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RIIO-GD1: Initial Proposals – Step-by-step guide for the cost efficiency assessment methodology

Consultation – Supporting Document

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Overview:

This Supporting Document to the RIIO-GD1 Initial Proposals sets out a detailed explanation of our cost assessment methodology in a step-by-step format. This document is aimed at those seeking a detailed understanding of our cost efficiency assessment. Stakeholders wanting a more accessible overview should refer to the Overview consultation document.

Associated documents

Main consultation papers

RIIO-GD1: Initial Proposals - Overview

Supporting documents

RIIO-GD1: Initial Proposals – Supporting document – Outputs, incentives and innovation

RIIO-GD1: Initial Proposals – Supporting document – Cost efficiency

RIIO-GD1: Initial Proposals – Supporting document – Finance and uncertainty

Associated documents

RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix

RIIO-GD1: Initial Proposals –Impact assessment

RIIO–T1/GD1: Financial model

Cost of capital study for RIIO–T1 and RIIO-GD1

Licence consultation documents

RIIO-T1 and RIIO-GD1: Draft licence conditions – First informal licence drafting consultation

Supporting Document 3: Draft RIIO-GD1 Gas Distribution licence changes

Supporting Document 4: Response template for RIIO-T1 & GD1-First licence drafting consultation

RIIO GD1 Price Control Financial Handbook

Other associated documents (for GD only)

RIIO-GD1: Initial Proposals for Gas distribution networks (GDNs) - Headlines

Initial Assessment of RIIO-GD1 business plans and proportionate treatment

Decision on strategy for the next gas distribution price control – RIIO-GD1

Handbook for implementing the RIIO model - Ofgem, October 2010

Glossary for all the RIIO-T1 and RIIO-GD1 documents

Contents

1. Benchmarking methodology

Introduction

1.1. This Appendix presents a detailed explanation of our cost assessment methodology in a step-by-step guide format. It provides further clarity on the analysis we have undertaken and presented in the Initial Proposals Cost Efficiency document (Ref: 103/12)[1].

1.2. The first section presents an overview of the process we have undertaken to set the baselines. The second section discusses the normalisations and adjustments we have made on the submitted costs. Our regression, efficiency assessment and baseline setting methodologies and statistical tests are discussed in following sections.

Overview of the benchmarking process

1.3. We have used both regression and qualitative benchmarking to determine cost baselines for RIIO-GD1 using the following

- We collated historical data for all costs and workloads for the period 2008-09 to 2010-11, and forecast data for the period 2011-12 to 2020-21. In addition we have used high level capex expenditure and workload for the period back to 2002-03 in our aggregated analysis.
- We identified controllable and non-controllable costs.
- We normalised the controllable costs to ensure consistency of data reporting across the industry, and to remove costs we considered unsuitable for benchmarking or appropriate for benchmarking separately, eg. TMA costs.
- We corrected the costs for differences in regional labour, urbanity, sparsity and other environmental factors.
- We identified regression and non-regression cost activities.
- For individual activities where we identified an appropriate cost driver and for the aggregated cost groups we have developed 3 year historical and 2 year forecast panel data models to determine the modelled costs for 2010-11 and 2013-14.
- We compared the modelled costs with the normalised adjusted costs to determine the efficiency scores.
- We calculated the industry upper quartile benchmark scores for 2010-11 and for 2013-14.
- We used qualitative assessment to make workload adjustments to the RIIO-GD1 forecast workloads.

1 Accessible at: http://www.ofgem.gov.uk/Networks/GasDistr/RIIO-GD1/ConRes/Documents1/GD1%20Cost%20Efficiency%20Initial%20proposals%20270712.pdf

- We used the historical 2010-11 and 2 year' forecasts4 regression equation coefficients (i.e. the constant and the slope values) to estimate separate sets of workload adjusted modelled costs for 2013-14 to 2020-21.
- We applied the 2010-11 and 2013-14 industry upper quartile benchmark scores on the separate respective sets of workload adjusted modelled costs for 2013-14 to 2020-21.
- We reversed the regional labour, sparsity, urbanity and other environmental factor adjustments for 2013-14 to 2020-21 on the respective sets of upper quartile workload adjusted modelled costs.
- We included additional allowances for the costs that were benchmarked outside the regression analysis.
- We applied our view of RPEs and ongoing efficiency.
- Where aggregating was required (i.e. bottom-up approach), we aggregated the cost activities to get a view of the aggregated baselines.
- We determined our final cost allowances based on an unweighted average of our totex and bottom-up approaches.

Submitted data, normalisations and adjustments

Submitted controllable and non-controllable costs

1.4. The data we used for benchmarking was submitted by the GDNs in the Regulatory Reporting Packs (2002-03 to 2010-11), and in the Forecast Business Plans (2011-12 to 2020-21). The data for 2005-06 to 2020-21 was submitted on a disaggregated basis split by cost activity. The data for 2002-03 to 2004-05 which relates only to capex was submitted on an aggregated basis.

1.5. We identified controllable and non-controllable costs which we have explained in Appendix 1 of the Initial Proposals Cost Efficiency document. We have excluded NTS flat capacity charges, R&D costs, smart metering costs and RPEs from the controllable costs we benchmarked, but include new streetworks.

1.6. We adopted total controllable expenditure (totex) as our measure of total costs. This measure relates more closely to the current state of technology, government regulation and environmental concerns, and the operators' levels of efficiency. We defined controllable totex as:

Controllable Totex = controllable [opex + capex + repex] + shrinkage.

1.7. We used a seven year moving average to smooth capex because of related sporadic expenditure in some of the GDN cost activities particularly LTS and other capex.

1.8. For repex the distinction between tiers 1, 2 and 3 does not exist for historical costs. We have therefore carried out a historical regression using historical data for all mains replacement and associated services. Then in rolling costs forwards to determine our view of costs for the RIIO-GD1 period, we have only used tier 1 workload. This is explained further in Chapter 8 of the Initial Proposals Cost Efficiency document.

Normalisations and adjustments

1.9. We made data normalisations and adjustments which we have explained in Appendix 1 of the Initial Proposals Cost Efficiency document.

1.10. The capex data we used to calculate the seven year moving average was submitted on an aggregated basis for the years 2002-03 to 2004-05. We assumed that for each of the adjustments, the ratio of the total adjusted costs to normalised capex for 2005-06 remains constant for the period 2002-03 to 2004-05. For example, if a GDN's capex regional labour adjustment costs were 5 per cent of its normalised capex in 2005-06, then a 5 per cent regional labour adjustment is applied to the normalised costs for years 2002-03 to 2004-05.

1.11. We used the costs we derived at the end of this process (i.e. normalised and adjusted costs) for our regression analysis, i.e. the figures in the normalised adjusted totex heading in Table 1.1 but on an annual basis.

Table 1.1: Example of normalisation and adjustment process

	Historical annual average								
Costs and adjustments	EoE	Lon	NW	WM	NGN	Sc	So	WWU	Industry
Submitted controllable totex	286.8	260.4	245.3	175.1	199.3	184.7	377.9	220.0	1950
Totex normalisations	-5.7	-3.3	-6.4	-3.4	-4.4	-9.9	-5.7	-9.4	-48
Normalised totex	281.0	257.1	238.9	171.7	194.9	174.9	372.2	210.6	1901
Totex adjustments									
Regional labour	4.7	-25.5	5.7	4.0	4.6	3.8	-19.8	4.0	-18
Sparsity	-1.0	2.0	1.2	0.1	-0.4	-1.2	0.9	-2.1	0
Urbanity	-0.6	-10.6	0.1	0.1	0.2	0.0	-5.2	0.1	-16
Salt cavity			-0.6						-1
Total totex adjustments	3.2	-34.1	6.5	4.3	4.3	2.6	-24.1	2.0	-35
Normalised adjusted totex	284.2	223.0	245.4	176.0	199.2	177.5	348.1	212.5	1866
	RIIO-GD1 Forecasts annual average								
	EoE	Lon	NW	WM	NGN	Sc	So	WWU	Industry
Submitted controllable totex	288.9	278.9	233.8	173.4	229.8	179.1	357.3	240.4	1982
Totex normalisations	-30.2	-37.1	-24.2	-11.4	-12.8	-25.0	-41.4	-16.1	-198
Normalised totex	258.6	241.8	209.6	162.0	217.0	154.1	315.9	224.4	1783
Totex adjustments									
Regional labour	3.7	-21.2	4.3	3.3	5.2	3.9	-15.9	5.1	-12
Sparsity	-0.7	1.4	0.9	0.1	-0.4	-1.2	0.8	-2.6	-2
Urbanity	-0.4	-10.2	0.1	0.1	0.2	0.1	-4.1	0.1	-14
Salt cavity			-0.6						-1
Total totex adjustments	2.7	-30.0	4.8	3.6	5.0	2.8	-19.1	2.6	-28
Normalised adjusted totex	261.3	211.8	214.4	165.6	221.9	156.9	296.8	226.9	1756

Note: Submitted controllable totex excludes RPEs.

Regression analysis

Regression and non-regression cost activities

1.12. We have identified seven regression cost activities and 13 non-regression cost activities which are discussed in Chapter 1 of the Initial Proposals Cost Efficiency document. We also undertake regressions for totex, opex, capex and repex.

