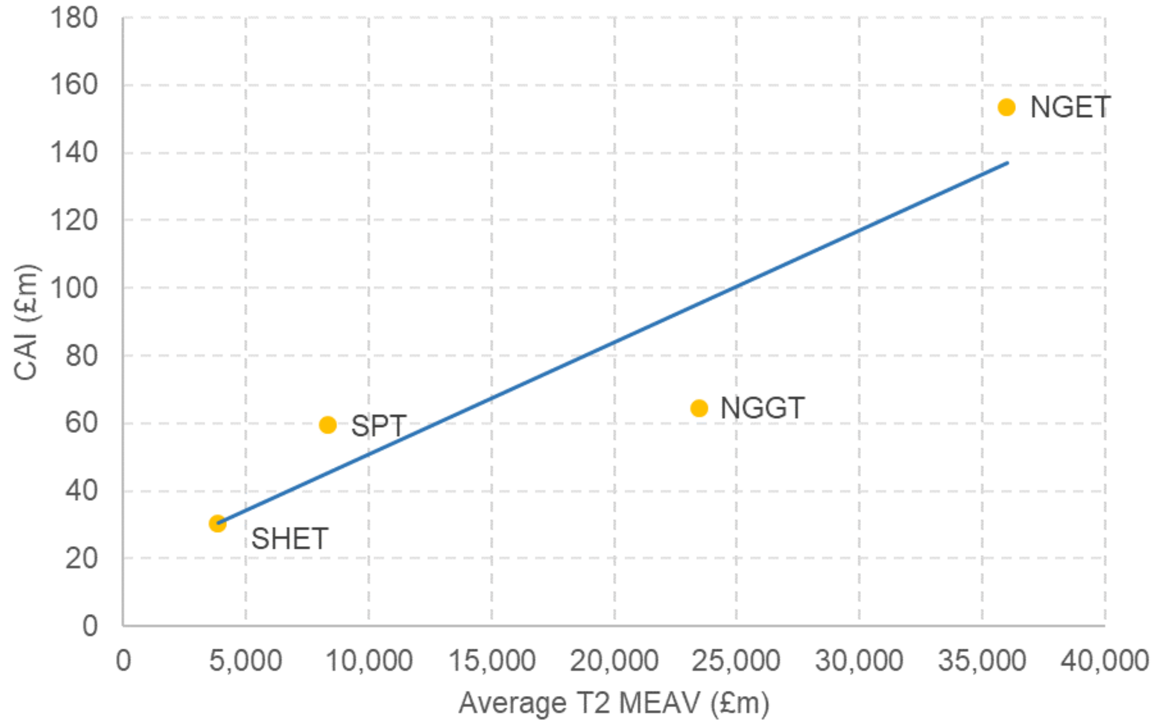
Figure 4.4: Ofgem's Modelled CAI vs. Average T2 Capex and Line of Best Fit



Source: NERA analysis of Ofgem's Cost Assessment File

79 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 67.

Figure 4.5: Ofgem's Modelled CAI vs. Average T2 MEAV and Line of Best Fit



Source: NERA analysis of Ofgem's Cost Assessment File

As the figures show, the estimated relationship between CAI and MEAV is calibrated by a regression line that (because of how OLS regression coefficients are estimated) passes through the middle of the two data points for the Scottish TOs, and through the middle of the two data points for National Grid. Hence, Ofgem's modelling will tend to suggest NGGT is efficient, while NGET is inefficient. In fact, the regression line is forced to pass through the data points for these two companies, and NGET happens to have higher costs per unit of MEAV.

This finding does not prove NGET is inefficient. Rather, it is a natural consequence of Ofgem's assumption that differences in CAI can be explained by differences in MEAV and capex, and that controlling for these factors is sufficient to account for differences between a gas and electricity transmission company. As we discuss further in Section 4.3.1 a more thorough examination of this hypothesis shows it is not valid.

Indeed, when ECA included NGET as a dummy variable for ET in an alternative regression model to partly control for NGET's size relative to the Scottish TOs) it found "the inclusion of the NGET dummy variable causes the coefficients for MEAV and Total Capex to become insignificant".[80]

80 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 65.

4.2.5. Ofgem's models do not control reliably for the differences in efficient costs across companies

In summary, across both the CAI and BSC regressions, the statistical performance of the model is exaggerated by including two very large companies and two very small companies in the dataset. Ofgem and ECA's use of regression diagnostics that focus on the reliability of coefficients are not likely to capture this, but the most important results from this form of modelling, efficiency gaps between modelled and actual/forecast costs, depend crucially on the fit of the model.

In fact, the model performs poorly at explaining differences between TOs' costs, which is revealed most starkly when examining the modelled efficiency gaps, especially for the two smaller companies (SPT and SHET). ECA warns Ofgem about these limitations of the models, but Ofgem has not heeded these warnings and used the models directly to set allowances for indirect costs for the T2 control period.

To rely on such spurious statistical modelling to set allowances would, if continued into the Final Determination, represent a significant error in Ofgem's cost assessment process.

4.3. Statistical Tests Show Ofgem's Model is Mis-specified

While the modelling Ofgem has conducted has a very limited ability to explain differences between TOs' costs, we also find that the specific models Ofgem relied on to set proposed allowances suffer from numerous, significant statistical problems. As we discuss below, the problems we identify further undermine the robustness of Ofgem's favoured models as a means of predicting efficient costs for the T2 control period.

4.3.1. Ofgem does not adequately justify pooling cost models for GT and ET businesses

As described in Section 2.2, Ofgem has pooled data on all four TOs into its regression models for CAI and BSC, encompassing both NGGT and the three electricity TOs (NGET, SHET and SPT). Therefore, an important assumption underpinning Ofgem's econometric modelling is its assumption that electricity and gas transmission businesses' indirect costs can be explained using the same cost function. However, Ofgem and ECA have failed to adequately test this hypothesis.

Ofgem justifies pooling data for BSC and CAI across sectors "due to the commonality of their sub-categories" of costs.[81] Observing that these companies have common cost categories says nothing about whether these cost categories themselves are determined by the same underlying cost drivers, and through the same functional relationship. Rather, the commonality of cost pools results from Ofgem using similar cost reporting structures for the regulated network companies within its jurisdiction. Indeed, ECA's analysis of TOs' BSC and CAI cost breakdowns across cost sub-categories only serves to confirm that they report costs for the same cost categories.[82]

81 Ofgem (9 July 2020), RIIO-2 DD – ET Annex, para.3.52, para. 3.45.

82 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, Chapter 2.

Ofgem and ECA also attempt to justify pooling data across ET and GT based on an examination of cost trends over time. For example, with respect to BSC, Ofgem states that:[83]

> "BSCs have shown similar trends for both ET and GT across both the RIIO-1 and RIIO-2 periods. This [therefore] provides confidence in pooling ET and GT for BSC benchmarking given that similar aggregate trends allow for our model to have a stronger predictive capability than if trends were diverging".

However, simply observing similar trends does not imply causation, and the factors driving GT BSCs up/down may be different from what is driving ET BSC costs up/down. Observing similar trends does not provide any information regarding the comparability of ET's and GT's cost structures and the statistical validity of pooling the datasets.

Furthermore, Ofgem's conclusion regarding pooling BSC data appears to contradict the similar assessment it makes on CAI. ECA notes in its report "there are diverging trends for CAIs across ET and GT, which may signal caution about pooling the two sectors".[84]

4.3.2. Statistical tests show there is not a common cost function for GT and ET, so Ofgem's model is mis-specified

We have conducted our own statistical tests show that the gas and electricity TOs do not have comparable cost structures, indicating that Ofgem's assumption that the indirect costs incurred by ET and GT can be adequately controlled for using a single statistical model is incorrect.

The tables below show the results of a sensitivity analysis in which we have tested Ofgem's preferred BSC and CAI models to the inclusion of a GT sector dummy variable (where not already included), an interaction term between the GT dummy and the relevant cost drivers, and re-estimated the models using only ET data.

Table 4.3 shows our sensitivity analysis for CAI:

- The first column of the table shows "Model 4" used by Ofgem and ECA to forecast modelled costs for RIIO-T2.
- Then "Test 1" shows the effect of including a dummy variable for NGGT. The coefficient on this variable is significant, and materially increases the coefficient on MEAV and reduces the coefficient on Capex. The coefficient on GT is negative, suggesting that NGGT's CAI is lower than the electricity TOs.
- We find similar results in "Test 2" and "Test 3", in which we interact the GT dummy variable with the other regressors (MEAV and Capex). The coefficient on the interaction term is significant.
- Given these results indicating a significantly different relationship between CAI and Ofgem's selected regressors for GT and ET, we re-estimate the model using only the three electricity companies. It shows that the coefficient on capex ceases to be

83 Ofgem (9 July 2020), RIIO-2 DD – ET Annex, para.3.52.

84 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.12.

statistically significant, and the coefficient on MEAV is twice as high as in Ofgem's favoured "Model 4".

These statistical tests show that the assumption made in Ofgem's preferred CAI model, that the TOs' CAI costs can be explained using a single cost function is incorrect. Hence, Ofgem's model is mis-specified.

Table 4.3: CAI Model Sensitivities to Pooling of GT and ET: Regression Results

	ECA Model 4 (MEAV + Capex)	CAI Test 1 (MEAV+Capex+ GT)	CAI Test 2 (MEAV+Capex+ GT*MEAV)	CAI Test 3 (MEAV+Capex+ GT*Capex)	CAI Test 4 (MEAV + Capex)
Sample	ET+GT	ET+GT	ET+GT	ET+GT	ET only
lnMEAV	0.231***	0.439***	0.439***	0.429***	0.449**
lnCapex	0.754***	0.395*	0.396*	0.415*	0.375
GT dummy		-0.63**			
GT dummy * lnMEAV			-0.063**		
GT dummy * lnCapex				-0.117**	
Constant	-2.435***	-2.164***	-2.165***	-2.188***	-2.129***
Observations	24	24	24	24	18
Adj R-squared	0.764	0.790	0.790	0.789	0.768

*Note: *** p<0.01, ** p<0.05, * p<0.1. Source: NERA analysis of Ofgem's supporting modelling files.*[85]

As Table 4.4 shows similar analysis for Ofgem's preferred "Model 7" for BSCs. Unlike for CAI, Ofgem's BSC model already includes a GT dummy variable. Hence, we have considered including an interaction term between the CSV and the GT dummy in addition to the GT dummy which controls for differences in the level of NGGT's costs ("Test 1"). This test is equivalent to "Test 2", in which we estimate a separate model for the ET companies (as we did in "CAI Test 4").

