Project TCB21
Individual Benchmarking Report
GTS - 489

GAS TSO

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Contents

Executive Summary

In the CEER Transmission System Cost Benchmarking Project (TCB21) the efficiency for the gas transmission system operators is estimated using two base models in Data Envelopment Analysis (DEA); G1445.V3 and G4450.V3 ; along with variants corrected for environmental factors; G1445.V3.env4 and G4450.V3.env3 . The models (see section 2.3) are solved in DEA using non-decreasing returns to scale, excluding outliers, primarily for 2020.

GTS has been classified as fully cost-efficient (non-outlier) in 4 models : G1445.V3, G1445.V3.env4, G4450.V3, G4450.V3.env3 .
GTS is a direct peer for 18 TSOs in total in these models.
GTS has been classified as fully costefficient in all 4 models, i.e G1445.V3, G1445.V3.env4, G4450.V3, G4450.V3.env3 .
In these models GTS is also a direct peer for 18 TSOs in total.
We note that GTS scores above the mean in 4 models.

The support for the cost efficiency scores has been established using five analyses in this report: scale efficiency (section 3.2), partial opex-capex efficiency (section 3.3), peeling efficiency (section 3.4), robust efficiency (section 3.5), and cross efficiency (section 3.6).

The direct and indirect causes for the efficiency results for GTS are naturally multiple and linked to the history and structure of the operator. Here, we briefly comment on the dynamic cost development compared other TSOs, see Chapter 5.

Over the period, GTS has improved its productivity in absolute terms and efficiency in comparison with the sample. The average productivity gain for GTS is 0.52 per cent per year and the efficiency catch up is 0.67 percent per year.

The Totex development was positive for GTS during the period 2016-2020 compared to output growth. The Totex changed by -0.39 percent per year compared to 3.37 per cent per year for the sector. The grid output changed on average with 0.01 percent per year, which is weaker than the mean output growth in the sector.

GTS changed the Opex by -3.59 per cent per year for the period. Compared to the sector, where the mean change in Opex has been 3.34 per cent per year, this has contributed to strengthen the relative opex-efficiency for GTS.

Capex surpassed grid growth for GTS by 0.87 per cent per year compared to the sector with a mean excess of 4.11 percent per year. The relative position to the sector improved. This contributed positively to the efficiency score for GTS in 2020.
More clues about probable sources of performance differences linked to the age structure (section 2.5), cost structure (section 2.6) and general profile GTS are found within the indicators and KPIs in section (section 2.7).

Finally, there are also model-based factors that may have an impact on the result for GTS such as the interest, inflation and salary indexes, age-limits, overhead allocation and the environmental factors used to control for operating complexity. The direct impact of changes in these on the score for GTS are reported in the sensitivity analysis (see section 4) with details in Appendix.

Acronyms

Table 0.1: Acronyms in the report.

Acronym	Definition
CAPEX	CAPital EXpenditure
CEA	Cross Efficiency Analysis
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DRS	Decreasing Returns to Scale
ex.asep	excluding asset-separated operators
exo	excluding outliers
fte	full time equivalents
I	Indirect support services (activity)
L	LNG terminal services (GAS only, activity)
M	Maintenance services (activity)
NDRS	Non-Decreasing Returns to Scale
O	Other (out-of-scope) services (activity)
OPEX	OPerating EXpenditure
OS	Optimal scale of operations
P	Planning services (activity)
RDEA	Robust DEA
S	System operations (activity)
SE	Scale Efficiency
SF	Energy storage services (GAS only, activity)
T	Transport services (activity)
TCB21	(CEER) Transmission Cost Benchmarking project 2021
TO	Offshore transport services (activity)
TOTEX	TOTal EXpenditure
UC	Unit cost (cost per NormGrid or physical unit)
UCC	Unit cost Capex
UCO	Unit cost Opex.
UCT	Unit cost Totex.
VRS	Variable Returns to Scale
X	Market facilitation services (activity)

Chapter 1

Outline

The following material is a summary of results, descriptive data and sensitivity analyses for GTS with code number 489 in the TCB21 benchmarking based on data processed 15/08/2024. This release is exclusively made to the authorized NRA and the information contained in this release is not reproduced as such in any other project report for TCB21. All underlying information in this release is subject to the confidentiality agreement of TCB21. This report with associated data files is part of the final deliverables for the TCB21 project. The contents of this report is strictly confidential.

The benchmarking model of the TCB21 project uses a total expenditure measure as input and the costs drivers listed in section 2.3 below. In addition, it is a Data Envelopment Analysis (DEA) model which means that it determines the best practice among the TSOs and uses this as the standard for evaluating each of the firms in the sample. Indeed, one major advantage of DEA compared to e.g. statistical (parametric) benchmarking models is that the improvement targets are defined by one or several identifiable units in the sample that can be reviewed for comparability beyond the mere data specification.

DEA constructs a best practice frontier by departing from the actual observations and by imposing a *minimal set of additional assumptions*:

1. One assumption is that of *free disposability* which means that one can always provide the same services and use more costs and that one can always provide less services at given cost levels. In the base model, this is an entirely safe assumption, but it does allow us to identify more comparators for any given TSO.

2. Another assumption is that of *convexity*. It basically means that one can make weighted averages of the performance profiles of two or more TSOs. This is a more technical assumption widely used in economics.