Criteria for evaluating regression models

1.13. During GDPCR1 and DPCR4 we relied significantly on the goodness of the fit measure, the R-squared, to evaluate our models. R-squared however has some limitations that must be noted:

- The R-squared tells how well an estimated model fits the actual data. However, it does not indicate whether a model should be used or not. A model can have a very high R-squared, but fails an important test, i.e. a model specification test. Under such circumstances, the use of such a model based solely on an R-squared is not appropriate.
- The R-squared does not decrease, but usually increases when another cost driver is added to a regression. This limits its use in deciding whether one or several variables should be added to a model.
- Models can have a high R-squared but deliver parameter estimates that are difficult to interpret. For example, multicollinearity may result in a large amount of variation in totex being explained by the model. However, it may not be possible to isolate the effects of individual drivers with any precision.
- A comparison of R-squared is only meaningful when the dependent variables are the same. For example the R-squared value for a model estimated with data transformed into logarithmic format cannot be compared with that for a model estimated with the same data in their level format. To compare models with different dependent variables it is necessary to put them on like-for-like terms.
- The data fit and therefore the R-squared can be poor because of a mixture of relatively highly efficient and highly inefficient companies in an industry. Our ultimate aim is to estimate relative efficiency – the more inefficiency, the less well our models will fit the data – there is no target level for the goodness of fit.

1.14. While it is desirable to explain cost differences between companies that are not attributable to differences in efficiency, the model evaluation process should not rely on only maximising the goodness of fit.

1.15. Our criteria (in no particular order of priority) which we developed during DPCR5 and are using to evaluate our RIIO-GD1 regression models are:

- Identifying and selecting cost drivers using engineering knowledge.
- Using cost drivers which are outside the control of network operators.
- Including key cost drivers.
- Using reliable data.

- Using a CSV when the sample size is small or when key cost drivers are statistically insignificant.
- Using an objective and transparent approach to determine CSV weights.
- Using a rational functional form of the model.
- Using models with sensible modelled outcomes.
- Good statistical fit of the model.
- Using statistical tests to test for robustness of the models.

Cost drivers

1.16. The final set of cost drivers that we have selected for our analysis is discussed in Appendix 1 and in Chapters 5 to 7 of the Initial Proposals Cost Efficiency document.

1.17. We used seven year moving average workloads for capex connections workload and capex mains reinforcement workload in the totex and top-down capex regressions, which also use seven year moving average capex costs. The mains workload was only available at the total mains level for 2002-03 to 2004-05. We made an assumption that the historical workload data diameter split for mains remained stable up to 2005-06. We then apportioned data across mains categories (i.e. diameter bands), using the split of data/proportions provided in 2005-06. Similarly, historical connections workload data was only available at total connections and total services levels. We made an assumption that the historical workload data for connection remained stable up to 2005-06. We then apportioned data across connection categories (i.e. new, existing housing and non-domestic) using the 2005-06 split of data.

Calculating CSV weights and CSVs

1.18. Our criteria for constructing a CSV for RIIO-GD1 regression analysis are:

- when the sample is too small to handle multiple drivers, and/or
- when some of the costs drivers are statistically insignificant, but both our engineering knowledge and other industry understanding gives us reason to believe that combining them into one variable could account for changes in costs better.

1.19. The last two characteristics are essentially small sample issues. Cost drivers are likely to be important in driving costs but a small number of comparators may make it difficult to isolate significant effects for individual drivers.

1.20. We have considered a number of different approaches to setting CSV weights including:

- using engineering knowledge to determine the weights;
- using a statistical technique based on a regression using standardised cost drivers to calculate the weights; and

- using the contribution of the disaggregated cost activity to totex to determine the appropriate disaggregated driver weight and the residual applying to any additional cost drivers.

1.21. We developed an approach whereby engineering knowledge is used to select drivers, but a statistical technique based on a regression using standardised cost drivers is used to calculate the driver weights. The weights that are calculated using this approach are easy to replicate, and cannot be manipulated. We developed this approach for the DPCR5 Initial Proposals. The GDNs raised concerns that this can lead to driver weightings that are counter-intuitive, and suggested to use engineering knowledge to allocate CSV weights.

Table A1.2: Calculation of RIIO-GD1 CSV weights

Cost driver	Repex workload	Capex mains reinforcement workload	Capex connections reinforcement workload	Emergency CSV	Total number of external condition reports	Maintenace MEAV	MEAV
Regression	A	B	C	D	E	F	G
Totex	Repex costs / Totex costs	Capex mains reinforcement costs / Totex costs	Capex connection costs / Totex costs	Emergency costs / Totex costs	Repairs costs / Totex costs	Maintenace costs / Totex costs	1-A-B-C-D-F
Topdown opex				Emergency costs / Topdown opex costs	Repairs costs / Topdown opex costs	Maintenace costs / Topdown opex costs	1-D-E-F
Capex		Capex mains reinforcement costs / Capex costs	Capex connection costs / Capex costs				1-B-C
NB: All costs are controllable, normalised, adjusted costs							

1.22. We have recognised the GDNs' concerns and adopted the third approach of basing the CSV weights on industry spend proportions (i.e. ratios of controllable, normalised and adjusted costs) for the disaggregated cost activities to which the drivers apply. The residual is then applied to the scale variable, MEAV as illustrated in Appendix Table A1.2, where A, B, C, D, E, F and G are the weights for the corresponding cost drivers. We consider that this approach is both intuitive and takes into account the relative importance of each cost driver based on knowledge of the GDNs' costs.

1.23. As set out in Appendix Table A1.2 of the Initial Proposals Cost Efficiency document, our totex model uses the following CSV weightings: 43 per cent on repex workload, 2 per cent on mains reinforcement workload, 2 per cent on connections workload, 4 per cent on the emergency service CSV, 6 per cent on external condition reports, 5 per cent on maintenance MEAV, and 38 per cent (i.e. 100-43-2-2-6-5-4) on MEAV. We then calculated the totex CSV as follows:

$$\text{Totex CSV} = RX^{0.43} * MR^{0.02} * CN^{0.02} * EM^{0.04} * ER^{0.06} * MT^{0.05} * MV^{0.38} \qquad [A1]$$

Where RX is repex workload, MR is mains reinforcement workload, CN is connections workload, EM is the emergency service CSV, ER are external condition reports, MT is the maintenance MEAV, MV is the full MEAV.

Functional form and estimated model

1.24. We have used a Cobb-Douglas functional form and estimated a panel time fixed-effects model using the Ordinary Least Squares (OLS) technique as explained Appendix 1 of the Initial Proposals Cost Efficiency document.

Forecasts and historical costs models

1.25. We have estimated separate models using 3 year historical data, 2 year forecasts and 8 year forecasts. The 3 year historical model utilises a panel set of historical actual data for the period 2008-09 to 2010-11. This model provides us with an indication of the historical relative performance of the companies, and the most recent year in particular provides an indication of the companies' current levels of performance.

1.26. The 2 year forecasts model utilises a panel data set of forecasts for the first two years of RIIO-GD1, i.e. 2013-14 to 2014-15. We consider that the more immediate forecasts for the first two years of RIIO-GD1 are generally more robust than those for the latter years because the wide range of assumptions for deterioration in asset health and work volumes has a compounding effect. This model provides us with an indication of the expected short-run future performance of the companies.

1.27. The 8 year forecasts model estimates a panel data set for the entire RIIO-GD1 period, i.e.2013-14 to 2020-21. This model provides us with an indication of the expected long-run future performance of the companies. As explained in Chapter 1 of the Initial Proposals Cost Efficiency document, we are not using this model for our analysis.

Benchmarking approaches

1.28. We have undertaken our benchmarking using three approaches of aggregation, i.e. top-down, middle-up and bottom-up approaches. Our top-down approach uses a single regression model to assess the efficient level of controllable totex (excluding certain costs considered outside the regression and adjusted for regional factors) in the 2010-11 or 2013-14 base year. This approach gives us a high level view of the relative performance of companies and overcomes opex-capex trade-offs.

1.29. Our middle-up approach draws together three separate regressions for total controllable opex, capex and repex. The normalisations and regional adjustments are made at the disaggregated cost activity levels and then aggregated to total opex, capex and repex. The totex modelled costs are then calculated by adding the modelled costs for the three separate regressions as explained in the efficiency assessment section below.

1.30. The bottom-up approach aggregates the seven disaggregated regression cost activities with the 13 non-regression disaggregated cost activities identified in Chapter 1 of the Initial Proposals Cost Efficiency document. The efficient aggregated costs are then calculated by adding the efficient costs of each of the seven separate regression cost activities and the efficient costs of each of the 13 non-regression costs activities and then benchmarking them at the upper quartile (UQ). Its advantages are:

- Each of the seven disaggregated regression cost activities uses cost drivers that are closely aligned to the cost activities.
- We are able to use a technical review to assess the efficiency of each of the 13 non-regression disaggregated cost activities.
- We are able to use qualitative assessment to make workload adjustments for both the regression and non-regression disaggregated costs activities.
- Each workload adjustment we make impacts only on one specific disaggregated cost activity.

Efficiency assessment

Converting modelled log cost into cost

1.31. Our panel data regressions have been estimated using OLS technique and logarithmic transformations of the data (except for the connections regression), and with fixed time-effects, i.e. year specific intercepts.