These tests show that there is in fact statistically significant evidence of a different relationship between BSCs for GT and ET businesses. As such, Ofgem's assumption that all TOs' BSCs are driven by a common cost function is invalid, and its model is mis-specified.

Neither Ofgem's CAI nor BSC models can therefore be relied upon to forecast the TOs' costs over the RIIO-T2 control period.

[85] In all our analysis, we adopt cost data provided by Ofgem in its supporting modelling files. We understand that both SPT and NG are providing updates to the underlying data on cost drivers to Ofgem. We have examined the impact of the updated data on our analysis and confirmed that these results do not change materially as a result.

Table 4.4: BSC Model Sensitivities to Pooling of GT and ET: Regression Results

	Model 7 (CSV + GT)	NERA Test 1 (CSV+GT+GT*CSV)	NERA Test 2 (CSV)
Sample	ET+GT	ET+GT	ET only
CSV	0.801***	0.799***	0.799***
GT Dummy	-0.314***	-0.985***	
GT Dummy * CSV		1.395***	
lnMEAV			
GT Dummy			
GT Dummy * lnMEAV			
Constant	3.212***	3.212***	3.212***
Observations	24	24	18
Adj R-squared	0.776	0.767	0.779

*Note: *** p<0.01, ** p<0.05, * p<0.1. Source: NERA analysis of Ofgem's supporting modelling files.*

4.3.3. Ofgem's preferred models fail the RESET test, suggesting the assumed functional form is incorrect

Both models Ofgem has used to set allowances for BSC and CAI respectively fail the "Ramsey RESET" test for model mis-specification.[86] Failure of this test indicates that there may be non-linearities in the relationships between costs and Ofgem's selected drivers for which the model fails to account. The consequence of non-linearities is that the modelled coefficients are biased,[87] and the modelled costs for individual TOs materially over or under stated.

Despite its failure, Ofgem's consultants have not reviewed the functional form of the model specification to address non-linearities or tested different drivers that would better capture the relationship between indirect opex and outputs. Ofgem's consultants:

- State that the need for additional terms or alternative model specifications to address non-linearities "must be balanced against the need for a simple and transparent model, with regressors backed by economic and technical logic, particularly in a small sample setting";[88] and
- Rank the RESET test as "low" importance[89] in its model selection process since it "does not usually provide sufficient evidence for rejecting a model outright".[90] In making the

86 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, Table 13 and p.56-57 (BSC) and Table 18, p.63-64 (CAI).

The Ramsey RESET test is specified in Ramsey (1969), Tests for Specification Errors in Classical Linear Least Squares Analysis, Journal of the Royal Statistical Association, Series B, 71, 350–371 and summarised by Wooldridge, Jeffrey M. (2013), Introductory Econometrics, A Modern Approach – RESET as a General Test for Functional Form Misspecifcation, Fifth Edition, p.306.

87 A biased estimator is defined as "an estimator whose expectation, or sampling mean, is different from the population value it is supposed to be estimating". It follows that the estimator cannot be robustly relied upon for prediction purposes as it is unlikely to reflect the "true" impact of the regressor on the dependent variable. Source: Wooldridge Jeffrey M., Introductory Econometrics, A Modern Approach, Second Edition (2002), Glossary, p.792.

88 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.57 and p.64.

89 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, Table 6, p.42.

90 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.57 and p.64.

latter statement, ECA cites Ofgem's academic advisor's report (Professor Andrew Smith) which suggests that "it would be overly cautious to reject a model based on a failed RESET test alone, [and] its usage may be best for distinguishing between two similar models rather than rejecting a model entirely".[91]

This use of the RESET test mischaracterizes its importance in ensuring a reliable model specification and accurately forecasting modelled costs to inform regulated companies' revenues.

The RESET test is designed to detect that the assumed model specification is wrong. If the model specification is wrong, the estimated coefficients are biased, and the cost forecasts for individual companies inaccurate. Whilst failure of the test does not provide the practitioner with any particular alternative model, standard econometric textbooks explain that failure of the RESET test means alternative functional forms may be more appropriate, e.g. adding different drivers, and adding non-linear terms.[92] We discuss the implications arising from failure of the RESET test by Ofgem's models in more detail in Section 4.4.1.

The understatement of the RESET test's importance contradicts with Ofgem's own use of the test at previous price reviews. For example, at RIIO-ED1 in its DD Ofgem explained that "some of these tests are more critical than others, particularly the Ramsey RESET test because it is directly relevant in assessing the validity of a given model specification".[93] Therefore, in evaluating the outcomes of the statistical tests during the ED1 process Ofgem "re-specified models when the RESET test failed, […] reviewed the functional form of the model and tested different drivers".[94] In its FD for RIIO-ED1 Ofgem re-stated that the "key statistical tests are the RESET and the pooling test".[95]

Despite statements from Ofgem. ECA and Professor Smith, failure of the RESET test presents evidence that Ofgem's indirect cost models are mis-specified, which undermines the models' ability to reliably forecast efficient costs for RIIO-T2.

4.3.4. Ofgem ignores the panel structure of the data, which may reduce the reliability of its models

Ofgem uses a "panel" data structure to estimate regression equations, containing observations on multiple (four) companies over multiple (six) years of historical data. With panel data, a number of alternative regression techniques are available, including:

- The Pooled Ordinary Least Squares (POLS) approach which effectively pools the cross-sectional data together and treats each observation as an individual data point, and ignores the time and company dimension of the data; and

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91 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.34.

92 See for example Wooldridge, Jeffrey M. (2013), Introductory Econometrics, A Modern Approach, Fifth Edition, p.306.

93 Ofgem (30 July 2014), RIIO-ED1: Draft determinations for the slow-track electricity distribution companies Business plan expenditure assessment Supplementary annex to RIIO-ED1overview paper, para.A.3.4.

94 Ofgem (30 July 2014), RIIO-ED1: Draft determinations for the slow-track electricity distribution companies Business plan expenditure assessment Supplementary annex to RIIO-ED1overview paper, para.A.3.3.

95 Ofgem (28 November 2014), RIIO-ED1: Final determinations for the slow-track electricity distribution companies - Business plan expenditure assessment, para. A3.24.

- Panel-based approaches which explicitly recognise the panel structure of the data and capture company-specific effects:
  - These include the Random Effects (RE) model which controls for time invariant unobserved effects for each company which are uncorrelated with the independent variables.[96] The RE model relies on between-company variation to estimate the coefficients.
  - Alternatively, a Fixed Effects (FE) model can be used to control for time invariant, unobserved effects specific to each company but which are correlated to the independent variables in the regression.[97] The FE model relies on within-company variation to estimate the regression coefficients.[98] In practice, the FE model is equivalent to a linear regression model in which the constant term varies over the individual companies.

Standard econometric tests exist to inform the choice between these alternative statistical approaches (see Table 4.5 below).

Table 4.5: Tests for Panel Estimators

Test	Description
Breusch and Pagan LM test (for random effects)	The Breusch and Pagan LM test examines how the variance of the residuals varies across individuals in the panel (in this case, companies). If variances of residuals differ across entities, random effects may be a more appropriate specification. Under the test, the null hypothesis is that the variance of the random effect is zero and therefore you should not reject the POLS model.
Hausman test (for the fixed and random regression models)	Allows to decide between a fixed or random effects model. Under the Hausman test, the null hypothesis is that the random effects model should not be rejected. Formally, the test is designed to test the null hypothesis that the error term is uncorrelated with the regressors.

Source: NERA.

As described in Section 2.2, Ofgem relies on pooled OLS models to set TOs allowances for CAI and BSC over the T2 period.

While the choice between these alternatives may not be clear-cut in small samples, standard statistical tests indicate that a RE or FE estimator may be more robust in this case. Both Ofgem's CAI and BSC preferred models fail the Breusch and Pagan test, suggesting that panel effects should be considered.[99] For CAI, Ofgem's consultants find that the results of the Hausman test support the use of the RE estimator,[100] whilst for BSC it supports the use of an FE estimator.[101]

96 Wooldridge Jeffrey M., Introductory Econometrics, A Modern Approach, Second Edition (2002), Glossary, p.801.

97 Wooldridge Jeffrey M., Introductory Econometrics, A Modern Approach, Second Edition (2002), Glossary, p.795.

98 Wooldridge, Jeffrey M. (2013), Introductory Econometrics, A Modern Approach, Fifth Edition, p. 484.

99 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, Table 13, p.56 and Table 18, p.63.

100 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.63-64.

101 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, Table 13, p.56.

Despite this evidence and failing the BP test, Ofgem relies on pooled OLS estimators for both its CAI and BSC regression models "given their relative simplicity, transparency, and favourable small sample properties".[102] ECA also:

a. Dismisses the use of the RE and FE models for its preferred BSC regression because the R-squared drops significantly and the coefficients on CSV are greater than 1, "which counterintuitively suggests diseconomies-of-scale";[103]

b. Dismisses the use of the RE model for its preferred CAI regression because it results "in implausible efficiency scores for NGET"[104] and dismisses the use of a FE model because the coefficient on MEAV becomes insignificant (and negative);[105]

c. Dismisses an alternative CAI regression model using FE estimators with Total Capex as cost driver on grounds that it "suggests an entirely opposite conclusion for SHET compared to the Total Capex + MEAV POLS model (Model 4): that its RIIO-2 submission is highly inefficient (efficiency score of 1.41 compared to 0.87)", despite finding that the efficiency scores under this model are narrower.[106]

d. Retains the pooled OLS model for both CAI and BSC "due to its reliable small sample properties and its relative simplicity and transparency" [107] and because it considers "a POLS model to be more reliable in a small sample setting".[108]

Despite the statistical tests described above indicating RE or FE estimators may be more appropriate, points (a), (b) and (c) all state that, because the RE or FE estimator generated results ECA found implausible, it dismissed them. A more natural conclusion from this analysis would be that the model specification may be wrong, or that there is too little data to reliable estimate econometric models that compare the TOs' indirect costs reliably.

And in response to point (d), whilst POLS may have better properties for estimating coefficients in a small sample setting relative to panel estimators, the tests used by ECA in its model selection process suggest that the panel structure of the data should be accounted for. Failure to do so means that in the case of FEs, the POLS estimator may be biased and inefficient, and in the case of REs, the POLS estimator is inefficient.[109] Indeed, ECA notes that because FE models account of the dataset's panel structure they "produce unbiased and

102 Ofgem (9 July 2020), RIIO-2 DD – ET Annex, para.3.52, para. 3.48.

103 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.57.