3. The third assumption is that of *non-decreasing returns to scale* or as it is sometimes called, *(weakly) increasing returns to scale*. It means that if we increase the costs of any given TSO with some percent, we should also be able to increase the service output, the costs drivers, with at least the same percent. We can also formulate this as an assumption that it can be a disadvantage to be small, but not to be large. It is important that this assumption is not just imposed *ex ante*. The statistical analysis of alternative returns to scale models suggests that it actually is a reasonable assumption to make in the sample of gas transmission operators in this study.

The best practice DEA model and the theory behind it are further explained in the main report and its accompanying appendices. Some useful common notation is listed in Table 0.1

1.1 Project documentation

The project has advanced through activity definitions, data collection, verification and validation, thereafter model analysis and specification, prior to the presentation of preliminary findings and possible models at WS3. The individual report is not reproducing material from the common documentation below, to which we refer for any general information about the process, data, models and methods. In particular, the following project reports/notes are essential to the project methods, analyses and findings:

1. Note on Aggregation for Transparency, V1.0, 2022-04-07.
2. Note on Comparability, V1.1, 2022-09-08.
3. Note on Environmental Modelling, V1.4, 2023-01-13.
4. Environmental Analysis Matrix Electricity, V1.1, 2023-03-15.
5. Environmental Analysis Matrix Gas, V1.1, 2023-03-15
6. NormGrid Weights, V1.2, 2024-04-16.
7. Method and Calculations, V1.2, 2024-06-30.
8. Special Conditions Response Note, V1.0, 2024-06-30.
9. Model Specification GAS, V1.0, 2024-06-30.
10. Model Specification ELEC, V1.0, 2020-07-30.

The documentation also includes project presentations for common models that are not reproduced in this report, see the list below.

1. WS2 Benchmarking Development TCB18-TCB21, X02, 2022-06-22.
2. WS3 Model specification ELEC/GAS, V02, 2023-04-12.
3. WS4 Model results ELEC/GAS, V02, 2023-06-26.
4. WS5 Final model results ELEC/GAS V11, 2023-11-23.

The presentation material has been distributed to the participants before (draft) and after the workshops (final with minutes from the workshop).

1.2 Reading guide

The remainder of the report is divided into four main chapters with the following main contents:

2 *Data*, a chapter providing an overview of GTS data (section 2.1), model inputs and outputs (section 2.3), technical profile compared to the other TSOs (section 2.4), age profile (section 2.5), cost structure (section 2.6) and a large set of indicators and KPIs to characterize the dataset and the position of GTS in section (section 2.7).

3 *Results*, providing for each model the individual scores for GTS and mean scores for the gas TSOs. Sections in the chapter provide support for the scores in terms of Scale efficiency (Section 3.2), Partial Opex/Capex efficiency (Section 3.3),peeling DEA for validation of the thickness of the frontier and grey units in section 3.4, robust DEA results with confidence intervals in section 3.5 and dual price analysis in Cross Efficiency in section 3.6.

4 *Sensitivity analyses*, documenting the sensitivity of the DEA results with respect to the real interest rate (section 4.1), assetlife assumptions (section 4.2), labour cost indexes LCI (section 4.3), inflation indexes (section 4.5), and allocation rules for indirect costs (section 4.6).

5 *Cost development analysis* documents for GTS and the reference set the development of total and partial cost measures over time, relative to the base cost, grid growth for GTS and the mean TSO in TCB21, respectively.

Documentation for used parameter values, notation with formulae for the indicators in section 2.7, graphs for unit-cost values for capex and opex, as well as graphs for labour cost indexes per country are relegated to an Appendix.

Chapter 2

Data

The data collected in the TCB21 project is extremely rich and cannot be fully represented in a short summary. Hence, the reporting for each individual operator includes the following documents in addition to this report:

1. Asset sheet with Normgrid values, XLSX asset dump. Cf. 2.1.
2. Cost data sheet (Capex and Opex), XLSX cost dump
3. Variable data sheet, XLSX list of environmental parameters

2.1 Assetdata

Below in Table 2.1, we provide an overview of the model data used and some descriptive statistics for GTS. The definitions of the NormGrid parameters are given below:

1. NGa - Normgrid (totex, annuity)
2. NGa.noage - Normgrid (totex, annuity), no age-limit for assets
3. NGCa - Normgrid (capex, annuity)
4. NGOpex - Normgrid (opex, annual), no age-limit for assets
5. pc - piece-count, corrected for ownership-share

Table 2.1: Detailed asset summary (usage share included) 2020

	Code	pc 2020	NGOpex	NGCa	NGa	NGa.noage	Mean.age
pipes	10	20,533	219,169	285,476	504,645	504,645	59
regulators	20	7,052	26,216	3,835	30,051	57,849	46
compressors	30	85	118,474	23,084	141,559	210,291	38
cp	40	1,266	0	0	0	0	42
ms	50	0	0	0	0	0	
cc	60	2	2,371	0	2,371	5,160	28
NORMGRID TOTAL	0	28,900	366,021	312,143	678,164	777,482	43

2.2 Capex-break

In the gas benchmarking, 2 operators were subject to the capex-break method described in the main report. The application of Capexbreak was not made to prevent an infeasible target, but to avoid an absurd datapoint.

2.3 Model input and output

The single input (Totex) and the relevant outputs for the benchmarking models for GTS are listed in Tables 2.2 to 2.5 below. The exact calculation of the inputs and outputs is documented in the separate confidential spreadsheets provided for each TSO in the project.