1.32. The equation below gives a standard output from our functional form of the model.

$$\log(Y) = \mathrm{C} + \beta \log(X) + \varepsilon \qquad \text{[A2]}$$

where C is the year-specific intercept. For our historical model $C = C_{2009}$ in 2009, $C = C_{2010}$ in 2010, and $C = C_{2011}$ in 2011 and for our 2 years' forecasts model $C = C_{2014}$ in 2014 and $C = C_{2015}$ in 2015;

and where Y is the measure of costs – e.g. totex or opex; X is the cost driver – e.g. MEAV or a CSV; β is the slope value; ε is the error term (unexplained costs); and log is the natural logarithm.

1.33. We use the results from our regression model to estimate modelled costs (i.e. in £). In this example we estimate modelled costs for 2011 using the constant and cost driver for 2011:

$$\text{Modelled cost}_{2011}\ (\text{£}) = \alpha * [\text{exponential}\{C_{2011} + \beta \log(X_{2011})\}] \qquad [A3]$$

1.34. As the regressions are run using logarithmic transformations of the data, the exponential transformation into costs tends to underestimate the modelled costs for a given cost driver. We resolved this by multiplying each modelled cost with an estimate of the expected value of exponential (ε), which we refer to as an alpha correction factor (α) in this analysis. This procedure is valid as long as the errors are homoscedastic, otherwise the alpha correction factor is not a constant.The alpha correction factor for each regression model is calculated using the following procedure:

- Let y = normalised adjusted costs; x = cost driver, and i = ith GDN.
- Obtain the fitted values lôgy from the regression of log(y) on log(x).
- For each observed i, create ŝi = exponential(lôgyi).
- Regress y on the single variable ŝ without an intercept.
- The coefficient on ŝ is the alpha factor α.

1.35. The alpha correction factor can also be estimated using Microsoft Excel as the ratio of the sum of the product of each GDN's normalised adjusted costs and modelled costs, to the sum of the product of each GDN's modelled costs squared for the entire period of the regression panel data, i.e.:

$$\alpha = \frac{\text{Sum (Normalised adjusted cost} * \text{modelled cost)}}{\text{Sum (modelled cost} * \text{modelled cost)}} \qquad [A4]$$

Calculating efficiency scores

1.36. For each regression model, we have compared the normalised adjusted costs to the modelled costs to determine a relative efficiency score for each GDN as illustrated in Table A1.3.

1.37. We have calculated the efficiency scores for our top-down approach using the following equation:

$$\text{Efficiency score} = \frac{\text{Normalised adjusted cost (£)}}{\text{Modelled cost (£)}} \qquad [A5]$$

1.38. The efficiency scores for our middle-up approach are calculated using the following equation.

$$\text{Efficiency score} = \frac{[\text{Normalised adj opex (£)} + \text{normalised adj capex (£)} + \text{normalised adj repex (£)}]}{[\text{modelled opex (£)} + \text{modelled capex (£)} + \text{modelled repex (£)}]} \qquad [A6]$$

1.39. We calculate efficiency scores for our bottom-up analysis using the same method as the middle-up (i.e. equation [A6]). We calculate efficiency scores based on an aggregation of the costs for the seven disaggregated regression cost activity costs and then use these efficiency scores to determine the benchmark score.

1.40. We then adjust the efficiency scores for each GDN to ensure that the average efficiency score across the industry is exactly 100 per cent for each of our top-down, middle-up and bottom-up analyses. This adjustment ensures that the scores for each approach are on a comparable basis. The formula we use is:

$$\text{Standardised efficiency score} = \frac{\text{GDNs efficiency score}}{\text{Industry average efficiency score}} \quad [A7]$$

Table A1.3: Example of calculating standardised efficiency scores

Cost group	Nomalised adjusted costs (£m)	Modelled costs (£m)	Efficiency score	Industry average efficiency score	Standardised efficiency score
	(a)	(b)	(a)/(b)		
Work management	16	18	0.89	A	0.89/A
Emergency	14	14	1.00	B	1.00/B
Repairs	12	10	1.20	C	1.20/C
Maintenance	15	14	1.07	D	1.07/D
Connections	10	10	1.00	E	1.00/E
Mains	13	16	0.81	F	0.81/F
Tier 1	40	42	0.95	G	0.95/G
Bottom-up	120	124	0.97	H	0.97/H
Middle-up	300	310	0.97	I	0.97/I
Top-down	300	312	0.96	J	0.96/J

1.41. Detailed standardised efficiency scores for our models are presented in A1.2.

Calculating the benchmark score

1.42. We are defining efficient costs from our benchmarking at the upper quartile (UQ) level of efficiency rather than the frontier to acknowledge that a part of the difference in costs across the GDNs relates to factors other than GDNs' relative efficiency (i.e. there are statistical errors).

Table 1.4: Benchmark scores used in analysis

Cost group	Historical models (2011)	2 years' forecasts models (2014)
Work management	0.943	0.970
Emergency		
Repairs		
Maintenance		
Connections		
Mains		
Tier 1		
Bottom-up		
Middle-up	0.952	0.955
top-down	0.951	0.960

1.43. We have set our benchmark score for each of the cost groups presented in Table 1.4 as an UQ of the GDNs' standardised scores. We have calculated the benchmark scores for only 2011 for the historical models and for only 2014 for the 2 year forecasts models. The benchmark score for the seven disaggregated regression cost activities is based on the method which calculates efficient scores using the aggregated actual and modelled costs (see paragraph 1.40 above). The benchmark score is therefore identical for all the seven cost activities.

Determining the baselines

1.44. We calculate the baselines using the following steps, which are discussed in the respective sections below:

- applying workload adjustments,
- calculating the workload adjusted forecast UQ efficient costs,
- reversing the adjustments,
- including additional costs associated with applying our adjustments for activities assessed outside the regression analysis,
- applying our view of RPEs and productivity improvements, and
- combining the results of our analysis.

Calculating workload adjusted forecast modelled costs

1.45. We have made adjustments to the forecast workloads in our qualitative assessment at the disaggregated cost activity level as discussed in the respective sections of Chapters 5, 6 and 7 of the main Initial Proposals Cost Efficiency document.

1.46. The workloads from our disaggregated regression cost activities (i.e. repex workload, mains reinforcement workload, connections workload and external condition reports) feed into the CSVs for our opex, capex, repex and totex models. The CSVs increase/reduce when the workloads are adjusted upwards/downwards. Similarly, adjustments made on the assets that are included in the MEAV calculation are reflected in the respective CSVs. We have calculated workload adjusted CSVs for the RIIO-GD1 forecast years using the CSV methodology discussed above.

1.47. Equation [A3] sets out how we estimate the modelled costs for 2011. We used this relationship to calculate the forecast modelled costs for RIIO-GD1 years 2014 to 2021, by replacing only the CSV for 2011 (2014 in the case of the 2 year forecasts model) with the workload adjusted CSV for the respective years. For example, the historical regression based workload adjusted modelled cost for 2014 is calculated as:

$$\text{WA modelled cost}_{2014}\,(£) = \alpha * [\text{exponential}\{C_{2011} + \beta\log(\text{WA } X_{2014})\}] \qquad \text{[A8]}$$

Where WAX_{2014} is the workload adjusted cost driver/CSV for 2014.

1.48. The workload adjusted modelled costs for the middle-up approach are calculated separately for opex, capex and repex and then aggregated. The workload adjusted modelled costs for the bottom-up approach are calculated separately for each of the seven disaggregated regression cost activities.

Calculating workload adjusted forecast upper quartile efficient costs

1.49. The top-down and middle-up workload adjusted UQ efficient costs are calculated by applying the historical (2 year forecasts) model's 2011 (2014) UQ industry benchmark score on the forecast modelled costs. The workload adjusted UQ efficient costs for the bottom-up approach are calculated separately for each of the seven disaggregated regression cost activities using the historical (2 year forecasts) model's 2011 (2014) aggregate-based UQ industry benchmark score (i.e. the benchmark score presented in Table 1.3). For example, the historical regression based UQ efficient cost for 2014 uses the formula:

$$\text{UQ WA efficient cost}_{2014} = \text{WA modelled cost}_{2014} \times \text{benchmark score}_{2011} \qquad \text{[A9]}$$

Where $\text{benchmark score}_{2011}$ = 0.951 for the top-down model
= 0.952 for the middle-up model
= 0.943 for each of the seven cost activity models

Reversing the adjustments

1.50. We have calculated regional labour, urbanity, sparsity and salt cavity (North West only) adjustments for each year of RIIO-GD1. We reverse the adjustments that we added/subtracted from the normalised costs prior to running the regressions by subtracting/adding them from/to the UQ WA efficient costs for each forecast year. The reverse adjustments for the top-down and middle-up approaches are identical. Those for the seven disaggregated regression cost activity models are cost activity-specific (see Chapters 5 to 7 of the main Initial Proposals Cost Efficiency document).

1.51. We also make a workload based adjustment to the reverse adjustments. The logic for this adjustment is that if the adjusted workload increases/reduces, then the reverse adjustments should also increase/reduce. We use the ratio of non-workload adjusted modelled costs to workload adjusted modelled cost as our adjustment factor. Increases/reductions in workloads increase/reduce the adjustment factor to above/below 1 unit, i.e.;

$$\text{Workload adjusted reverse adjustment factor (WARAF)} = \frac{\text{Modelled cost}}{\text{WA modelled cost}} \qquad \text{[A9]}$$

1.52. We then calculate UQ workload adjusted efficient costs for each year of RIIO-GD1 with the regional and company specific adjustments reversed. The UQ workload adjusted efficient cost after the reverse adjustments for 2014 is for example calculated as:

$$\text{Reverse adjusted UQ WA efficient cost}_{2014} = \text{UQ WA efficient cost}_{2014} \text{ x } \text{WARAF}_{2014} \text{ [A10]}$$

Including additional costs after the regressions

1.53. We have also included additional costs to the companies' baselines for the top-down, middle-up totex and the seven disaggregated regression cost activities. They involve adding back our view of efficient costs for activities which we benchmarked separately or atypical costs which we considered unsuitable for benchmarking.