104 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.64.

105 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.60.

106 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.62.

107 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.57.

108 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.64.

109 Efficiency describes whether the estimator uses all available information to establish a statistical relationship between variables. If extra information is contained within company specific fixed or random effects, then the POLS estimator does not use this information and is therefore inefficient or more uncertain. If any explanatory variables correlate with the company specific effects, then fixed effects estimation is robust to such correlation but POLS estimation result in omitted variable bias. If variables correlate, then random effects cannot be the correct specification. See: Professor Andrew Smith (June 2019), Note for Ofgem on Diagnostic Tests in Efficiency Benchmarking Studies, p. 11-12.

consistent parameter estimates in the presence of correlation between company effects and cost drivers”.[110]

ECA’s consideration of alternative panel data estimators therefore confirms there is a wide range of sensitivity to modelled costs over the T1 and T2 periods, depending on the chosen estimator (pooled OLS, RE and FE) and none of these models can be robustly relied upon to set T2 allowances.

4.3.5. Ofgem’s use of endogenous cost drivers results in biased cost forecasts

Ofgem (following advice from its advisor, Professor Andrew Smith) discusses, but fails to address, the endogeneity of cost drivers used in its regressions. For instance, Professor Andrew Smith states that “In regression analysis the explanatory variables are assumed to be exogenously given and not under the control of the firm. However, this assumption may not hold for some variables, for example, measures of quality. This introduces a possible source of bias since, for example, factors that are omitted from the model (and which are therefore part of the error term) may be correlated with both costs and quality”.[111]

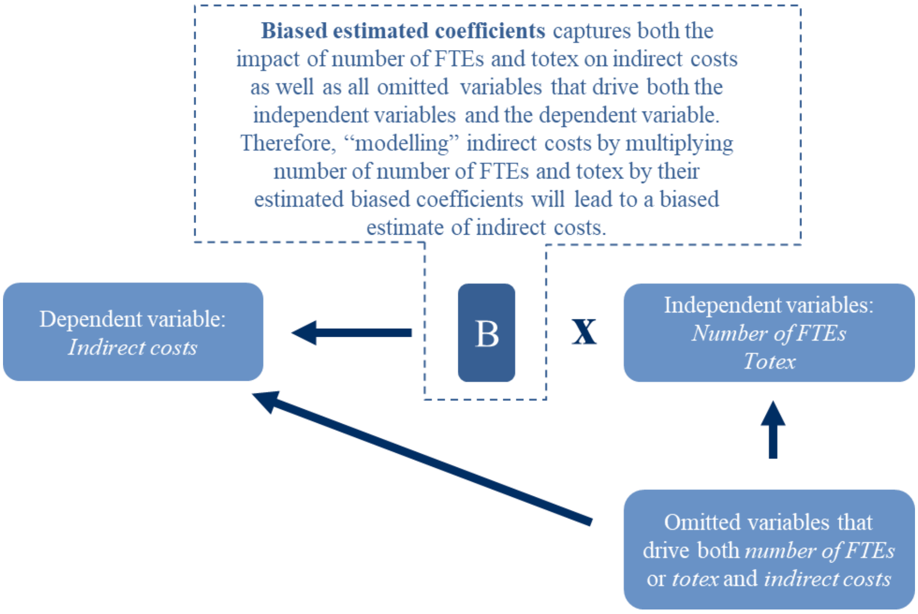
Despite Ofgem’s own recognition of the problem of endogeneity in econometric models, its econometric models probably do suffer from endogeneity bias. If this is the case, the estimated coefficients on its cost drivers are biased and do not explain how indirect costs change as a consequence of changes to the cost drivers.

For instance, Ofgem uses the number of full-time equivalent (FTE) employees and totex as independent variables to explain the dependent variable (BSCs). It is likely that both the number of FTE employees and totex would correlate with omitted variables that also cause changes in indirect opex, such as differences in the levels of outputs achieved by companies. In fact, all other variables that cause changes in indirect costs are likely correlated with changes in companies’ totex. We illustrate the endogeneity bias in Figure 4.6 below.

[110] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.33.

[111] Professor Andrew Smith is correct to note that omitted variable bias may result from an endogenous variable that is correlated with an omitted variable that also correlates with the independent variable. Professor Andrew Smith is incorrect to state all exogenous variables must not be under the control of the firm. The choice of colour scheme for a company logo is under the control of the firm but is likely an exogenous explanatory variable because it does correlate with omitted variables that determine indirect costs that the company incurs. Source: Professor Andrew Smith (June 2019), Note for Ofgem on Diagnostic Tests in Efficiency Benchmarking Studies, p. 12.

Figure 4.6: Illustration of Omitted Variable Bias in Ofgem's Model



Source: NERA illustration.

Consequently, Ofgem's estimated coefficient on totex likely captures not only the impact of changes in totex on indirect opex but also, to the extent each cost correlates with totex, the impact of omitted variables on indirect costs.

Therefore, the inclusion of endogenous cost drivers as independent variables means that Ofgem does not estimate coefficients that capture the causal impact of those cost drivers on indirect costs, and Ofgem's forecasts of costs for RIIO-T2 are biased.

4.3.6. Ofgem's cost drivers are under the control of companies, so distort incentives and undermine the model's ability to quantify inefficiency

Both the number of FTE employees and totex, which are included in Ofgem's BSC CSV, are controllable by network companies, in the sense that they can choose to employ more people or spend more money if they choose to do so. Hence, under Ofgem's approach to setting allowances for indirect costs during RIIO-T2, companies could be spending money or employing staff to perform inefficient functions that are not required to meet the needs of customers, and they would receive higher allowances for indirect costs as a result.

The use of FTEs and totex as drivers undermines the ability of Ofgem's model to reliably estimate the degree to which the TOs' current and forecast costs are inefficient.

The use of these drivers also contradicts Ofgem's own principles for selecting appropriate cost drivers, that requires drivers to "be beyond the control of the network company, as far as is reasonably practicable, to avoid distorting company incentives in ways which might be ultimately inefficient".[112]

[112] Ofgem (28 June 2019), RIIO-2 tools for cost assessment, para 2.28.

4.4. Ofgem's Results Are Not Robust to Alternative Model Specifications

Contrary to the standard Ofgem sets in its "RIIO-2 tools for cost assessment" paper, ECA's models are not stable to "changes in, for example, the data sample or precise model specification".[113] In fact, the regressions Ofgem has selected perform extremely poorly against this criterion, and modelled costs for the TOs are extremely sensitive to the use of alternative model specification that are no less reasonable than the models Ofgem proposes to use.

4.4.1. Alternative assumptions regarding cost functions show a wide range of modelled costs for the TOs

The four TOs are very different sizes. SPT and SHET operate 4,449 and 3,111 km of network respectively. By contrast, NGET and NGGT operate 14,915 km and 7,660 km of network respectively.

Given these differences in scale, how the regression modelling accounts for differences in the cost function, in other words the structural relationship between cost drivers and modelled costs, across companies becomes a material determinant of modelled costs for individual companies over RIIO-T2. Ofgem assumes a Cobb-Douglas cost function in its models which imposes a single form of cost structure for all companies regardless of size. This assumption appears unlikely to be valid in reality, and the relationship between cost drivers and total CAI costs and BSCs (or the degree to which companies realise returns to scale) may vary with firm size, as noted by Ofgem[114] and Prof. Smith in his report to Ofgem in June 2019.[115]

As we explain in Section 4.2.2 above, ECA claims that the intercept term in its regression using a Cobb-Douglas cost function "should partially"[116] control for differences in companies fixed costs respectively.[117] Ofgem and ECA misinterpret the implications of their assumed cost function. The intercept term of the regression using a Cobb-Douglas cost function does not capture fixed costs but merely scales how changes in input costs affect CAI costs or BSCs.[118] Ofgem, through its choice of cost function, assumes that this scaling factor is common across all network companies regardless their size.

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113 Ofgem (28 June 2019), RIIO-2 tools for cost assessment, para 2.46.

114 In June 2019, Ofgem noted: "Cobb-Douglas models are relatively easy to replicate and interpret but suffer from the imposition of single degree economies of scale being assumed across the industry (ie all companies are assumed to have the same level of economies of scale). Therefore, the use of this form could require the introduction of other variables that can reflect variations in economies of scale across companies. Moreover, the Cobb-Douglas functional form reflects given convexity assumptions for the production function, which might not be suitable in presence of lumpy investments". Source: Ofgem (28 June 2019), RIIO-2 tools for cost assessment, para.2.37.

115 See Professor Andrew Smith, University of Leeds (June 2019), Note for Ofgem on Diagnostic Tests in Efficiency Benchmarking Studies, p.9.

116 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, p. 55.

117 In reporting this aspect of ECA's analysis, Ofgem omits to mention ECA's cautionary advice about the model only "partially" controlling for differences in companies' fixed costs. Source: Ofgem (9 July 2020), RIIO-2 Draft Determinations – Scottish Power Transmission, para 3.86.

118 Ofgem assumes a Cobb-Douglas cost function which has the following form (using CAI costs as an example):

$$CAI\ Costs = A(Capex^{\alpha} MEAV^{\beta})$$

Consequently, Ofgem does not control for fixed costs in its regression which means its model is likely mis-specified. In order to control for fixed costs, Ofgem would need to adopt a different functional form.

As we explain above in Section 4.3.3, that Ofgem's models fail the RESET test suggests its assumption of a Cobb-Douglas cost function does not hold and its model is mis-specified. We have therefore considered different ways of controlling for alternative cost functions (relationships between cost drivers and costs). We have tested linear models, quadratic terms as well as interaction terms.

For BSC we estimated a series of models (see Table 4.6) using MEAV as the only cost driver, given the endogeneity of the other components of Ofgem's CSV (FTEs and totex), discussed above in sections 4.3.5 and 4.3.6. The models shown all pass ECA's Phase 1 model selection criteria.[119]

Table 4.6: BSC Regression Results for Alternative Cost Functions

	Log Models		Linear Models	
	MEAV	MEAV + MEAV-Squared	MEAV	MEAV + MEAV-Squared
MEAV	0.729***	-13.565***	0.002***	-0.002***
MEAV-Squared		0.774***		0***
Constant	-3.726***	61.502***	-0.909	18.817***
Adj. R-Squared	0.681	0.939	0.812	0.979
Observations	24	24	24	24

*Note: *** p<0.01, ** p<0.05, * p<0.1.*
Source: NERA analysis of Ofgem's supporting modelling files.