Table 2.2: Model data, G1445.V3, 2020

Type	Name	Value	Mean	TSO/mean
Input	dTotex.cb	404,170,161	135,382,735	2.99
Output	yCompressors.pc	85	17	4.86
Output	yPipes.surface.mplp	33,362	198,357	0.17
Output	yPipes.surface.hp	22,322,712	6,273,049	3.56
Output	yNGCex_10	631,432	385,457	1.64

Table 2.3: Model data, G1445.V3.env4, 2020

Type	Name	Value	Mean	TSO/mean
Input	dTotex.cb	404,170,161	135,382,735	2.99
Output	yCompressors.pc	85	17	4.86
Output	yPipes.surface.mplp.L	44,363	244,902	0.18
Output	yPipes.surface.hp.GG	27,939,528	7,969,534	3.51
Output	yNGCex_10	631,432	385,457	1.64

Table 2.4: Model data, G4450.V3, 2020

Type	Name	Value	Mean	TSO/mean
Input	dTotex.cb	404,170,161	135,382,735	2.99
Output	yConnectionpoints.ip_tot	84	20	4.17
Output	yPipes.vol.hp	4,658,227	1,187,212	3.92
Output	yPipes.volkm.v.16	35,644,945	23,390,123	1.52
Output	yNGOex_10	146,852	26,609	5.52

Table 2.5: Model data, G4450.V3.env3, 2020

Type	Name	Value	Mean	TSO/mean
Input	dTotex.cb	404,170,161	135,382,735	2.99
Output	yConnectionpoints.ip_tot	84	20	4.17
Output	yPipes.vol.hp	4,658,227	1,187,212	3.92
Output	yPipes.volkm.v.16.LSGG	60,198,531	42,178,027	1.43
Output	yNGOex_10	146,852	26,609	5.52

2.4 Profile

The specific profile of GTS compared to the other operators in TCB21 is illustrated in Figs. 2.1 to 2.4 below. For each model, the level for TSO GTS is indicated in red and in blue the median level for the TSOs in TCB21 for 2020.

The relative gridsize in Fig. 2.5 depicts the gridsize (measured in NormGrid)of the reference set, scaled such that the mean is set to 100, compared to the size of GTS. This analysis gives an impression of the scale differences in the benchmarking.

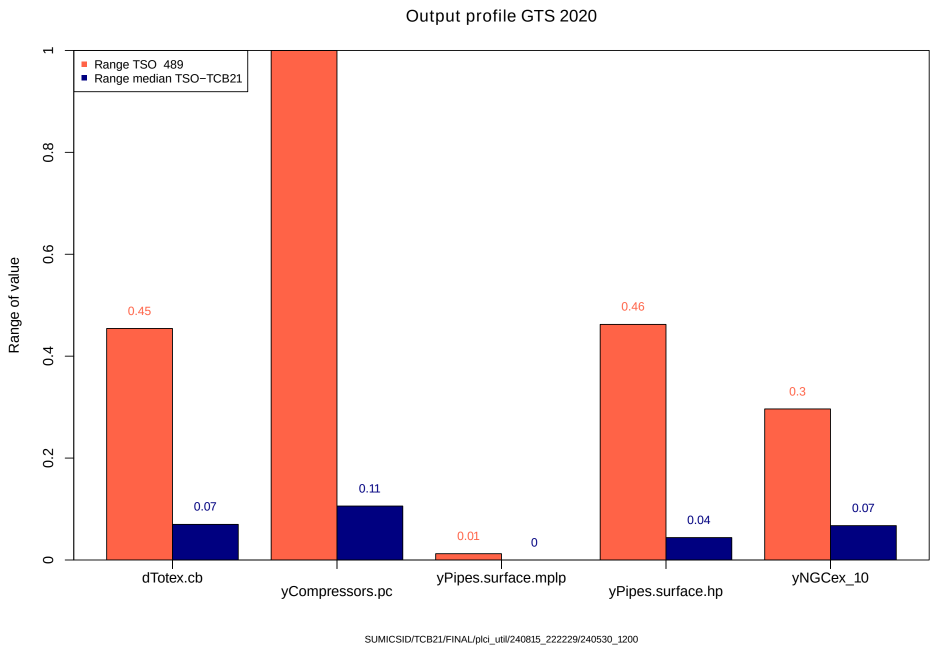

Figure 2.1: Inputs and outputs compared to median range in TCB21 (0.0 = minimum, 1.0 = maximum) for GTS in model G1445.V3 , 2020 .