Applying RPEs and productivity assumptions

1.54. We have developed our view of RPEs and ongoing productivity for RIIO-GD1, which are discussed in Chapter 2 of the Initial Proposals Cost Efficiency document. We apply them on the reverse adjusted UQ efficient costs (with additional costs) to determine our baselines for our top-down and middle-up approaches. We use 2011 as our base year for RPEs for all our models, and for productivity for the historical costs models, but use 2014 to be the productivity base year for the 2 year forecasts models.

1.55. Our view of RPEs and ongoing productivity for the bottom-up approach is applied on the reverse adjusted UQ efficient costs (with additional costs) for the disaggregated regression cost activities.

1.56. We have used technical assessments of the GDNs' forecasts to determine our view of efficient costs for each GDN for each of the 13 non-regression costs activities. We have applied our view of RPEs to each of the 13 non-regression costs activities but not applied additional ongoing efficiencies to the non-regression activities as our assessment is based directly on the GDNs' forecasts which already includes their view of ongoing efficiency. We then sum the cost baselines for each of the disaggregated cost activities to determine our aggregated baselines for the bottom-up approach.

Combining the results of our analysis

1.57. We have explained in Chapter 9 of the Initial Proposals Cost Efficiency document our decision to determine our baselines using an unweighted average of the results of the four approaches, i.e. top-down historical, bottom-up historical, 2-years forecasts top-down, and 2-years forecasts bottom-up.

1.58. Most of our results in the Initial Proposals Cost Efficiency document are presented on the bottom-up basis to provide greater transparency and to split out the elements of our adjustments. We then apply a reconciliation between our historical bottom-up analysis and our final result which is based on the average of the 4 approaches as illustrated in Table A1.4.

1.59. Table 1.5 below presents the calculation of our Initial Proposal totex allowances (pre-IQI). Column (A) shows the GDNs' submitted forecasts with non-controllable costs and costs funded through uncertainty mechanisms excluded. We have also excluded costs associated with loss of metering and replaced it with our assumptions for each of the GDNs.

1.60. Column (B) sets out the companies' forecasts adjusted for our ouput disallowances as discussed in Chapter 9 of the Initial Proposals Cost Efficiency document. Columns (C) to (G) set out our proposed adjustments to the forecasts under each of the four assessment approaches and the average of these. Columns (H) and (I) set out our totex allowances pre-IQI and the percentage adjustments to the companies' forecasts (pre-IQI).

1.61. Column (J) shows the reconciliation between our allowances based purely on our bottom-up approach and the allowances based on the average of the 4 methods.

Table 1.5: Combining the elements of the cost analysis to determine our totex allowances (pre-IQI)

GDN	(A) Sub normalised forecast (£m p.a.)	(B) Sub normalised forecast with output adj (£m p.a.)	(C) % adj under H totex model	(D) % adj under H Bottom-up	(E) % adj under 2YF totex	(F)% adj under 2YF Bottom-up	(G) Average of 4 methods % redn	(H) Ofgem totex allowance pre-IQI = (B)*(I) (£m p.a.)	(I) % reduction to GDN forecasts =(A-J)/A	(J) Reconcn between allowances based purely on bottom-up and allowances based on average of the 4 methods
EoE	280.5	266.3	13%	15%	8%	12%	12%	233.7	17%	3.5%
Lon	276.6	238.1	19%	19%	15%	19%	18%	195.4	29%	1.6%
NW	226.6	197.6	9%	16%	4%	15%	11%	176.0	22%	6.4%
WM	172.8	155.1	5%	14%	0%	14%	8%	142.6	17%	7.1%
NGN	228.6	209.3	9%	7%	4%	5%	6%	196.1	14%	0.9%
Sc	176.9	159.4	12%	11%	8%	9%	10%	143.7	19%	1.0%
So	345.8	333.2	13%	12%	8%	8%	10%	299.3	13%	1.7%
WWU	242.2	206.8	17%	18%	13%	15%	16%	173.6	28%	2.8%

Note: sub = submitted; adj = adjustments; H = historical; 2YF = 2 years' forecasts.

Statistical tests

1.62. We developed a number of statistical tests in consultation with our academic advisor for the panel data models that we estimated by Ordinary Least Squares (OLS) for DPCR5. These tests provide an indication of the robustness of the modelling results and also indicate where some of the parameter estimates from the regressions might be biased and require an adjustment to avoid misleading results. We investigate the outcome of the statistical tests and make appropriate adjustments. We also use the results from these tests to feed into our judgement in identifying the best models. The tests are:

- Ramsey RESET test for model misspecification,
- F-test for parameter stability
- White test for heteroscedasticity
- Test for outliers, and the
- Jarque-Bera test for normality.

1.63. Some of these tests are more critical than others. The first two, Ramsey RESET test and the F-test for parameter stability are more important because they are directly relevant in assessing the validity of a given model specification. The tests of heteroscedasticity and normality are generally used to determine appropriate methods for assessing the accuracy of the estimates and hypothesis tests. The outlier tests are used to determine whether to include or exclude an observation. These tests are briefly discussed below.

Ramsey RESET test

1.64. The Ramsey Regression Specification Error Test (RESET) is a general test for model misspecification. For example, the test might identify incorrect functional form - some or all of the variables (i.e. the costs and the driver) should be transformed to logs, powers, reciprocals, or in some other way.

1.65. We have estimated our models using clustered standard errors to allow for the fact that the set of observations in the panel are not independent but clustered by GDN.

F-test for parameter stability

1.66. The F-test examines whether the slope coefficients are stable over time. If any differences are not found to be statistically significant, then the data can be pooled over the given years. If they are statistically different then there is no justification for pooling the data.

White test for heteroscedasticity

1.67. When an OLS regression is run it produces estimates of the standard errors for each of the coefficients in the model. These standard errors are a measure of the uncertainty surrounding the parameter estimates and can be used to perform hypothesis tests on the coefficients from the model.

1.68. Heteroscedasticity can cause the standard errors (and therefore any hypothesis testing) to be biased. It typically occurs when the variation in the residuals is very different over time. For example, if the residuals were very large in magnitude in some periods compared to others then we might think that the spread of residuals is not constant which would be an indication of heteroscedasticity. Heteroscedasticity may also be driven by the error variance differing as a result of the model not fully capturing scale differences for the cross-section of comparators.

1.69. We test for heteroscedasticity since any violation might be an indicator of a more general model misspecification. The White test examines whether the residual variance of the variable in the regression model is constant (homoscedasticity). If there is evidence of variation in the residual variance (heteroscedasticity) it implies that the standard errors of the coefficients (and therefore any hypothesis testing) are biased.

Outlier tests

1.70. We are concerned about data being misreported or being derived from different allocation methods, which make costs/drivers non-comparable. In addition, because our comparative analysis is undertaken in order to set an efficient level of expenditure, an extreme observation is bound to significantly influence the outcome of the price level set when it skews the efficiency scores on which the analysis is based. Therefore, there is justification on these grounds to identify outliers and devise means of handling them.

1.71. An outlier is an observation that is different to the others in a dataset and has influence over the entire dataset's characteristics. In terms of regression analysis, variation in the data is necessary to carry out estimation. However, outliers can have a disproportionate impact (influence or leverage) on the sign, size and statistical significance of estimated coefficients. Therefore, outliers can make models perform worse in terms of overall fit and standard errors. In efficiency analysis, outliers may skew the efficiency score.

1.72. Nevertheless, it is important not to exclude an outlier unless its values can be attributed to measurement error instead of a chance of occurrence that reflects the underlying model. Effectively, the detection of an outlier provides a basis for investigating the data further, instead of excluding that observation.

1.73. There are several tests (i.e. Grubbs' test, Dixon's Q-test and Tietjen-Moore test)[2] that can be used to for outliers. We use the standardised residuals test.

Jarque-Bera test

1.74. The Jarque-Bera test is used to test whether the residuals are consistent with a normal distribution. Normality of residuals is not a necessity, but it is an indication of a well behaved model.

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[2] Grubbs, F. E., 1969. Procedures for detecting outlying observations in samples. Technometrics 11:1-21. R. B. Dean and W. J. Dixon (1951) "Simplified Statistics for Small Numbers of Observations". Anal. Chem., 1951, 23 (4), 636–638 Gary Tietjen and Roger Moore (August 1972), "Some Grubbs-Type Statistics for the Detection of Several Outliers", Technometrics, Vol. 14, No. 3, pp. 583-597.

Methodology for calculating regional labour indices[3]

Introduction

1.75. As part of RIIO-GD1 quantitative analysis we have calculated direct and contract labour indices for both London and Southern GDNs based on a methodology used in GDPCR1. However, unlike the GDPCR1 approach which used only London as a high cost region, we have identified and used two high cost regions, London and the South East. We have applied a single weighted average, based on population numbers, to all other regions excluding London and the South-East, so that the national average is equal to one. This group of regions (i.e. all regions of England, Scotland, Wales and Northern Ireland excluding London and South East) is referred to as Elsewhere in this Appendix.