Table 4.7 shows similar analysis for CAI, using both the drivers included in Ofgem's favoured "Model 4" (MEAV and Capex). The models shown all pass ECA's Phase 1 model selection criteria.[120]

As can be seen, the parameter "A" simply scales the costs of cost drivers to get total CAI costs. In other words, should the costs related to capex and MEAV double, CAI costs would rise by (2xA). Ofgem takes the logarithm of its assumed cost function to get its regression model:

$$CAI\ Costs = \ln A + \alpha \ln Capex + \beta \ln MEAV$$

It estimates the coefficients (α,β) in the regression model using cost driver data of MEAV and capex. Note that the intercept estimates the logarithm of A: the scaling factor, and not fixed costs. If Ofgem were to account for fixed costs (FC), then its original cost function should be specified:

$$CAI\ Costs = FC + \ A(Capex^{\alpha} MEAV^{\beta})$$

119 With the exception of the MEAV linear model which we estimate has a statistically insignificant constant term.

120 With the exception of the MEAV and capex linear model which we estimate has a statistically insignificant constant term.

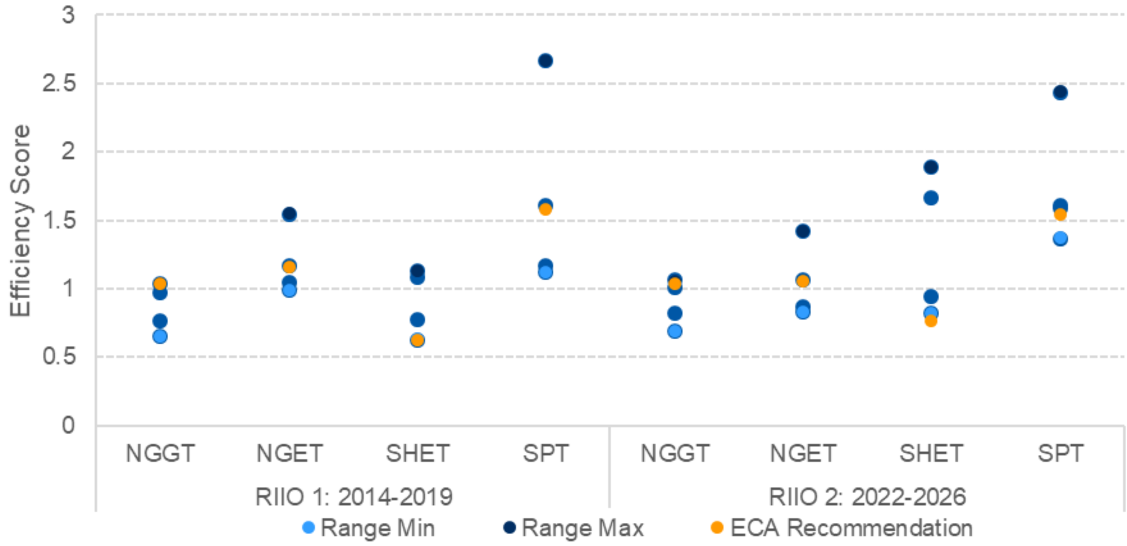
Table 4.7: CAI Regression Results for Alternative Cost Functions

	MEAV + Capex	MEAV + MEAV-Squared	Capex + Capex-Squared	MEAV + Capex + Capex Squared	MEAV + MEAV-Squared + Capex	MEAV + Capex + MEAV*Capex
Log Models						
lnMEAV	0.231***	-14.246***		0.148*	-10.313***	-2.577***
lnMEAV-Squared		0.794***			0.574***	
lnCapex	0.754***		-5.887***	-3.63*	0.56***	-4.149***
lnCapex-Squared			0.579***	0.379**		
lnCapex*MEAV						0.495***
Constant	-2.435***	67.065***	18.503***	10.854*	46.562***	25.281***
Adj. R-Squared	0.764	0.742	0.766	0.785	0.965	0.886
Observations	24	24	24	24	24	24
Linear Models						
MEAV	0.002***	-0.011***		0.002***	-0.007***	
MEAV-Squared		0***			0***	
Capex	0.164***			0.143*	0.081***	
Capex-Squared				0		
Capex*MEAV						
Constant	-17.419**	78.536***		-13.298	41.779***	
Adj. R-Squared	0.903	0.944		0.898	0.985	
Observations	24	24		24	24	

*Note: *** p<0.01, ** p<0.05, * p<0.1.*
Source: NERA analysis of Ofgem's supporting modelling files.

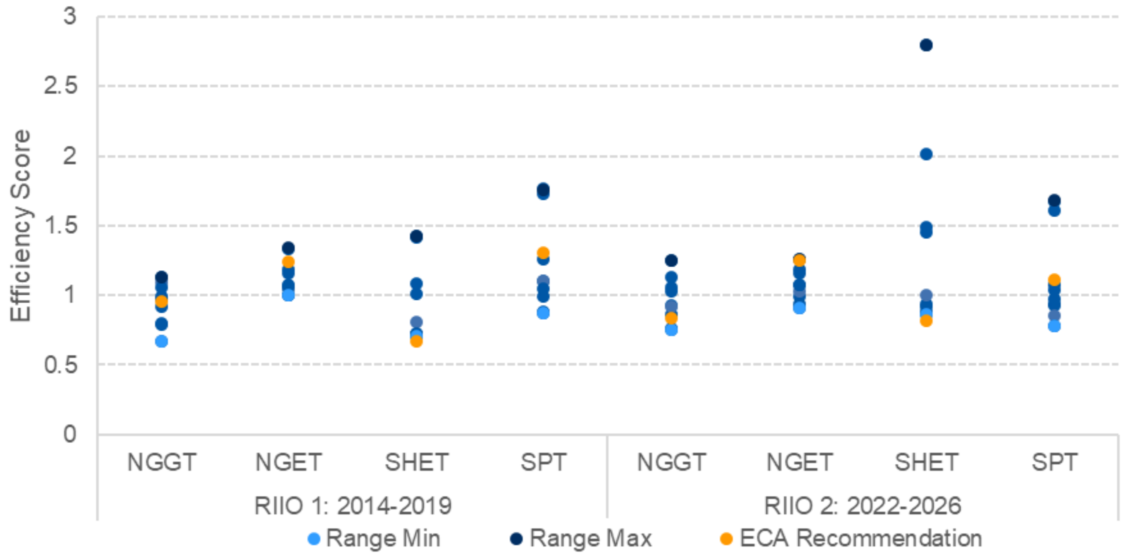
These models, which all pass ECA's "Phase 1" model selection criteria, imply an extremely wide range of modelled costs for each company over the RIIO-T2 control period, as shown in Figure 4.7 and Figure 4.8 below for CAI and BSC respectively.

Figure 4.7: Efficiency Scores for BSC Across a Range of Models that Pass ECA's Phase 1 Model Selection Criteria



Source: NERA analysis of Ofgem's supporting modelling files.

Figure 4.8: Efficiency Scores for CAI Across a Range of Models that Pass ECA's Phase 1 Model Selection Criteria



Source: NERA analysis of Ofgem's supporting modelling files. Note: We illustrate the efficiency score for NGGT implied by ECA's modelled and prior to Ofgem's adjustment.

Hence, the model selection criteria established by Ofgem and ECA do not lead to a clear decision on the appropriate functional form for explaining the TOs' indirect costs (possibly due to the small sample size). Ofgem's decision to rely on a single model masks this uncertainty, which has very significant implications for the ranges of uncertainty around the TOs' modelled efficiency gaps (i.e. ratio of company forecast to modelled cost).

There is therefore a wide range of uncertainty around the degree to which individual TOs' "efficient costs" vary from their business plan forecasts.

4.4.2. Ofgem has considered only a narrow range of drivers for TOs' BSCs; changing model specification materially affects modelled costs

ECA has only estimated a very narrow range of models for appraising the TOs' CAI and BSC costs. While it discusses qualitatively the choice between alternative drivers, some of its qualitative explanations are inconsistent, its approach of only estimating a small number of drivers means it has not assessed the sensitivity of its modelling to changes in the specification, and it has not tested its hypotheses about which factors explain the TOs' costs:

- With regards to BSC, ECA explains the rationale for including its selected drivers. It states that "BSCs reflect a mix of both semi-variable and 'fixed' costs that will increase by step changes in response to both size / volume and the complexity of an organisation. Hence, while scale-related drivers are the starting point for BSCs, an ideal cost driver will suitably reflect both scale *and* activity".[121] It then identifies MEAV as its "preferred cost driver given it simultaneously reflects the scale, complexity, characteristics, and composition of the network asset base".[122]
- ECA considers other drivers, but dismisses them. It dismisses the use of Customer Numbers on grounds that it not comparable across the ET and GT sectors, though without any quantitative evidence that this driver does not explain BSC costs. By contrast, ECA does not explain why it thinks the unit costs of gas and electricity transmission assets that determine MEAV do not suffer from this same shortcoming when used to explain BSCs.
- ECA also dismisses the use of throughput for comparability reasons between ET and GT but also notes that it "does not necessarily directly relate to scale for infrastructure that is designed to meet peak demand rather than aggregate throughput".[123] Again, ECA does not perform quantitative analysis to support this qualitative justification.
- ECA suggests peak demand may "be a better measure of scale" than throughput "given it will track system capacity". However, it dismisses testing this driver because "it is a difficult variable to accurately forecast, particularly in the gas sector".[124] Difficulties with forecasting are an inherent challenge when trying to predict future efficient costs. However, ECA could have performed a cross check on its results using this driver using historical data, at a minimum in the ET sector only.
- Finally, ECA dismisses Network Length stating that whilst it "may reflect scale, […] the perverse incentive to install more (lengthy) network assets in order to appear more efficient is obvious and network length only accounts for one dimension of scale". This explanation contradicts directly ECA's conclusions regarding the ability of TOs to influence MEAV, which also depends on the number, size and length of assets:[125]
  - "Networks would need to spend significantly to influence benchmarking results relative to the historical value of the network asset base. Network assets are also long-

[121] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.29-30.

[122] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.30.

[123] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.30.

[124] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.30.