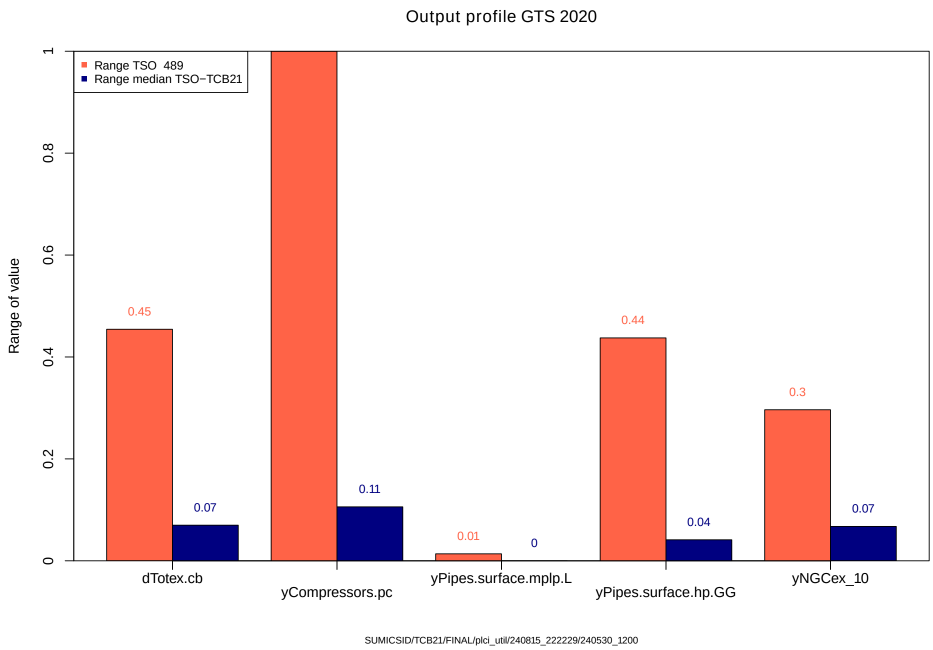

Figure 2.2: Inputs and outputs compared to median range in TCB21 (0.0 = minimum, 1.0 = maximum) for GTS in model G1445.V3.env4 , 2020 .

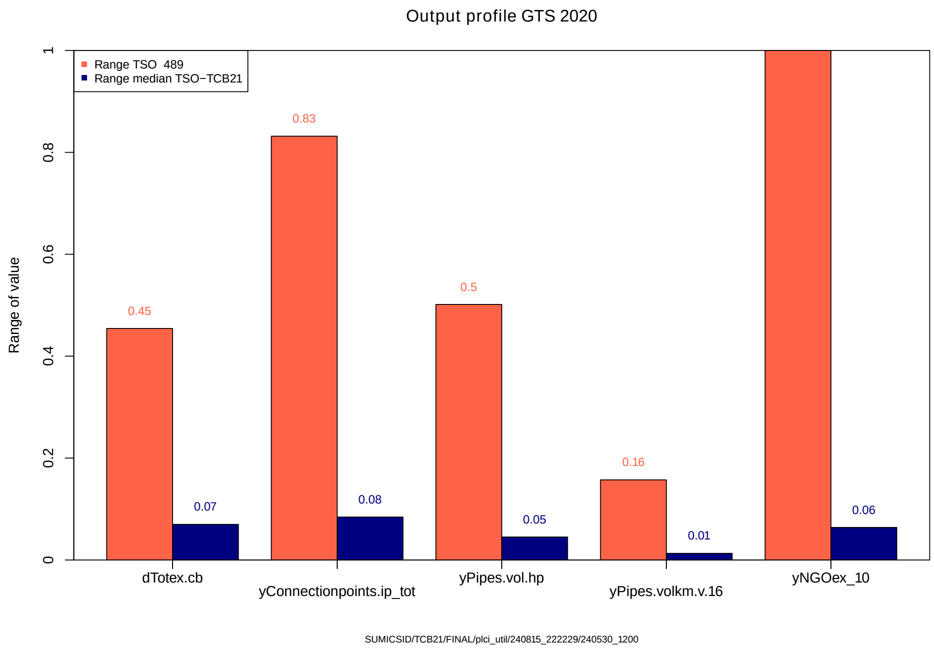

Figure 2.3: Inputs and outputs compared to median range in TCB21 (0.0 = minimum, 1.0 = maximum) for GTS in model G4450.V3 , 2020 .

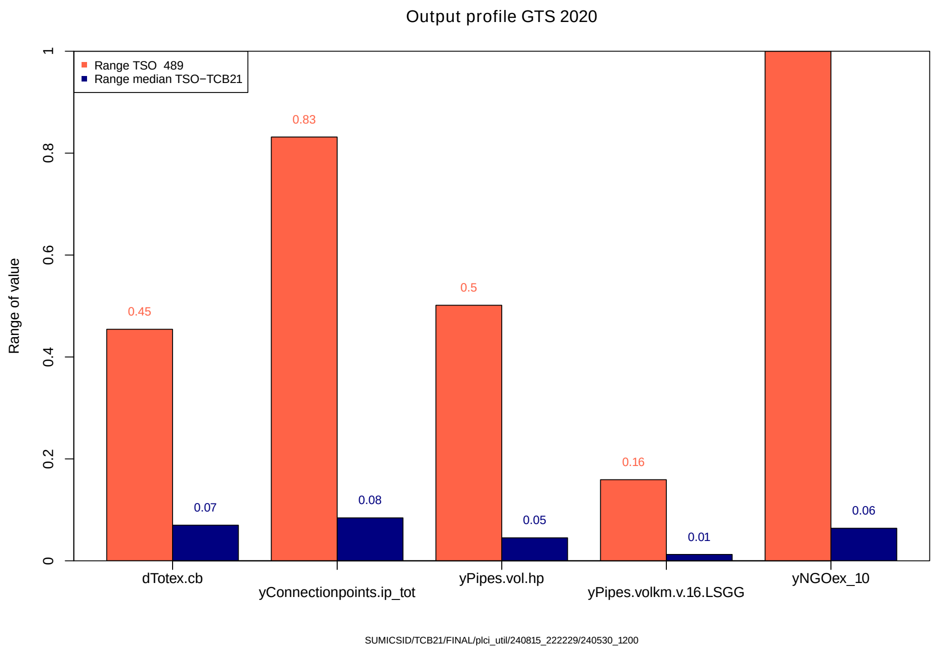

Figure 2.4: Inputs and outputs compared to median range in TCB21 (0.0 = minimum, 1.0 = maximum) for GTS in model G4450.V3.env3 , 2020 .