1.76. Following extensive consultations with the GDNs and our own research, we have taken GDNs' responses into account and reviewed and finalised our approach to calculating the direct and contract labour regional indices for RIIO-GD1. We are:

- using the Office of National Statistics (ONS) Annual Survey of Hours and Earnings (ASHE) data to calculate regional factors for both direct and contract labour,
- using the labour component of opex, capex and repex costs to calculate the percentage of work required to be done locally,
- assuming 40 per cent of work management will be carried out locally,
- using both Northern Ireland and British information in the calculation of regional factors as they are based on information on UK annual gross wages,
- using industry-specific occupational category weights based on averaging information submitted by the GDNs, and
- using the latest information on the areas of East of England's GDN area that falls within the M25.

1.77. We estimate our regional labour indices using the following seven stages:

- calculating the occupational weights,
- calculating UK's administrative regional wage indices,
- calculating the index for Elsewhere,
- estimating work done by London and Southern GDNs in the regions where they operate,
- estimating work that should be done locally by London and Southern GDNs,
- calculating the labour indices for London and Southern GDNs, and
- standardising the indices.

3 The data used in the illustrations of this Appendix are hypothetical.

Calculating the occupational weights

1.78. The GDNs provided us with a list of work professions/skills categories that are relevant to the gas distribution industry, and also suggested their respective weights based on the relative spend of each category. We calculated industry average weights for each occupational category based on the information we received as illustrated in Table 1.6. The first column represents occupational categories such as functional managers, engineering professionals, construction trades, electrical trades etc.

Appendix Table 1.6: Calculation of occupational category weights

Occupational category	Weight for GDN A (a)	Weight for GDN B (b)	Weight for GDN C (c')	Average Industry weight Average [(a), (b) and (c')]
A	0.12	0.08	0.16	0.12
B	0.22	0.25	0.19	0.22
C	0.24	0.22	0.22	0.23
D	0.17	0.22	0.23	0.21
E	0.25	0.23	0.20	0.23
Total	1.00	1.00	1.00	1.00

Calculating UK's administrative regions' wage indices

1.79. We calculated the UK's administrative regional wage indices as a weighted regional mean wage for each of the occupational categories using the Annual Survey of Hourly Earnings (ASHE) data published by the Office of National Statistics (ONS).

1.80. As illustrated in Table 1.7, we used three sets of data to calculate the wage index for each administrative region, i.e. the UK mean wage, the mean wages for the respective administrative regions and the occupational category weights. Data for some occupational categories was not available for some regions. We therefore standardised the occupational category weights to ensure that the total is one unit (i.e. 100%). The weighted wage index for Region X is 0.91 in this illustration.

Table 1.7: Calculation of regional wage indices

Occupational category	UK mean wage (a)	Administrative region X mean wage (b)	Administrative region X wage index (c') = (b)/(a)	Occupational category weight (d)	Standardised occupational category weight (e) = (d)/ total (d)	Weighted administrative region X wage index (f) = (c') x (e)
A	33,613	30,206	0.90	0.11	0.11	0.10
B	41,472	46,869	1.13	0.19	0.20	0.21
C	40,922	42,926	1.05	0.22	0.23	0.23
D	55,987	38,128	0.68	0.20	0.21	0.14
E	31,181	28,216	0.90	0.25	0.26	0.23
Total				0.97	1.00	0.91

Calculating the weighted index for Elsewhere

1.81. We calculated the labour indices for each administrative region in Elsewhere as set out in Table 1.7, i.e. the figures in the fourth column (i.e. (C')) are derived from Table 1.7. We then computed a weighted average index for Elsewhere as illustrated in Table 1.8. The index for Elsewhere is 0.95 in this illustration.

Table 1.8: Calculation of weighted labour index for Elsewhere.

Region	Population (millions) (a)	Weight (b) = (a)/total (a)	Regional ASHE based weighted indices (C')	Elsewhere Labour Index (d) = (b) * (C')
Northern Ireland	1799.4	0.04	0.81	0.03
North East	2606.7	0.06	0.94	0.05
North West	6935.8	0.15	0.94	0.14
Yorkshire & Humber	5301.3	0.12	0.94	0.11
East Midlands	4481.4	0.10	0.95	0.09
West Midlands	5455.2	0.12	0.92	0.11
East	5831.8	0.13	1.02	0.13
Wales	3006.5	0.07	0.91	0.06
Scotland	5222.2	0.11	1.00	0.11
Southwest	5273.7	0.11	0.95	0.11
Total	45914	1.00		0.95

Estimating work done by London and Southern in their operational administrative regions

1.82. We used population estimates published by the ONS to proxy work done in a given region. We assumed that a region's population share of the GDN's total population is proportionate to the work done by the GDN in that region as illustrated in Table 1.9.

Table 1.9: Estimating work done in a specific region

GDN	Total population '000 (a)	Population in London Region '000 (b)	Population in SE Region '000 (c')	Population eslewhere '000 (d)	% population in London Region (e) = (b)/(a)	% population in SE Region (f) = (c')/(a)	% population elswhere (g) = (d)/(a)
London	5,000	3,500	1,000	500	70	20	10
Southern	10,000	3,000	6,000	1,000	30	60	10

Estimating work done locally by London and Southern GDNs

1.83. We estimated work that should be done by London and Southern GDNs within London region, the South East region and Elsewhere. Our view is that only work needing to be done locally should be done within a relatively high cost region.

1.84. We assumed that 40 per cent of work management labour needs to be done locally. However, we believe that 100 per cent of each of the remaining direct and contract labour opex, capex and repex work needs to be done locally. This enabled us to estimate the overall percentage of the work needing to be done locally as illustrated in Table 1.10.

Table 1.10: Estimating work needing to be done locally and estimating labour indices

Cost activity	GDN's normalised labour costs (£m)	% of work needing to be done locally	Labour costs needing to be incurred locally (£m)
Work Management	20.0	40%	8.0
Emergency	10.0	100%	10.0
Repairs	20.0	100%	20.0
Maintenance	10.0	100%	10.0
Other Direct Activities*	2.0	100%	2.0
Capex	50.0	100%	50.0
Repex	80.0	100%	80.0
Total	192.0	94%	180.0
*NB Other Direct Activities less Xoserve, SIU and opex TMA			
London example			
Work needing to be done in London region	0.70 x 0.94	0.66	
Work needing to be done in SE region	0.20 x 0.94	0.19	
Work needing to be done elsewhere	1 - 0.66 - 0.19	0.15	
Regional factors			
London region Index	1.25	1.25 x 0.66	0.82
South East region Index	1.10	1.10 x 0.19	0.21
Elsewhere Weighted Average Index	0.95	0.95 x 0.15	0.15
London GDN index			1.18

1.85. The London example presented in Table 1.10 sets out how London and Southern GDNs' percentages of work needing to be done in London region, South East region and Elsewhere were calculated.

1.86. We identified East of England's London region population (which is around 4.6 per cent of East of England's population), added it to East of England and subtracted it from London. The Outer Metropolitan[4] effect is estimated by applying the London region (not London area) wage indices to the 4.6 per cent of East of England's direct and contract labour costs. The Elsewhere indices are applied on the remaining 95.4 per cent of its costs.

Standardising the indices

1.87. We used the indices for London and Southern GDNs, and set the other GDNs and Northern Ireland to the Elsewhere weighted average. We then standardised the GDNs' indices by dividing them by the industry average as illustrated in Table 1.11. We used the standardised indices in our benchmarking.

Table 1.11: Standardisation of GDNs' indices

GDN	Regional factor index (a)	Standardised regional factor index (a)/average(a)
East of England	0.95	0.96
London	1.18	1.19
North West	0.95	0.96
West Midlands	0.95	0.96
Northern	0.95	0.96
Scotland	0.95	0.96
Southern	1.10	1.11
Wales & West	0.95	0.96
Northern Ireland	0.95	0.96
Average	0.992	1.000

[4] The area within East of England's GDN area that falls within the M25.

Methodology for calculating sparsity indices

1.88. The sparsity indices calculation methodology we have developed for RIIO-GD1 is illustrated in Table 1.12 and summarised below:

- We identified district population sizes and surface areas for each GDN – i.e. columns A to D. We have been consistent with our methodology and used identical districts and population estimates to those we used for calculating direct and contract labour indices.
- We eliminated districts we believe to have no gas network coverage from the analysis.
- We calculated each GDN's district population density (i.e. number of people per square area) as a ratio of its district population to district area, i.e. A/C.
- We calculated industry population density as a ratio of total industry population to total industry area, i.e. 60,060,000/193,016 = 311.
- We classified all districts whose population density was less than industry population density as sparse, i.e. sparse <311 people per square Km.
- For each GDNs' sparse district:
    - We computed an un-weighted un-normalised sparsity index as district population density/industry population density, i.e. E/311.
    - We then normalised the un-weighted indices by converting them into deviations from the industry index of 1, i.e. 1-G.
- We computed district weights as district population relative to the GDNs total sparse population, i.e. A/6,564.
- We calculated each district's weighted indices as district weight multiplied by the district un-weighted normalised index, i.e. H x I .
- A GDN's sparsity index is obtained by summing up all its district indices – i.e. sum of column J, i.e. 0.11.