[125] ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p.30.

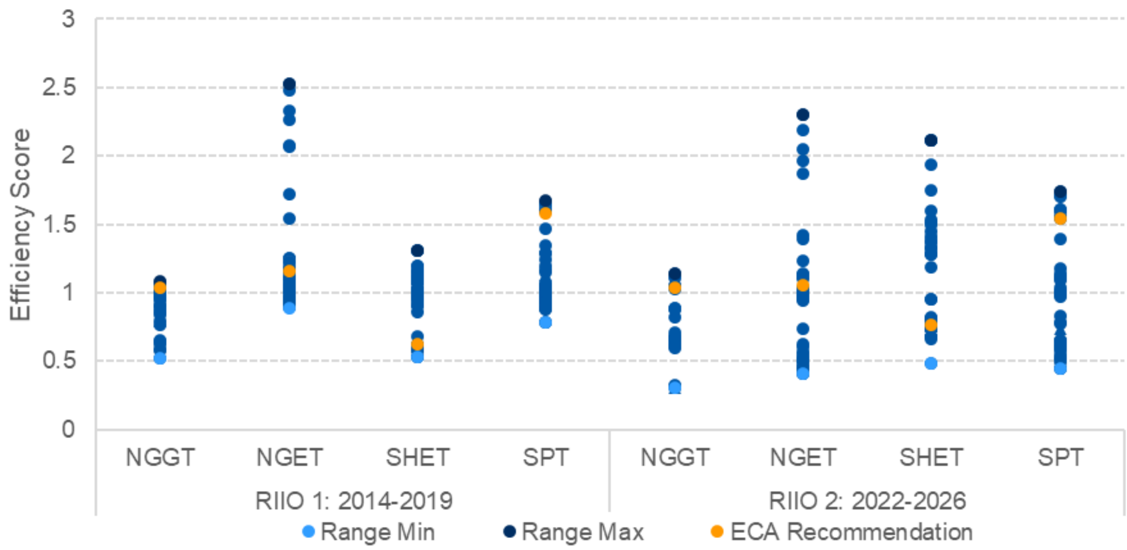
lived assets that may more reflect the investment decisions of past management, making their *current value* relatively exogenous with respect to *current operations"*

– Also, as we explain in Section 4.3.6, both FTEs and totex which ECA decides to include are under management control, which also contradicts its rationale for excluding network length.

There is therefore a case for performing sensitivities to examine a number of alternative specifications to explain BSCs with alternative cost drivers. All these models pass the ECA Phase 1 model selection criteria: the estimated coefficients are of sign and magnitude that align with economic logic, the coefficients are statistically significant, and the model has good statistical fit and explanatory power (as shown by the F-test for join significance and the Adjusted R-squared).

Like our sensitivities on alternative functional forms (see Section 4.4.1), these models show wide variation in forecast costs for the T2 control period (see Figure 4.9). These sensitivities further illustrate the wide range of uncertainty around the degree to which the TOs' "efficient costs" over the T2 period vary from their business plan forecasts. Our analysis suggests that SPT and NGGT in particular are treated as much less efficient using ECA's model results relative to the average in our alternative specifications.

Figure 4.9: Efficiency Scores for BSC Across a Range of Models that Pass ECA's own Model Selection Criteria



Source: NERA analysis of Ofgem's supporting modelling files and BPDT data.

4.4.3. Ofgem has considered only a narrow range of drivers for TOs' CAI; changing model specification materially affects modelled costs

Just as for BSCs (see Section 4.4.2) ECA has only considered quantitatively a small number of alternative drivers for CAI, which means Ofgem's allowances are subject to a wider range of uncertainty than ECA's analysis reveals:

- ECA considered both scale- and workload-related drivers and focused on those drivers that "were considered to be reasonably comparable between ET and GT",[126] that is: MEAV to reflect the scale and activity of TOs and Total Capex as a workload driver.
- ECA dismissed using other scale drivers noting that "pooling ET and GT for the CAIs assessment presents a difficulty in identifying comparable cost drivers. Potential cost drivers such as customer numbers, throughput, peak demand, and network length cannot be considered directly comparable between ET and GT".[127] As explained above, our analysis suggests that even in ECA's preferred model, ET and GT have different cost functions (see Section 4.3.1), so ECA's explanation for not considering these drivers would apply equally to its selected drivers. MEAV for GT and ET also depends on unit prices of replacing GT and ET assets, and there is no reason to necessarily expect these differences to capture the different impacts of MEAV on CAI for GT and ET.
- ECA states that it considered asset additions as a driver for CAI but notes that data for the ET sector "proved to be very 'lumpy', which led to implausible benchmarked results."[128] ECA (and Ofgem) have not provided Asset Additions data nor reported the detailed results of this modelling. It is therefore not possible to scrutinize or replicate the results. Interestingly however ECA recommends to Ofgem that:[129]
  - "In finalising its decision on the CAI assessment approach, Ofgem may wish to explore multivariate regressions that include Asset Additions in addition to a general scale cost driver, such as MEAV, or consider 'smoothing' Asset Additions, such as taking a multi-year average. While there may be endogeneity concerns with using Total Capex, like Asset Additions, it should reflect both asset replacements and reinforcements".
  - Notwithstanding this recommendation, neither ECA nor Ofgem has not tested any alternative workload driver, such as for example smoothed capex.

There is therefore a case for performing sensitivities to examine a number of alternative specifications to explain CAI. All these models pass the ECA Phase 1 model selection criteria: the estimated coefficients are of sign and magnitude that align with economic logic, the coefficients are and statistically significant, and the model has good statistical fit and explanatory power (as shown by the F-test for join significance and the Adjusted R-squared).

Like our sensitivities on alternative functional forms (see Section 4.4.1), these models show wide variation in forecast costs for the T2 control period (see Figure 4.10). These sensitivities further illustrate the wide range of uncertainty around the degree to which the TOs' "efficient costs" over the T2 period vary from their business plan forecasts. Our analysis suggests that ECA's estimate of SPT's efficiency score in CAI costs is particularly high, meaning that it treats SPT as much less efficient on CAI costs relative to our alternative model specifications that still pass ECA's own criteria.

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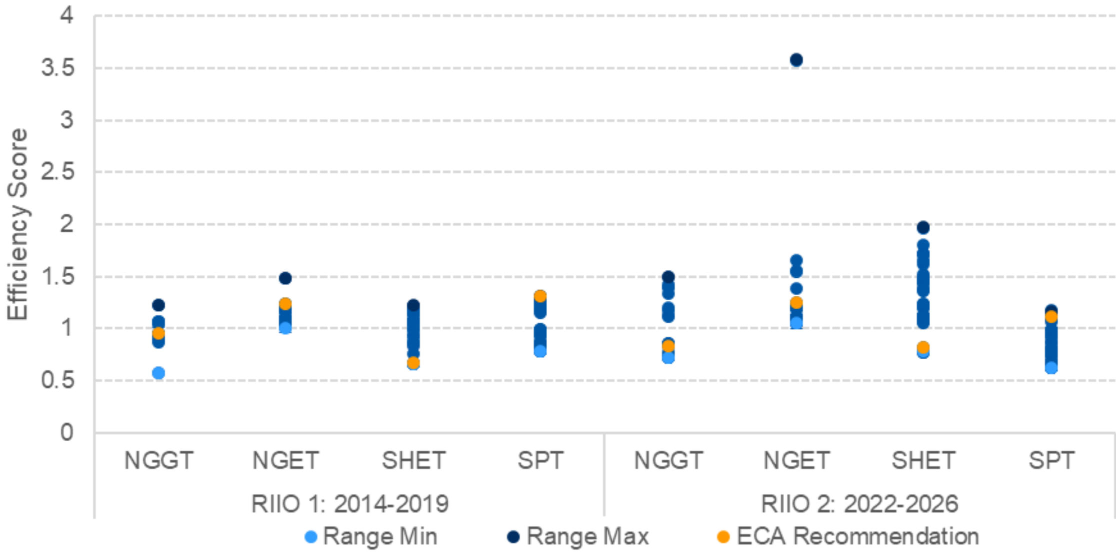
126 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p. 31.

127 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p. 31.

128 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p. 31-32.

129 ECA (7 May 2020), RIIO-GD2 and T2: BSC and CAI assessment methodology, Methodology Paper, p. 32.

Figure 4.10: Efficiency Scores for CAI Across a Range of Models that Pass ECA's own Model Selection Criteria



Source: NERA analysis of Ofgem's supporting modelling files and BPDT data. Note: We illustrate the efficiency score for NGGT implied by ECA's modelled and prior to Ofgem's adjustment.

4.5. Ofgem Fails to Consider the Extent of Ongoing Efficiency Embedded into Companies' Business Plans

Ofgem sets allowances for the T2 control period using its regression model, estimated using historical data for the T1 period, to forecast future changes in costs. It then overlays an additional target for ongoing productivity improvement on top of these cost forecasts.

However, this approach double counts ongoing productivity improvement. Companies' historical data already includes any benefits of ongoing efficiency improvement that companies achieved across the first six years of T1. These productivity improvements will tend to reduce the estimated regression coefficients, and thus forecast costs for the T2 period. By using its estimated regression models to forecast companies' BSC and CAI cost allowances in T2, Ofgem therefore extrapolates any historical trend rates of productivity improvement that companies achieved during T1 into the modelled allowances for the T2 period.

Overlaying an additional target for productivity improvement on top of the cost forecasts emerging from the regression double-counts these historical productivity improvements.

Ofgem could address this problem by stripping out historical productivity improvement before estimating the regression used to forecast RIIO-2 costs. However, this would require some subjective manipulation of historical cost data, and its regression analysis contains a number of other flaws, and Ofgem has no reliable evidence of any embedded inefficiency in the TOs' current indirect costs. Hence, a more defensible approach would be to extrapolate observed historical costs for each TO based on its assumptions about the scope for long-term productivity improvement, RPEs, and the scale of TOs' networks and investment programmes.

4.6. Conclusions

Ofgem has set allowances for indirect costs (both BSCs and CAI) using regressions, estimated using an extremely small dataset. Due to the limited availability of data, at past price reviews Ofgem has not conducted comparative benchmarking to assess TOs' efficiency and set allowances for CAI, and made only very limited use of it for BSC.