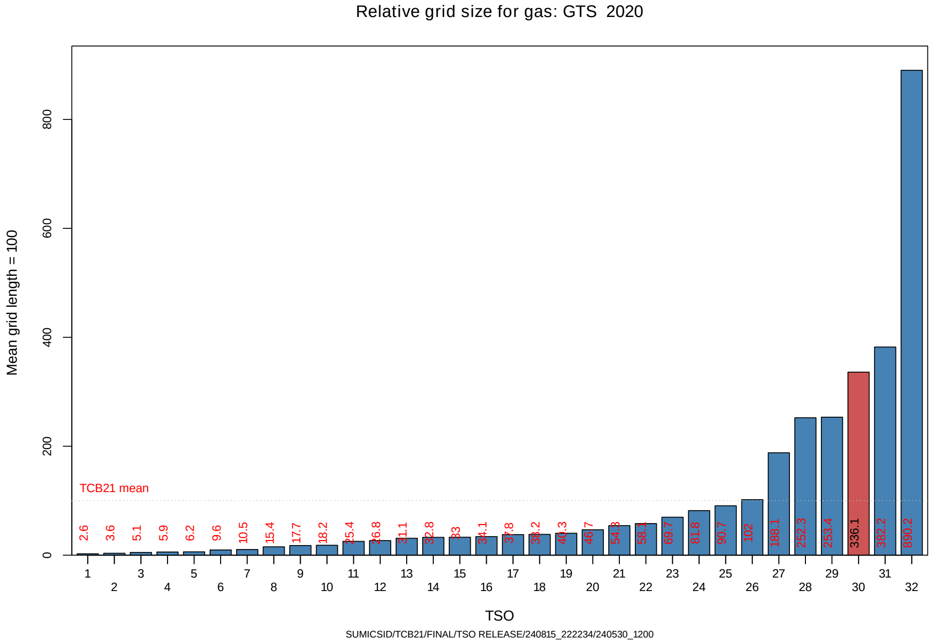

Figure 2.5: Relative gridsize in TCB21, (100=mean level in 2020).

2.5 Age

The age profile of the European operators in comparison to GTS is illustrated in Figs. 2.6 and 2.8 below.

In Figure 2.6 the ages for all assets in the gas dataset have been processed as a confidence interval, the yellow box marks the mean in bold black, the box edges are 25% and 75% quartiles and the outer whiskers are limits for one standard deviation up or down, respectively. The mean ages for the assets per type for GTS are indicated with a red triangle and a (rounded) number. A circle to the left or right of the confidence interval box indicates an outlier.

In Figure 2.7 we investigate the prevalence of overage assets (older than the techno-economic standard age, see Table 4.1) that are still used in 2020. The bars depict the average share of capital for different asset types on the vertical axis. The respective asset ages for GTS are depicted using red symbols, the blue symbols depict the mean age and shares, respectively, in the TCB21 project. Figure 2.8 depicts the corresponding pattern for piece-count, comparing the share of overage installations of each assettype.

2.6 Cost analysis

In this section we analyze the staff profile, the functional costs and the overhead allocation share for GTS compared to the gas operators in TCB21. The cost analysis is purely informative and does not intervene as such in the benchmarking. Using regression we may estimate the expected staff for GTS based on a simple model with one factor G; for gas NormGridOpex that explains 95 percent of the variance, enough for an estimation. The median staff for the set of DEA-peers (all core models, excluding outliers in terms of staff intensity) can then be estimated using a scaling of the cost factor G_p/G_k where G_p is the level for a peer p. In Fig.2.9 the predicted staff SP_k for GTS is represented as bar in light blue, the scaled peer level is graphed in dark blue.

In Fig 2.10 the allocation key for indirect expenditure (I) is based on total expenditure per activity excluding energy and depreciation, i.e. the graph can also be interpreted as the relative shares of expenditure by function. In Fig 2.11 we graph the actual allocation of indirect expenditure to the benchmarked activities

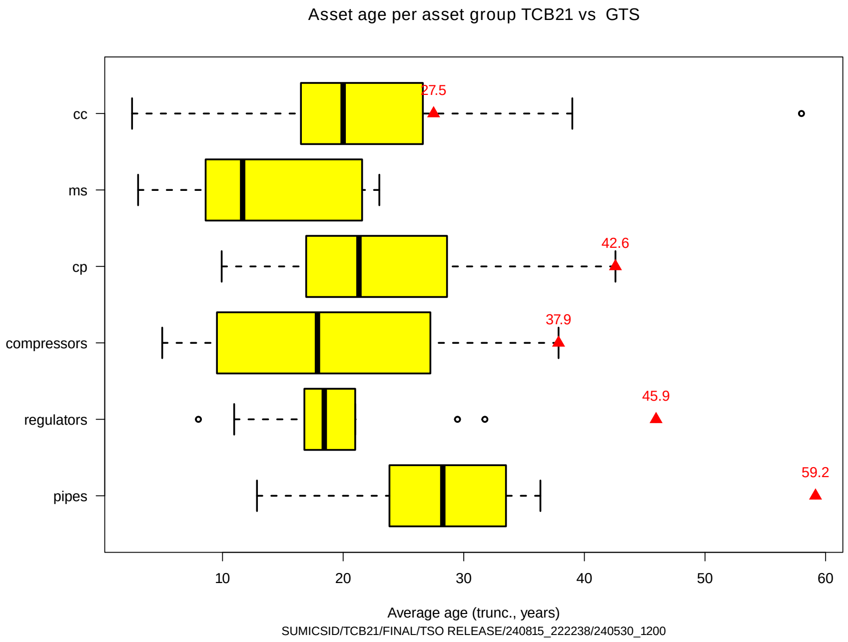

Figure 2.6: Asset ages (confidence interval) for all TCB21 and mean age for GTS in red.