Table 1.12: Summarised sparsity methodology for RIIO-GD1

	Population '000		Area (Sq Km)		Population Density - number of people per Square Km		Unweighted Unnormalised District Sparsity Indices	Unweighted Normalised District Sparsity Indices	GDN Weight	Weighted Sparsity Indices
District	GDN	Industry	GDN	Industry	GDN	Industry	GDN	GDN	GDN	GDN
	A	B	C	D	E = A/C	F = B/D	G = E/311	H = 1-G	I = A/6564	J = H x I
1	664	664	794	794	837	837	-	-	-	-
2	303	494	4142	6768	73	73	0.23	0.77	0.05	0.04
3	100	511	2227	2227	45	229	0.14	0.86	0.02	0.01
4	312	312	5013	5013	62	62	0.20	0.80	0.05	0.04
..	1120	1120	538	538	2081	2081	-	-	-	-
..	205	1124	2715	3789	76	297	0.24	0.76	0.03	0.02
Nth	0	1011	0	2624	0	385	-	-	-	-
Total	6,564	60,060	25,497	193016	257	311				0.11

1.89. We have compared the GDNs' sparsity rankings using different definitions (see Table 1.13). Only the district-based definition provides granular-level analysis. The remaining four definitions provide high level analysis. The high level analyses suggest that Northern is more sparse than East of England, and that Scotland is more sparse than Wales & West. However, the more granular district based analysis suggests the opposite. We have decided to use the district based analysis because we believe it is more robust and intuitive.

Table 1.13: GDNs' sparsity rankings using different definitions

GDN	RIIO-GD1 - District-based population per sq Km	County-based population per sq Km	Number of customers per sq Km	Network length per sq Km	Throughput per sq Km
EoE	3	4	4	3	4
Lon	8	8	8	8	8
NW	7	7	7	7	7
WM	5	5	5	5	5
N	4	3	3	4	3
Sc	2	1	1	1	1
So	6	6	6	6	6
WW	1	2	2	2	2

1.90. We are comparing a specific GDN's sparsity relative to the rest of the industry. We consider the overall sparsity impact on the industry to be neutral. Our methodology standardises the indices so that the industry median is 1. We use the median instead of the mean because of the skewed nature of the indices.

1.91. During GDPCR1, the GDN that was considered to have the largest sparsity factors was given an allowance of £2m (2005-06 prices), which translates into £2.23m in 2009-10 prices. We have decided to retain £2.23m as a 2010-11 allowance for the GDN with the highest sparsity index in RIIO-GD1.

1.92. We have compiled emergency and repairs direct and contract labour costs for the GDN with the largest sparsity index. We apply the Microsoft Excel inbuilt solver function onto the labour costs for the most sparse GDN and set it to convert the GDNs' average sparsity indices into a set of standardised indices that generate:

- An industry median is equal to 1.
- A sparsity index for the most sparse GDN, which creates a total adjustment of £2.23m when applied to its 2010-11 direct and contract labour emergency and repairs costs.

1.93. We make a final adjustment to ensure that the maximum absolute adjustment of £2.23m applies only to the GDN with the highest sparsity index. We halve the deviations (from the industry median of 1) of sparsity indices that are less than 1. For example if the index is 0.80, we recalculate it as 1-[(1-0.8)/2] = 1-0.1 = 0.9.

1.94. We created templates and instructions for each company in March 2012 to illustrate how the GDNs' average sparsity indices are converted into a set of standardised sparsity indices. The only changes we have made after sharing those templates are, (1) the application of the sparsity indices to only two cost activities, emergency and repairs and not emergency, repairs, maintenance, connections, mains reinforcement and repex costs as was the case in March 2012; and (2) the halving of the indices that are less than one.