Reflecting the paucity of data, the statistical performance of the CAI and BSC regressions are extremely poor, in particular because of the difficulty of comparing the costs of two very large companies and two very small companies. Ofgem and ECA's use of regression diagnostics that focus on the reliability of coefficients are not likely to capture this, but the most important results from this form of modelling, efficiency gaps between modelled and actual/forecast costs, depend crucially on the fit of the model.

In fact, the model performs poorly at explaining differences between TOs' costs, which is revealed most starkly when examining the modelled efficiency gaps, especially for the two smaller companies (SPT and SHET). ECA warns Ofgem about these limitations of the models, but Ofgem has not heeded these warnings and used the models directly to set allowances for indirect costs for the T2 control period.

Given these differences in scale, how the regression modelling treats scale economies becomes a material determinant of how the degree to which predicted costs for individual companies over RIIO-T2. Ofgem's modelling has used Cobb-Douglas functional forms, which assume "constant returns to scale". This assumption appears unlikely to be valid in reality. We have experimented with a number of different ways of controlling for scale economies in the regression models, and we find modelled costs for individual companies vary materially depending on the specification of scale economies. Similarly, modelled costs also vary materially if we alter the model specification by changing the drivers included in the model.

While the modelling Ofgem has conducted is highly sensitive to different choices of drivers and changes in the way scale economies are specified we have also shown that the models relied upon by Ofgem to set allowances also suffer from a number of statistical problems. These problems undermine the robustness of Ofgem's modelling as a means of predicting efficient costs for the T2 control period.

- First, Ofgem has pooled data on all four TOs into a single model, encompassing both NGGT (the gas TO) and the three electricity TOs. Our statistical tests have shown that Ofgem's assumption that GT and ET companies have the same cost function is invalid.
- Ofgem has used models that fail the "Ramsey RESET" test, an important test for model mis-specification. Despite statements from ECA and Ofgem's academic advisor (Andrew Smith), this is an important test for model mis-specification. Its failure identifies that there are non-linearities in the relationships between costs and Ofgem's selected drivers for which the model fails to account. The consequence of this failure is that the modelled coefficients could be biased, and the modelled costs for individual TOs nay be materially over or under stated.
- Ofgem also uses "panel" data to estimate regression equations. Standard econometric tests can inform the choice between alternative statistical approaches to estimating regressions with panel data. While the choice between these alternatives may not be

clear-cut in small samples, standard statistical tests indicate that a "random effects" or "fixed effects" estimator may be more robust than Ofgem's POLS approach. Running these alternative models shows a wide range of sensitivity to modelled costs over the T2 period, which further undermines the reliability of Ofgem's conclusion to disallow some portion of the TOs' indirect opex forecasts. .

- Another flaw in Ofgem's models is the "endogenous" nature of cost drivers it has used to explain variation in costs. For instance, Ofgem has used (amongst other drivers) totex and the number of FTE employees to explain indirect costs. These are endogenous, as they are controllable by the company and may both influence and be influenced by the dependent variable in Ofgem's regressions.

Finally, Ofgem has included an uncertainty mechanism in its price control that would adjust the CAI allowances upwards if TOs increase their expenditure during the T2 control period ("Opex Escalator"). To calibrate this mechanism, Ofgem has used the coefficient on the capex driver from its CAI regression. For the reasons set out above, this estimated coefficient is extremely unreliable, given the various statistical problems we have identified with the regression model. Moreover, Ofgem's approach ignores the effect of higher capex on CAI that is captured via the coefficient on MEAV, and ignores how changes in capex also affect BSCs.

5. Overall Assessment of Ofgem's Opex Cost Assessment

In this chapter we set out the conclusions from our appraisal of Ofgem's assessment of the TOs' opex for the T2 control period.

5.1. The Flaws in Ofgem's Cost Assessment Process Suggest It Has No Robust Evidence that Submissions are Unreasonable

For the reasons set out above, we recommend that Ofgem's comparative benchmarking models and its benchmarking of NOCs do not constitute a reliable basis on which the draw conclusions the TOs' efficient costs over the RIIO-T2 control period. These models contain a number of logical and statistical flaws. In fact, as we explain in chapters 3 and 4, Ofgem has no substantive evidence that the levels of expenditure currently proposed by the TOs includes any element of inefficiency. Ofgem's proposal to disallow large amounts of TOs' opex is therefore unreliable.

A more reliable approach to setting opex allowances would be to set allowances based on current levels of indirect costs for each company, with indexation over time for inflation, RPEs, ongoing productivity and (if appropriate) changes in NOCs and capex due to changing workload requirements.

5.2. Ofgem's Opex Escalators Fail to Compensate TOs for Changes in Output Requirements

5.2.1. Ofgem's proposed UM is unlikely to remunerate changes in indirects as capex changes

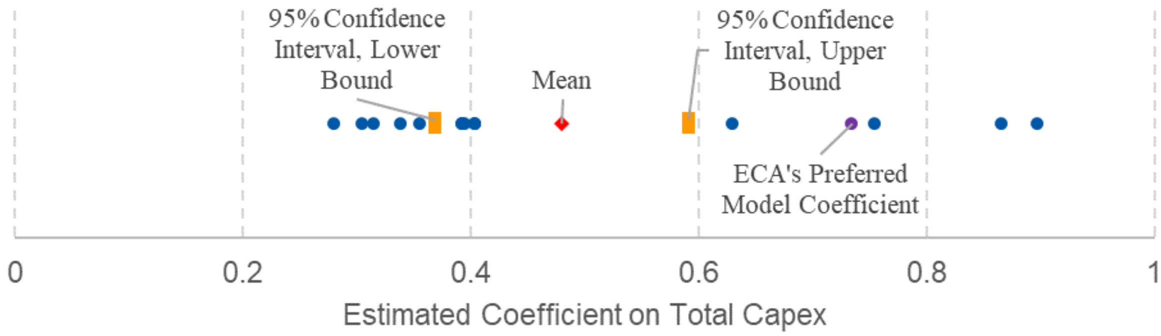
Ofgem proposes an opex escalator indexation UM for all TOs, as we discuss in Section 2.3.4. To calibrate its mechanism, Ofgem has used the coefficient on the capex driver from its CAI regression and proposes to apply a 0.754 per cent uplift to TO's CAI allowances for each 1 per cent uplift in capex allowances that occur throughout T2.

For the reasons that we set out in Chapter 4, Ofgem's estimation of this coefficient is extremely unreliable, given the various statistical problems we have identified with its preferred econometric model. Across the econometric models that we have run as alternatives to Ofgem's preferred model to set CAI allowances, which all pass Ofgem's model selection criteria, we have estimated coefficients on capex that vary between 0.28 and 0.897. We illustrate the dispersion in our estimated coefficients on total capex in Figure 5.1 below.

Our estimated coefficients on total capex vary significantly across alternative model specifications to explain CAI costs. We find that the 95 per cent confidence of estimated coefficients is wide, with range of 0.22, and we note that very few of our models estimated coefficients on capex within that confidence interval.

Our analysis places ECA's preferred model coefficient towards the high-end of our range and outside of our 95 per cent confidence interval. However, one should not interpret this result as implying ECA's coefficient adequately or over-compensates companies for changes in costs arising from changes in capex. A lower coefficient on capex would result in higher coefficients, i.e. the constant term or the coefficient on other cost drivers (e.g. MEAV). If the coefficient on capex is too high, it probably means Ofgem has set allowances that do not vary with capex that are too low.

Figure 5.1: Estimated Coefficients on Total Capex Across Our Alternative Models That Pass Ofgem's Model Criteria



Source: NERA Analysis.

There is therefore a very wide range of uncertainty around about the amount by which opex adjusts with changes in capex, and a risk that any point estimate from a regression equation fails to adequately compensate TOs for changes in indirect costs resulting from changes in capex.

Ofgem's approach also ignores the effect of changes in capex on MEAV. Whilst Ofgem adopts its estimated coefficient on its capex cost driver to use in the opex escalator, capex incurred by the TOs also increases MEAV. Hence, the effect of capex on indirect costs will be captured by both the coefficient on MEAV and the coefficient on capex. It may be more appropriate to add the two coefficients together to calibrate the rate at which allowances adjust in the uncertainty mechanism.

In addition, Ofgem does not explain, or provide economic rationale, for why it proposes an opex escalation mechanism for CAI allowances in response to outturn changes in capex but not for BSC allowances. TOs are likely to efficiently incur more BSCs as well as CAI costs following increases in capex during T2. In fact, Ofgem's BSC model would imply higher allowances because increases in capex would increase Ofgem's chosen cost driver, its CSV that incorporates MEAV, number of FTEs, and totex. Therefore, Ofgem's approach may not adequately compensate TO's for efficient changes in BSCs due to capex programmes under UMs in T2.

5.2.2. Ofgem's NOCs escalator has no clear link to any economic or technical analysis

As we describe in Section 2.3.4, Ofgem proposes an opex escalator for NOC allowances for ET companies based on outturn capex allowances during T2 that occur due to UMs. Ofgem's proposed escalator adjusts ET companies' NOCs by 0.5 per cent of any uplift to their RAVs resulting from project delivery.

To our knowledge, Ofgem does not provide:

- A rationale for the opex escalator beyond stating that it considers "that if [an opex escalator is being proposed for CAI], then by applying the same rationale, a NOC uplift should also be provided in line with the observed relationship described above, ie an efficient uplift to NOCs can be established by observing the historical relationship of NOCs to the RAV".[130]

- Details for how it estimates the historical relationship of NOCs to the RAV. Instead, Ofgem merely states that it determines the 0.5 per cent uplift through "the analysis of historical data to establish the relationship of NOCs to the RAV".[131] We are therefore unable to assess Ofgem's calculations.

Ofgem's proposed opex escalator for NOCs is therefore opaque and it does not provide a clear technical or economic rationale for its proposition.

In addition, Ofgem does not explain, or provide economic rationale, for why it proposes an NOCs escalation mechanism for ET only and not for NGGT as well. NGGT may efficiently incur more NOCs due to increases in RAV. Without further evidence, Ofgem's decision appears subjective.

5.3. Ofgem Places Undue Confidence on its Econometric Modelling to Set its TIM and BPIM

As we discuss in Sections 2.3.5 and 2.3.6, Ofgem awards and penalises TOs for their business plan submissions through its TIM and BPIM. TOs are eligible for more rewards and fewer penalties if Ofgem deems their business plan to contain more "high-confidence costs":

- In the TIM, Ofgem calculates a higher incentive rate (and confidence metric) for TOs if it deems that its business plan has more "high-confidence costs"; and
- In the BPIM, Ofgem issues penalties based on "low-confidence costs" in its Stage 3 assessment and rewards based on "high-confidence costs" in its Stage 4 assessment.