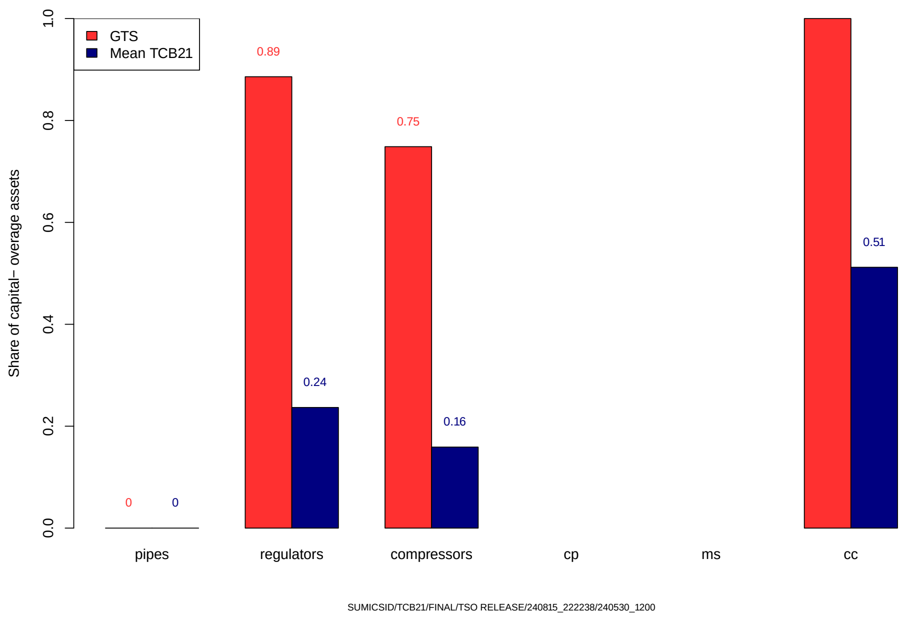

Figure 2.7: Share of overage assets in capital 2020, mean TCB21 in blue, GTS in red.

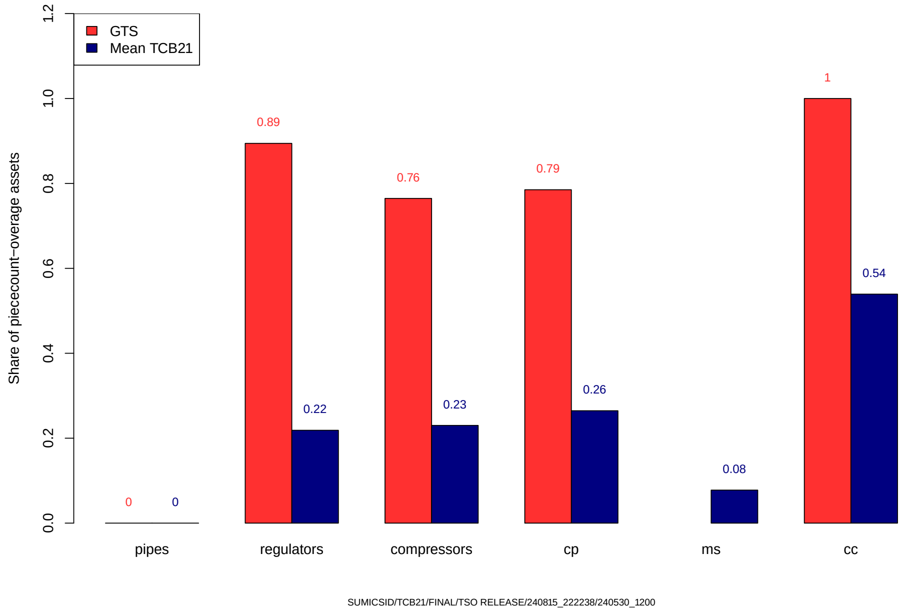

Figure 2.8: Share of overage assets in piece-count 2020, mean TCB21 in blue, GTS in red.

T,M,P per operator, along with the mean allocation in the sample.