Supporting tables and figures

Figure A1.1: Flow chart summary of our assessment

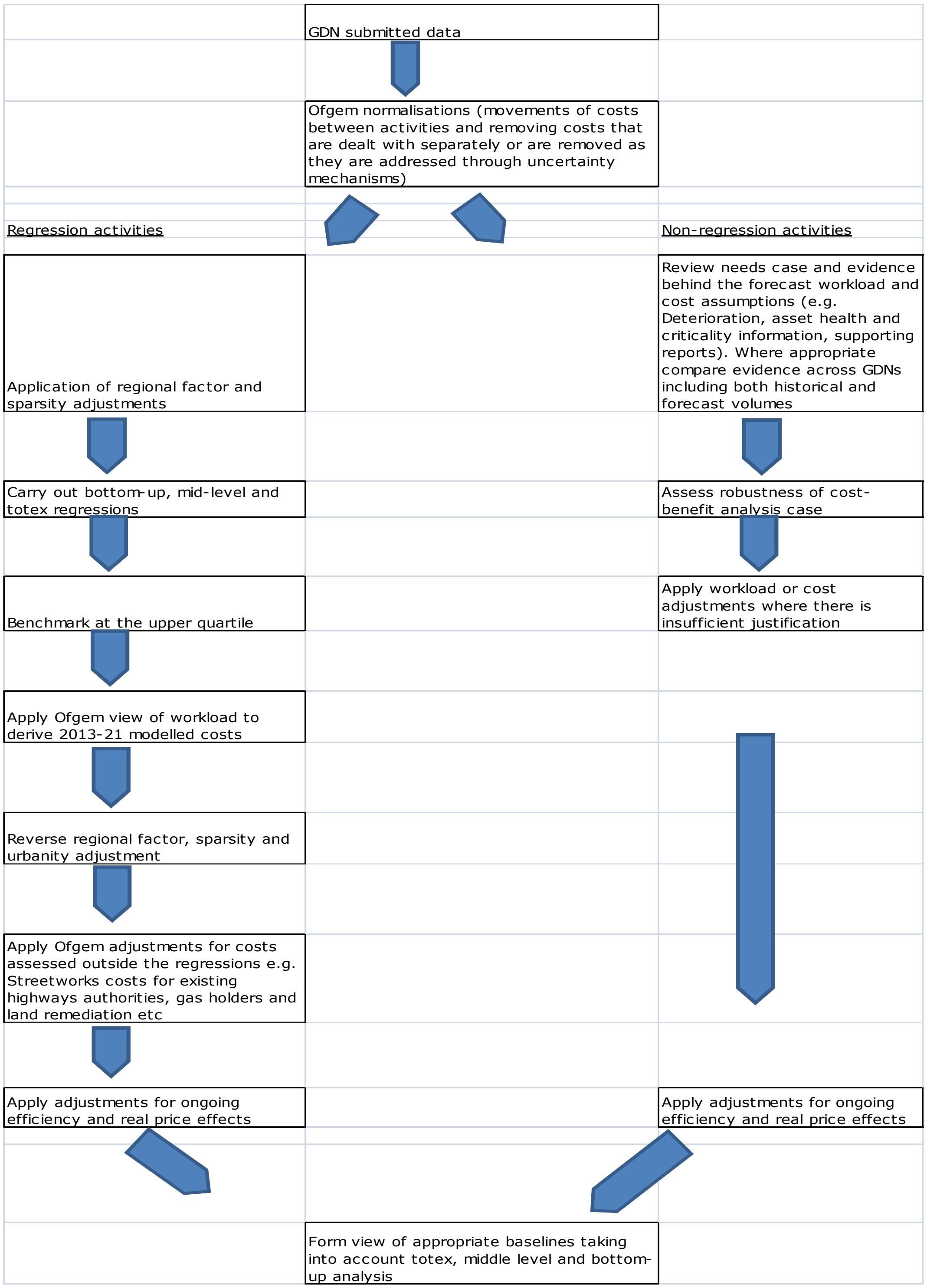

Figure A1.2: Cost drivers' flow chart

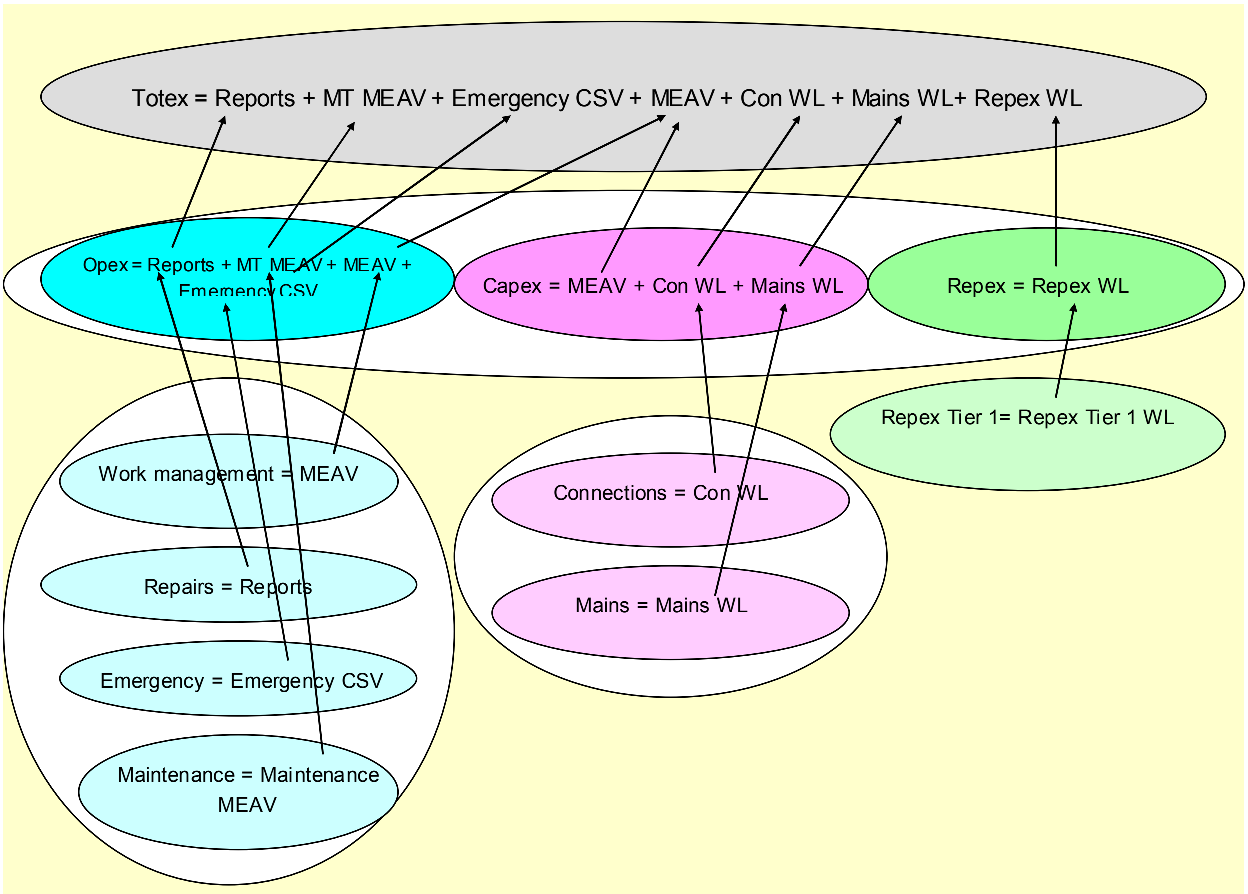

Table A1.1: Efficiency scores

GDN	Cost activity	GDPCR1 Historical Costs 2009	GDPCR1 Historical Costs 2010	GDPCR1 Historical Costs 2011	RIIO 2 year forecasts 2014	RIIO 2 year forecasts 2015
East of England	Totex (single model)	1.00	0.97	0.97	0.94	0.96
	Totex (single model) NGG model	0.98	0.95	0.95	0.93	0.94
	Totex (Aggr. Cap+Rep+Opex)	0.98	0.96	0.96	0.93	0.95
	Totex (Aggr. Cap+Rep+Opex) NGG model	0.97	0.94	0.94	0.91	0.93
	Work Management	1.00	1.04	1.14	1.07	1.06
	Emergency	1.01	1.00	1.05	0.89	0.91
	Repair	0.97	0.87	0.87	0.87	0.87
	Maintenance	1.05	1.10	0.99	1.02	1.00
	Mains Reinforcement	0.58	0.58	0.58	1.13	0.75
	Connections	1.10	1.11	1.27	0.96	0.97
	Repex (Tier 1)	1.00	0.98	0.96	0.93	0.95
London	Totex (single model)	1.11	1.09	1.11	1.12	1.12
	Totex (single model) NGG model	1.11	1.09	1.10	1.10	1.11
	Totex (Aggr. Cap+Rep+Opex)	1.13	1.10	1.11	1.12	1.12
	Totex (Aggr. Cap+Rep+Opex) NGG model	1.12	1.09	1.10	1.10	1.10
	Work Management	0.89	0.99	0.98	0.98	0.98
	Emergency	1.26	1.26	1.13	0.90	0.94
	Repair	1.18	1.37	1.23	1.18	1.18
	Maintenance	0.86	0.89	0.89	0.84	0.83
	Mains Reinforcement	0.74	0.74	0.74	1.02	1.15
	Connections	1.09	1.15	1.17	1.45	1.43
	Repex (Tier 1)	1.09	0.98	1.01	1.05	1.10
North West	Totex (single model)	1.02	1.01	1.03	0.98	0.98
	Totex (single model) NGG model	1.01	1.00	1.03	0.97	0.97
	Totex (Aggr. Cap+Rep+Opex)	1.01	0.99	1.02	0.97	0.97
	Totex (Aggr. Cap+Rep+Opex) NGG model	1.00	0.98	1.01	0.96	0.96
	Work Management	1.01	1.08	1.09	1.04	1.05
	Emergency	1.14	1.13	1.23	1.08	1.10
	Repair	1.11	1.03	1.10	0.84	0.84
	Maintenance	1.05	1.16	1.35	1.12	1.11
	Mains Reinforcement	1.77	1.77	1.77	0.78	1.03
	Connections	0.99	0.70	0.86	0.65	0.66
	Repex (Tier 1)	0.99	1.01	1.01	1.00	0.99
West Midlands	Totex (single model)	0.91	0.96	0.96	0.92	0.93
	Totex (single model) NGG model	0.91	0.96	0.96	0.92	0.92
	Totex (Aggr. Cap+Rep+Opex)	0.92	0.97	0.97	0.94	0.94
	Totex (Aggr. Cap+Rep+Opex) NGG model	0.92	0.96	0.97	0.93	0.94
	Work Management	0.96	1.00	1.03	1.00	1.01
	Emergency	0.77	1.02	1.12	0.89	0.93
	Repair	0.82	0.77	0.83	0.79	0.81
	Maintenance	0.91	0.83	0.86	0.88	0.87
	Mains Reinforcement	0.93	0.93	0.93	0.60	0.65
	Connections	0.85	0.89	0.82	1.06	1.08
	Repex (Tier 1)	0.95	1.09	1.14	1.03	1.02

Table A1.1 cont.

GDN	Cost activity	GDPCR1 Historical Costs 2009	2010	2011	RIIO 2 year forecasts 2014	2015
Northern	Totex (single model)	0.92	0.88	0.89	0.96	0.97
	Totex (single model) NGG model	0.93	0.90	0.90	0.97	0.98
	Totex (Aggr. Cap+Rep+Opex)	0.92	0.89	0.90	0.96	0.97
	Totex (Aggr. Cap+Rep+Opex) NGG model	0.93	0.91	0.90	0.97	0.97
	Work Management	1.06	0.96	0.96	1.01	1.03
	Emergency	0.87	0.77	0.78	0.96	0.95
	Repair	0.89	0.76	0.98	1.08	1.11
	Maintenance	1.00	0.87	0.88	0.96	0.97
	Mains Reinforcement	1.03	1.03	1.03	1.11	1.06
	Connections	0.93	0.95	0.92	0.92	0.91
	Repex (Tier 1)	0.90	0.93	0.91	0.98	0.95
Scotland	Totex (single model)	1.05	1.08	1.02	0.99	0.98
	Totex (single model) NGG model	1.04	1.08	1.02	0.99	0.99
	Totex (Aggr. Cap+Rep+Opex)	1.06	1.10	1.04	1.02	1.02
	Totex (Aggr. Cap+Rep+Opex) NGG model	1.06	1.10	1.04	1.04	1.03
	Work Management	1.11	0.97	0.99	0.96	0.98
	Emergency	1.07	0.99	0.92	1.14	1.11
	Repair	1.15	1.07	1.07	1.14	1.14
	Maintenance	1.23	1.30	1.19	1.21	1.23
	Mains Reinforcement	1.03	1.03	1.03	0.83	0.83
	Connections	1.16	1.06	0.95	0.89	0.89
	Repex (Tier 1)	1.01	1.06	0.96	0.92	0.92
Southern	Totex (single model)	1.07	1.07	1.09	1.04	1.01
	Totex (single model) NGG model	1.06	1.07	1.09	1.05	1.02
	Totex (Aggr. Cap+Rep+Opex)	1.05	1.06	1.07	1.01	0.99
	Totex (Aggr. Cap+Rep+Opex) NGG model	1.04	1.05	1.07	1.02	1.00
	Work Management	0.98	0.97	0.90	0.91	0.93
	Emergency	1.08	0.98	0.92	1.12	1.09
	Repair	1.25	1.31	1.05	0.96	0.95
	Maintenance	1.18	1.11	0.96	0.87	0.88
	Mains Reinforcement	0.85	0.85	0.85	0.65	0.72
	Connections	1.01	1.14	1.15	1.16	1.15
	Repex (Tier 1)	1.06	1.04	1.09	1.02	1.02
Wales & West	Totex (single model)	0.93	0.93	0.93	1.05	1.04
	Totex (single model) NGG model	0.96	0.96	0.95	1.07	1.06
	Totex (Aggr. Cap+Rep+Opex)	0.93	0.94	0.93	1.05	1.05
	Totex (Aggr. Cap+Rep+Opex) NGG model	0.96	0.97	0.96	1.07	1.07
	Work Management	0.97	1.00	0.90	1.03	0.96
	Emergency	0.80	0.86	0.85	1.03	0.97
	Repair	0.63	0.82	0.87	1.13	1.10
	Maintenance	0.72	0.74	0.88	1.10	1.11
	Mains Reinforcement	1.07	1.07	1.07	1.88	1.81
	Connections	0.86	1.00	0.86	0.91	0.91
	Repex (Tier 1)	0.99	0.92	0.93	1.07	1.06