Ofgem categorises all costs that are determined through econometric modelling and econometric benchmarks as "high-confidence costs".[132]

As we demonstrate throughout this report, Ofgem's econometric benchmarking models and its assessment of NOCs are extremely imprecise and suffer from various statistical flaws. Moreover, as we demonstrate in Section 4, a wider range of alternative models that meet Ofgem's own model selection criteria indicate a significantly wider range of different cost estimates than its chosen "preferred" models. By relying on a single CAI and BSC model. Ofgem exaggerates the precision with which this form of analysis can forecast efficient opex for the T2 control period.

Therefore, Ofgem's categorisation of opex as "high-confidence costs" places undue confidence in its own econometric models. Its proposition to reward companies for forecasting costs that agree with its regression models is not necessarily rewarding "high-quality" business plans or efficient companies, but instead companies with cost forecasts that happen to conform to Ofgem's choice of econometric benchmarking model. In doing so,

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130 Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para 4.64.

131 Ofgem (9 July 2020), RIIO-2 Draft Determinations - Electricity Transmission Annex, para 4.66.

132 Ofgem (9 July 2020), RIIO-2 Draft Determinations – Core Document, para 10.17.

Ofgem may be distorting company incentives, by incentivising companies to align their cost forecasts with Ofgem's modelling rather than submit their best cost forecasts.

Appendix A. Alternative Model Specifications

A.1. Alternative BSC Regression Results

Table A.1: Regression Results for Alternative BSC Model Specifications which Pass Ofgem's Selection Criteria (GT+ET)

MEAV	Scale	Scale + Workload			Scale + Workload +Time Trend				Scale + Workload + GT Dummy			
MEAV	0.729***	0.646***	0.637***	0.697***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	0.825***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests
Total Capex		0.338***										
Smoothed Capex[133]			0.341***									
Capex Change				-0.577*								
GT Dummy									-0.504***			
Time												
Constant	-3.726***	-4.89***	-4.813***	-3.389***					-4.495***			
Observations	24	24	24	20					24			
Adj. R-squared	0.681	0.727	0.714	0.709					0.724			
F-test	Pass	Pass	Pass	Pass					Pass			
Hausman test	Pass	Pass	Pass	Pass					Pass			
Breusch-Pagan test	Fail	Fail	Fail	Pass					Fail			
VIFs below 10	Pass	Pass	Pass	Pass					Pass			
Reset test[134]	Fail	Fail	Fail	Fail					Fail			
Normality test	Pass	Pass	Pass	Pass					Pass			

Trans Units	Scale	Scale + Workload	Scale + Workload +Time Trend	Scale + Workload + GT Dummy

133 We constructed a smoothed capex variable using the average of the natural logarithm of company capex from 2014-21.

134 We performed the RESET test manually rather than rely on STATA's in-built test. Therefore, our RESET test may give slightly different, albeit not necessarily less correct, results to STATA's in-built test.

Trans Units	0.322***	0.328***	0.326***	0.306***	Fail Phase I Tests	0.329***	0.327***	Fail Phase I Tests	0.578***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests
Total Capex		0.734***				0.742***						
Smoothed Capex			0.838***				0.838***					
Capex Change				-0.65**								
GT Dummy									-1.662***			
Time trend						0.101***	0.093***					
Constant	1.68***	-2.555***	-3.124***	1.797***		-2.954***	-3.455***		0.996***			
Obs	24	24	24	20		24	24		24			
Adj R2	0.568	0.879	0.91	0.597		0.92	0.945		0.92			
F-test	Pass	Pass	Pass	Pass		Pass	Pass		Pass			
Hausman test	Fail	Fail	Fail	Pass		Pass	Pass		Fail			
Breusch-Pagan test	Fail	Pass	Fail	Fail		Fail	Fail		Pass			
VIFs below 10	Pass	Pass	Pass	Pass		Pass	Pass		Pass			
Reset test	Fail	Pass	Fail	Fail		Fail	Pass		Fail			
Normality test	Pass	Pass	Pass	Pass		Pass	Pass		Pass			

Trans Units_Alt	**Scale**	**Scale + Workload**			**Scale + Workload +Time Trend**				**Scale + Workload + GT Dummy**			
Trans Units_Alt	0.374***	0.364***	0.36***	0.355***	Fail Phase I Tests	0.365***	0.361***	Fail Phase I Tests	0.578***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests
Total Capex		0.659***				0.666***						
Smoothed Capex			0.748***				0.748***					
Capex Change				-0.58**								
GT Dummy									-1.334***			
Time trend						0.101***	0.094***					
Constant	1.509***	-2.224***	-2.705***	1.638***		-2.623***	-3.039***		0.996***			
Obs	24	24	24	20		24	24		24			
Adj R2	0.65	0.901	0.922	0.676		0.942	0.959		0.919			
F-test	Pass	Pass	Pass	Pass		Pass	Pass		Pass			

Hausman test	Fail	Fail	Fail	Pass		Pass	Pass		Fail			
Breusch-Pagan test	Fail	Pass	Pass	Fail		Fail	Fail		Pass			
VIFs below 10	Pass	Pass	Pass	Pass		Pass	Pass		Pass			
Reset test	Fail	Pass	Fail	Pass		Pass	Pass		Fail			
Normality test	Pass	Pass	Pass	Pass		Pass	Pass		Pass			

Network Length	**Scale**	**Scale + Workload**			**Scale + Workload +Time Trend**				**Scale + Workload + GT Dummy**			
Network Length	1.276***	1.201***	1.211***	Fail Phase I Tests	1.268***	1.189***	1.201***	Fail Phase I Tests	1.297***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests
Total Capex		0.175***				0.186***						
Smoothed Capex			0.144**				0.15***					
Capex Change												
GT Dummy									-0.145*			
Time trend					0.069***	0.072***	0.07***					
Constant	-8.024***	-8.381***	-8.285***		-8.201***	-8.587***	-8.475***		-8.176***			
Obs	24	24	24		24	24	24		24			
Adj R2	0.952	0.965	0.958		0.97	0.987	0.978		0.955			
F-test	Pass	Pass	Pass		Pass	Pass	Pass		Pass			
Hausman test	Pass	Pass	Pass		Fail	Pass	Pass		Pass			
Breusch-Pagan test	Pass	Pass	Pass		Pass	Pass	Pass		Pass			
VIFs below 10	Pass	Pass	Pass		Pass	Pass	Pass		Pass			
Reset test	Fail	Pass	Pass		Fail	Pass	Pass		Fail			
Normality test	Pass	Pass	Pass		Pass	Pass	Pass		Pass			

*Note: *** p<0.01, ** p<0.05, * p<0.1. We perform a RESET test similar to that performed by ECA and consistent with Ofgem's approach at ED1, but with slightly different test specifications.*
Source: NERA analysis of Ofgem's supporting modelling files and BPDT data.

Table A.2: Regression Results for Alternative BSC Model Specifications which Pass Ofgem's Selection Criteria (ET Only)

MEAV	Scale	Scale + Workload			Scale + Workload +Time Trend			
MEAV	0.825***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests
Total Capex								
Average Capex								
Capex Change								
GT Dummy								
Time								
Constant	-4.49***							
Observations	18							
Adj. R-squared	0.73							
F-test	Pass							
Hausman test	Pass							
Breusch-Pagan test	Fail							
VIFs below 10	Pass							
Reset test	Fail							
Normality test	Pass							

Trans Units	Scale	Scale + Workload			Scale + Workload +Time Trend			
Trans Units	0.578***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	0.581***	0.487***	0.479***	Fail Phase I Tests
Total Capex						0.376***		
Smoothed Capex							0.398***	
Capex Change								
GT Dummy								
Time trend					0.106***	0.12***	0.103***	
Constant	0.997***				0.617***	-1.34***	-1.382**	
Obs	18				18	18	18	

Adj R2	0.925				0.959	0.992	0.981	
F-test	Pass				Pass	Pass	Pass	
Hausman test	Fail				Pass	Pass	Pass	
Breusch-Pagan test	Pass				Fail	Pass	Pass	
VIFs below 10	Pass				Pass	Pass	Pass	
Reset test	Fail				Pass	Fail	Fail	
Normality test	Pass				Pass	Pass	Pass	

Trans Units_Alt	**Scale**	**Scale + Workload**			**Scale + Workload +Time Trend**			
Trans Units_Alt	0.578***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	0.581***	0.487***	0.479***	Fail Phase I Tests
Total Capex						0.376***		
Smoothed Capex							0.398***	
Capex Change								
GT Dummy								
Time trend					0.106***	0.12***	0.103***	
Constant	0.997***				0.617***	-1.34***	-1.382**	
Obs	18				18	18	18	
Adj R2	0.925				0.959	0.992	0.981	
F-test	Pass				Pass	Pass	Pass	
Hausman test	Fail				Pass	Pass	Pass	
Breusch-Pagan test	Pass				Fail	Pass	Pass	
VIFs below 10	Pass				Pass	Pass	Pass	
Reset test	Fail				Pass	Fail	Fail	
Normality test	Pass				Pass	Pass	Pass	

Customer Numb	**Scale**	**Scale + Workload**			**Scale + Workload +Time Trend**			
Customer Numb	0.632***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	0.631***	0.559***	Fail Phase I Tests	Fail Phase I Tests

Total Capex						0.253***		
Smoothed Capex								
Capex Change								
GT Dummy								
Time trend					0.09***	0.101***		
Constant	-6.526***				-6.835***	-7.282***		
Obs	18				18	18		
Adj R2	0.954				0.979	0.992		
F-test	Pass				Pass	Pass		
Hausman test	Fail				Pass	Pass		
Breusch-Pagan test	Pass				Pass	Pass		
VIFs below 10	Pass				Pass	Pass		
Reset test	Fail				Pass	Pass		
Normality test	Pass				Pass	Pass		

Max Demand	**Scale**	**Scale + Workload**			**Scale + Workload +Time Trend**			
Maximum Demand	0.651***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	0.652***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests
Total Capex								
Average Capex								
Capex Change								
GT Dummy								
Time					0.095***			
Constant	1.794***				1.459***			
Observations	18				18			
Adj. R-squared	0.954				0.983			
F-test	Pass				Pass			
Hausman test	Pass				Pass			
Breusch-Pagan test	Pass				Pass			
VIFs below 10	Pass				Pass			

Reset test	Pass				Pass			
Normality test	Pass				Pass			

Network Length	**Scale**	**Scale + Workload**			**Scale + Workload +Time Trend**			
Network Length	1.297***	1.184***	Fail Phase I Tests	Fail Phase I Tests	1.29***	1.133***	Fail Phase I Tests	Fail Phase I Tests
Total Capex		0.196*				0.268***		
Smoothed Capex								
Capex Change								
GT Dummy								
Time trend					0.065***	0.08***		
Constant	-8.176***	-8.364***			-8.342***	-8.636***		
Obs	18	18			18	18		
Adj R2	0.962	0.968			0.974	0.988		
F-test	Pass	Pass			Pass	Pass		
Hausman test	Pass	Pass			Pass	Fail		
Breusch-Pagan test	Pass	Pass			Pass	Pass		
VIFs below 10	Pass	Pass			Pass	Pass		
Reset test	Fail	Pass			Pass	Fail		
Normality test	Pass	Pass			Pass	Pass		

*Note: *** p<0.01, ** p<0.05, * p<0.1. We perform a RESET test similar to that performed by ECA and consistent with Ofgem's approach at ED1, but with slightly different test specifications.*
Source: NERA analysis of Ofgem's supporting modelling files and BPDT data.