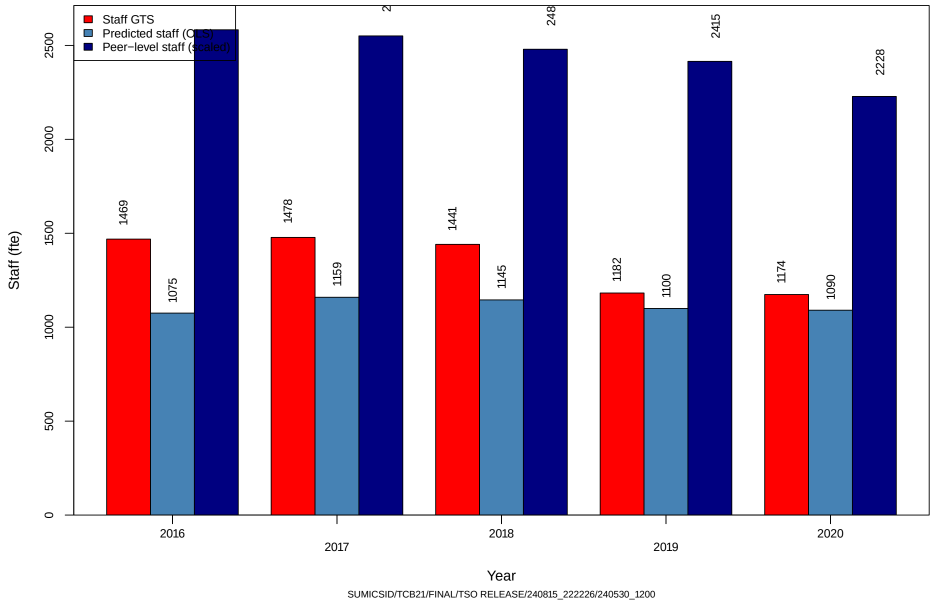

Figure 2.9: Actual staff (fte) compared to size-adjusted level for a median operator in TCB21.

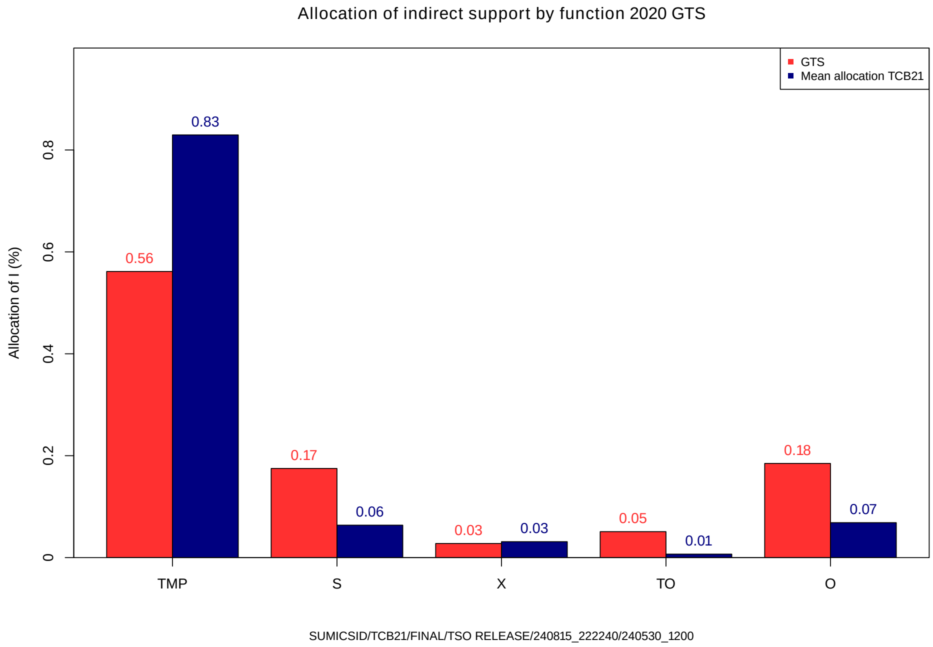

Figure 2.10: Allocation of overhead by function, mean and by operator, 2020.

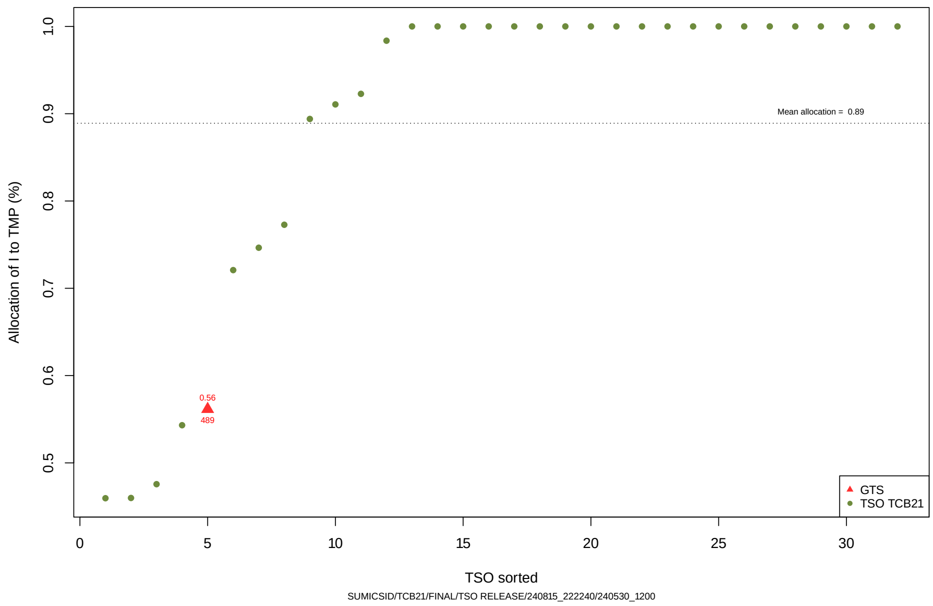

Figure 2.11: Overhead allocation (per cent) to TMP activities in TCB21.

2.7 Indicators

In addition to the non-parametric efficiency results, calculated from a multi-output frontier, we also present a series of KPI for different partial cost observations in Tables 2.6 to 2.13 below. The full sample is denoted as TCB21 in the tables, the *peers* used to calculate mean and median results are the 0 TSOs acting as frontier targets for GTS in one or several models.