Table A1.2: Efficiency rankings

GDN	Cost activity	GDPCR1 Historical Costs 2009	GDPCR1 Historical Costs 2010	GDPCR1 Historical Costs 2011	RIIO 2 year forecasts 2014	RIIO 2 year forecasts 2015
East of England	Totex (single model)	4	4	4	2	2
	Totex (single model) NGG model	4	2	3	2	2
	Totex (Aggr. Cap+Rep+Opex)	4	3	3	1	2
	Totex (Aggr. Cap+Rep+Opex) NGG model	4	2	2	1	1
	Work Management	5	7	8	8	8
	Emergency	4	5	5	1	1
	Repair	4	4	3	3	3
	Maintenance	5	5	6	4	5
	Mains Reinforcement	1	1	1	7	3
	Connections	7	6	8	5	5
	Repex (Tier 1)	5	4	4	2	2
London	Totex (single model)	8	8	8	8	8
	Totex (single model) NGG model	8	8	8	8	8
	Totex (Aggr. Cap+Rep+Opex)	8	8	8	8	8
	Totex (Aggr. Cap+Rep+Opex) NGG model	8	7	8	8	8
	Work Management	1	4	4	3	4
	Emergency	8	8	7	3	3
	Repair	7	8	8	8	8
	Maintenance	2	4	4	1	1
	Mains Reinforcement	2	2	2	5	7
	Connections	6	8	7	8	8
	Repex (Tier 1)	8	3	5	7	8
North West	Totex (single model)	5	5	6	4	4
	Totex (single model) NGG model	5	5	6	4	3
	Totex (Aggr. Cap+Rep+Opex)	5	5	5	4	3
	Totex (Aggr. Cap+Rep+Opex) NGG model	5	5	5	3	3
	Work Management	6	8	7	7	7
	Emergency	7	7	8	6	7
	Repair	5	5	7	2	2
	Maintenance	6	7	8	6	7
	Mains Reinforcement	8	8	8	3	5
	Connections	4	1	2	1	1
	Repex (Tier 1)	3	5	6	4	4
West Midlands	Totex (single model)	1	3	3	1	1
	Totex (single model) NGG model	1	3	4	1	1
	Totex (Aggr. Cap+Rep+Opex)	2	4	4	2	1
	Totex (Aggr. Cap+Rep+Opex) NGG model	1	3	4	2	2
	Work Management	2	5	6	4	5
	Emergency	1	6	6	2	2
	Repair	2	2	1	1	1
	Maintenance	3	2	1	2	3
	Mains Reinforcement	4	4	4	1	1
	Connections	1	2	1	6	6
	Repex (Tier 1)	2	8	8	6	5

Appendix Table AA1.2 continued

GDN	Cost activity	GDPCR1 Historical Costs 2009	2010	2011	RIIO 2 year forecasts 2014	2015
Northern	Totex (single model)	2	1	1	3	3
	Totex (single model) NGG model	2	1	1	3	4
	Totex (Aggr. Cap+Rep+Opex)	1	1	1	3	4
	Totex (Aggr. Cap+Rep+Opex) NGG model	2	1	1	4	4
	Work Management	7	1	3	5	6
	Emergency	3	1	1	4	4
	Repair	3	1	4	5	6
	Maintenance	4	3	3	5	4
	Mains Reinforcement	6	6	6	6	6
	Connections	3	3	4	4	4
	Repex (Tier 1)	1	2	1	3	3
Scotland	Totex (single model)	6	7	5	5	5
	Totex (single model) NGG model	6	7	5	5	5
	Totex (Aggr. Cap+Rep+Opex)	7	7	6	6	6
	Totex (Aggr. Cap+Rep+Opex) NGG model	7	8	6	6	6
	Work Management	8	3	5	2	3
	Emergency	5	4	3	8	8
	Repair	6	6	6	7	7
	Maintenance	8	8	7	8	8
	Mains Reinforcement	5	5	5	4	4
	Connections	8	5	5	2	2
	Repex (Tier 1)	6	7	3	1	1
Southern	Totex (single model)	7	6	7	6	6
	Totex (single model) NGG model	7	6	7	6	6
	Totex (Aggr. Cap+Rep+Opex)	6	6	7	5	5
	Totex (Aggr. Cap+Rep+Opex) NGG model	6	6	7	5	5
	Work Management	4	2	2	1	1
	Emergency	6	3	4	7	6
	Repair	8	7	5	4	4
	Maintenance	7	6	5	3	2
	Mains Reinforcement	3	3	3	2	2
	Connections	5	7	6	7	7
	Repex (Tier 1)	7	6	7	5	6
Wales & West	Totex (single model)	3	2	2	7	7
	Totex (single model) NGG model	3	4	2	7	7
	Totex (Aggr. Cap+Rep+Opex)	3	2	2	7	7
	Totex (Aggr. Cap+Rep+Opex) NGG model	3	4	3	7	7
	Work Management	3	6	1	6	2
	Emergency	2	2	2	5	5
	Repair	1	3	2	6	5
	Maintenance	1	1	2	7	6
	Mains Reinforcement	7	7	7	8	8
	Connections	2	4	3	3	3
	Repex (Tier 1)	4	1	2	8	7

Table A1.3: Statistical tests

		Historical Models									2 Years' Forecasts Models								
		Goodness of fit	Slope	Intercept (2010-11)	Driver test	Equation test	Slope test	Model Specification test			Goodness of fit	Slope	Intercept (2013-14)	Driver test	Equation test	Slope test	Model Specification test		
Cost Group Model	Model type	R^2	β	Constant	Probability t-statistic (P values)	Probability F-statistic (P values)	Probability F-statistic (P values)	Ramsey RESET (P values)	Log log proxy level R^2	Selected model	R^2	β	Constant	Probability t-statistic (P values)	Probability F-statistic (P values)	Probability F-statistic (P values)	Ramsey RESET (P values)	Log log proxy level R^2	Selected model
Totex - Ofgem	log-log	0.89	0.73	0.4	0.00	0.00	0.83	0.05	0.91	√	0.92	0.74	0.3	0.00	0.00	0.90	0.43	0.93	√
Totex - Ofgem	level	0.92	0.18	50.3	0.00	0.00	0.84	0.07		0	0.93	0.17	61.2	0.00	0.00	0.92	0.33		0
Capex - Ofgem	log-log	0.72	0.76	-1.9	0.00	0.00	0.56	0.86	0.75	√	0.72	0.76	-1.8	0.00	0.00	0.92	0.21	0.73	√
Capex - Ofgem	level	0.75	0.02	11.0	0.00	0.01	0.58	0.52		0	0.73	0.02	12.3	0.00	0.00	0.98	0.18		0
Opex - Ofgem	log-log	0.83	0.70	-2.3	0.00	0.00	0.40	0.27	0.84	√	0.95	0.76	-2.8	0.00	0.00	0.92	0.01	0.96	√
Opex - Ofgem	level	0.84	0.00	22.7	0.00	0.00	0.33	0.30		0	0.95	0.00	24.3	0.00	0.00	0.92	0.00		0
Repex (totex model)	log-log	0.88	0.83	0.9	0.00	0.00	0.52	0.08	0.89	√	0.91	0.89	0.7	0.00	0.00	0.97	0.04	0.86	√
Repex (totex model)	level	0.90	1.06	11.6	0.00	0.00	0.47	0.03		0	0.85	1.05	10.9	0.00	0.00	0.95	0.03		0
Work management	log-log	0.87	0.54	-2.0	0.00	0.00	0.48	0.75	0.86	√	0.94	0.59	-2.4	0.00	0.00	0.40	0.06	0.92	√
Work management	level	0.86	0.00	7.9	0.00	0.00	0.56	0.47		0	0.91	0.00	7.5	0.00	0.00	0.48	0.01		0
Emergency	log-log	0.73	0.88	-9.8	0.00	0.00	0.46	1.00	0.76	√	0.90	0.96	###	0.00	0.00	0.74	0.00	0.91	√
Emergency	level	0.76	0.00	1.9	0.00	0.00	0.46	0.90		0	0.91	0.00	0.0	0.00	0.00	0.78	0.00		0
Repairs	log-log	0.72	0.91	-6.4	0.00	0.00	0.80	0.61	0.69	√	0.85	1.03	-7.6	0.00	0.00	0.98	0.97	0.89	√
Repairs	level	0.69	0.00	0.3	0.00	0.00	0.73	0.95		0	0.89	0.00	0.0	0.00	0.00	0.98	0.57		0
Maintenance	log-log	0.66	0.66	-2.7	0.00	0.00	0.94	0.00	0.70	√	0.84	0.86	-4.1	0.00	0.00	0.89	0.29	0.87	√
Maintenance	level	0.71	0.00	3.2	0.00	0.00	0.89	0.02		0	0.86	0.00	2.5	0.00	0.00	0.88	0.07		0
Connections-gross	log-log	0.92	0.67	1.1	0.00	0.00	0.82	0.02	0.93	0	0.91	0.91	0.3	0.00	0.00	0.98	0.00	0.94	0
Connections-gross	level	0.94	1.00	2.8	0.00	0.00	1.00	0.74		√	0.94	1.18	0.0	0.00	0.00	0.96	0.03		√
Mains reinforcement-net	log-log	0.94	0.92	0.4	0.00	0.00	1.00	0.00	0.97	√	0.86	0.93	0.6	0.00	0.00	0.83	0.28	0.62	√
Mains reinforcement-net	level	0.96	1.12	0.7	0.00	0.00	1.00	0.00		0	0.61	1.21	1.1	0.00	0.00	0.99	0.16		0
Repex tier 1	log-log	0.95	0.87	0.7	0.00	0.00	0.33	0.28	0.96	√	0.96	0.86	0.7	0.00	0.00	0.95	0.00	0.96	√
Repex tier 1	level	0.96	1.02	9.3	0.00	0.00	0.27	0.26		0	0.96	0.96	12.2	0.00	0.00	0.94	0.00		0