A.2. Alternative CAI Regression Results

Table A.3: Regression Results for Alternative CAI Model Specifications which Pass Ofgem's Selection Criteria (GT+ET)

MEAV	**Scale**	**Scale + Workload**			**Scale + Workload +Time Trend**				**Scale + Workload + GT Dummy**			
MEAV	Fail Phase I Tests	0.231***	0.185**	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	0.636***	0.439***	Fail Phase I Tests	Fail Phase I Tests
Total Capex		0.754***								0.395*		
Smoothed Capex			0.851***									
Capex Change												
GT Dummy									-1.149***	-0.63**		
Time trend												
Constant		-2.435***	-2.554***						-1.596**	-2.164***		
Obs		24	24						24	24		
Adj R2		0.764	0.759						0.767	0.79		
F-test		Pass	Pass						Pass	Pass		
Hausman test		Pass	Fail						Fail	Fail		
Breusch-Pagan test		Fail	Fail						Fail	Pass		
VIFs below 10		Pass	Pass						Pass	Pass		
Reset test		Pass	Fail						Fail	Fail		
Normality test		Pass	Pass						Pass	Pass		

Trans Units	**Scale**	**Scale + Workload**			**Scale + Workload +Time Trend**				**Scale + Workload + GT Dummy**			
Trans Units	Fail Phase I Tests	0.135***	0.132***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	0.439***	0.338***	Fail Phase I Tests	Fail Phase I Tests
Total Capex		0.897***								0.403***		
Smoothed Capex			0.998***									
Capex Change												
GT Dummy									-2.02***	-1.342***		
Time trend												

Constant		-1.686***	-2.234***						2.655***	0.608*		
Obs		24	24						24	24		
Adj R2		0.838	0.867						0.923	0.982		
F-test		Pass	Pass						Pass	Pass		
Hausman test		Pass	Pass						Pass	Pass		
Breusch-Pagan test		Fail	Fail						Fail	Pass		
VIFs below 10		Pass	Pass						Pass	Pass		
Reset test		Pass	Fail						Fail	Pass		
Normality test		Pass	Pass						Fail	Pass		

Trans Units Alt	Scale	Scale + Workload			Scale + Workload +Time Trend				Scale + Workload + GT Dummy			
Trans Units Alt	Fail Phase I Tests	0.155***	0.149***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	0.439***	0.338***	Fail Phase I Tests	Fail Phase I Tests
Total Capex		0.865***								0.404***		
Smoothed Capex			0.961***									
Capex Change												
GT Dummy									-1.771***	-1.15***		
Time trend												
Constant		-1.567***	-2.074***						2.656***	0.608*		
Obs		24	24						24	24		
Adj R2		0.856	0.878						0.923	0.982		
F-test		Pass	Pass						Pass	Pass		
Hausman test		Pass	Pass						Pass	Pass		
Breusch-Pagan test		Fail	Fail						Fail	Pass		
VIFs below 10		Pass	Pass						Pass	Pass		
Reset test		Pass	Fail						Fail	Pass		
Normality test		Pass	Pass						Fail	Pass		

Network Length	Scale	Scale + Workload	Scale + Workload +Time Trend	Scale + Workload + GT Dummy

Network Length	0.846***	0.577***	0.535***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	0.975***	0.768***	0.801***	0.999***
Total Capex		0.63***								0.356***		
Smoothed Capex			0.692***								0.289*	
Capex Change												0.383**
GT Dummy									-0.864***	-0.498***	-0.567**	-0.877***
Time trend												
Constant	-3.313***	-4.595***	-4.567***						-4.22***	-4.56***	-4.432***	-4.428***
Obs	24	24	24						24	24	24	20
Adj R2	0.64	0.933	0.912						0.935	0.977	0.946	0.95
F-test	Pass	Pass	Pass						Pass	Pass	Pass	Pass
Hausman test	Fail	Fail	Pass						Fail	Pass	Fail	Pass
Breusch-Pagan test	Fail	Fail	Fail						Pass	Pass	Pass	Pass
VIFs below 10	Pass	Pass	Pass						Pass	Pass	Pass	Pass
Reset test	Fail	Pass	Fail						Fail	Pass	Fail	Fail
Normality test	Pass	Pass	Pass						Fail	Pass	Fail	Fail

*Note: *** p<0.01, ** p<0.05, * p<0.1. We perform a RESET test similar to that performed by ECA and consistent with Ofgem's approach at ED1, but with slightly different test specifications.*
Source: NERA analysis of Ofgem's supporting modelling files and BPDT data.

Table A.4: Regression Results for Alternative CAI Model Specifications which Pass Ofgem's Selection Criteria (ET Only)

MEAV	**Scale**	**Scale + Workload**			**Scale + Workload +Time Trend**			
MEAV	0.635***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	2.444**	Fail Phase I Tests
Total Capex								
Smoothed Capex							-3.407*	
Capex Change								
GT Dummy								
Time trend							-0.139***	
Constant	-1.59**						2.67	
Obs	18						18	

Adj R2	0.753						0.783	
F-test	Pass						Pass	
Hausman test	Fail						Pass	
Breusch-Pagan test	Fail						Pass	
VIFs below 10	Pass						Fail	
Reset test	Fail						Fail	
Normality test	Pass						Pass	

Trans Units	Scale	Scale + Workload			Scale + Workload +Time Trend			
Transmitted Units	0.439***	0.34***	0.331***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests
Total Capex		0.392***						
Smoothed Capex			0.423***					
Capex Change								
GT Dummy								
Time trend								
Constant	2.657***	0.665*	0.527					
Obs	18	18	18					
Adj R2	0.926	0.984	0.965					
F-test	Pass	Pass	Pass					
Hausman test	Pass	Pass	Pass					
Breusch-Pagan test	Fail	Pass	Pass					
VIFs below 10	Pass	Pass	Pass					
Reset test	Fail	Pass	Pass					
Normality test	Fail	Pass	Fail					

Trans Units_Alt	Scale	Scale + Workload			Scale + Workload +Time Trend			
Trans Units_Alt	0.439***	0.34***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests

Total Capex		0.392***
Smoothed Capex		
Capex Change		
GT Dummy		
Time trend		
Constant	2.657***	0.665*
Obs	18	18
Adj R2	0.926	0.984
F-test	Pass	Pass
Hausman test	Pass	Pass
Breusch-Pagan test	Fail	Pass
VIFs below 10	Pass	Pass
Reset test	Fail	Pass
Normality test	Fail	Pass

Customer Numb	Scale	Scale + Workload			Scale + Workload +Time Trend				
Customer Numb	0.479***	0.389***	0.399***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	
Total Capex		0.315***							
Smoothed Capex			0.274*						
Capex Change									
GT Dummy									
Time trend									
Constant	-3.045***	-3.554***	-3.453***						
Obs	18	18	18						
Adj R2	0.952	0.985	0.963						
F-test	Pass	Pass	Pass						
Hausman test	Pass	Pass	Pass						
Breusch-Pagan test	Pass	Pass	Pass						
VIFs below 10	Pass	Pass	Pass						

Reset test	Fail	Pass	Fail					
Normality test	Fail	Pass	Fail					

Max Demand	**Scale**	**Scale + Workload**			**Scale + Workload +Time Trend**			
Maximum Demand	0.496***	0.411***	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests	Fail Phase I Tests
Total Capex		0.28***						
Smoothed Capex								
Capex Change								
GT Dummy								
Time trend								
Constant	3.259***	1.752***						
Obs	18	18						
Adj R2	0.961	0.985						
F-test	Pass	Pass						
Hausman test	Pass	Pass						
Breusch-Pagan test	Pass	Pass						
VIFs below 10	Pass	Pass						
Reset test	Fail	Pass						
Normality test	Fail	Pass						

Network Length	**Scale**	**Scale + Workload**			**Scale + Workload +Time Trend**			
Network Length	0.975***	0.779***	Fail Phase I Tests	0.996***	0.981***	0.802***	0.818***	Fail Phase I Tests
Total Capex		0.338***				0.305***		
Smoothed Capex							0.269*	
Capex Change				0.363*				
GT Dummy								
Time trend					-0.054*	-0.037***	-0.051**	

Constant	-4.22***	-4.543***		-4.405***	-4.084***	-4.418***	-4.29***
Obs	18	18		15	18	18	18
Adj R2	0.941	0.98		0.954	0.955	0.987	0.967
F-test	Pass	Pass		Pass	Pass	Pass	Pass
Hausman test	Fail	Pass		Pass	Pass	Pass	Pass
Breusch-Pagan test	Pass	Pass		Pass	Pass	Pass	Pass
VIFs below 10	Pass	Pass		Pass	Pass	Pass	Pass
Reset test	Fail	Pass		Fail	Fail	Pass	Pass
Normality test	Fail	Pass		Fail	Fail	Pass	Pass

*Note: *** p<0.01, ** p<0.05, * p<0.1. We perform a RESET test similar to that performed by ECA and consistent with Ofgem's approach at ED1, but with slightly different test specifications.*
Source: NERA analysis of Ofgem's supporting modelling files and BPDT data.

Qualifications, assumptions and limiting conditions

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