Since GTS is a DEA-peer, the column for peers is left blank. The year is 2020 unless mentioned differently. The following sets of indicators are presented:

1. *KPI for staff cost shares*, shares of functional, indirect and personal costs.
2. *Aggregate Totex indicators*, total expenditure, normalized per relevant asset type.
3. *Aggregate Opex indicators*, total operating expenditure, normalized per relevant asset type.
4. *Aggregate Capex indicators*, total capital expenditure, normalized per relevant asset type.
5. *Technical indicators and ratios*, some technical ratios for the asset intensity.
6. *Disaggregated Capex indicators*, capex unit costs for specific asset types.
7. *Disaggregated Opex indicators*, opex unit costs for specific functions per asset type.
8. *Staff cost indicators*, cost per FTE and productivity per asset unit.

KPI for staff cost shares

The indicators for cost shares (notation and formulae in A.3) give an indication of Opex per function, as opposed to Capex, using the cost definitions in the project (thus excluding non-controllable costs for energy, taxes, land, etc). The staff cost shares inform about the percentage of Opex (in EUR) related to direct personnel costs as reported, with and without salary correction using the LCI. Finally, the share of indirect cost per Totex provide an information about the relative importance of indirect costs (full cost before allocations) in relation to Totex (excluding indirect costs). The ratio indirect cost to grid size (normgrid) gives a size-controlled metric.

Table 2.6: KPI for staff cost shares

	TSO 489	Mean TCB21	Median TCB21	Mean Peers	Median Peers
OpexShare.TMP	0.213	0.486	0.486		
OpexShare.S	0.085	0.147	0.098		
OpexShare.X	0.017	0.064	0.044		
OpexShare.TO	0.025	0.032	0.032		
OpexShare.SF	0.025	0.201	0.201		
OpexShare.L		0.333	0.254		
OpexShare.O	0.090	0.249	0.181		
OpexShare.I	0.137	0.201	0.162		
OpexShare.totex.all	0.346	0.550	0.539		
PersShare.opex.nosalind	0.485	0.369	0.413		
PersShare.opex.salind	0.412	0.366	0.374		
PersShare.totex.nosalind	0.083	0.157	0.130		
PersShare.totex.salind	0.063	0.167	0.123		
IndirShare.totex	0.134	0.141	0.123		

Aggregate Totex indicators

The aggregate indicators for Totex (notation and formulae in A.4), are unit-cost ratios with the total expenditure (for function TMP and including all assets) in relation to specific asset metrics; pipelinelength (total), pipeline volume, and compressor stations. The unit cost for Totex in relation to NormGrid Totex gives a general comparision.

Table 2.7: Aggregate Totex indicators

	TSO 489	Mean TCB21	Median TCB21	Mean Peers	Median Peers
UCT.pipe.km	33018	58288	44109		
UCT.comp.pc	4754943	9826221	7062973		
UCT.pipevol	87	148	111		
UCT.ng	596	911	859		

Aggregate Opex indicators

The aggregate indicators for Opex (notation and formulae in A.5) are unit-cost ratios with operating expenditure in-scope (TMP) expenditure (including standard overhead-allocation) in relation to specific asset metrics; pipelinelength (total), pipeline volume, and compressor stations. The unit cost for Opex in relation to NormGrid Opex gives a general comparision.

Table 2.8: Aggregate Opex indicators

	TSO 489	Mean TCB21	Median TCB21	Mean Peers	Median Peers
UCO.pipe.km	7029	27681	23892		
UCO.comp.pc	1012222	4960718	3469863		
UCO.pipevol	18	77	64		
UCO.ng.opex	12995	2796	934		

Aggregate Capex indicators

The aggregate indicators for Capex (notation and formulae in A.6) are unit-cost ratios with total capital expenditure (including all in-scope assets, real-annuity format, EUR, 2020) in relation to specific asset metrics; pipelinelength (total), pipeline volume, and compressor stations. The unit cost for Capex in relation to NormGrid Capex gives a general comparision.

Table 2.9: Aggregate Capex indicators

	TSO 489	Mean TCB21	Median TCB21	Mean Peers	Median Peers
UCC.pipe.km	25989.283	30607.385	24210.889		
UCC.comp.pc	3742721.555	4865503.239	3608345.621		
UCC.pipevol	68.235	70.639	66.887		
UCC.ng.capex	24.225	34.571	25.521		

Technical indicators and ratios

The technical indicators and ratios (notation and formulae in A.7) give different shares and intensities that could could inform the TSO about specific profiles and conditions without direct relation to costs or benchmarked data.

Table 2.10: Technical indicators and ratios

	TSO 489	Mean TCB21	Median TCB21	Mean Peers	Median Peers
comp.power.pipe.km	65.248	71.950	26.594		
metering.stations.pipe.km	0.000	0.002	0.000		
cp.comp.pipe.km	0.103	0.092	0.074		
cp.comp.power	0.002	0.087	0.002		
comp.pc.new	0.000	0.594	0.000		
comp.power.new	0.000	3895.625	0.000		
pipe.km.new	2.940	41.859	0.000		

Disaggregated Capex indicators

The disaggregated Capex metrics (notation and formulae in A.8) are formed as the ratio of partial Capex, i.e. the capital expenditure for a specific asset class (lines, transfo[rmers], etc) in relation to the physical data for the assets (e.g. pipelines, number of compressors, etc). Note that these partial unit-costs are not corrected for dimensions or location, as in the case of the NormGrid.

Table 2.11: Disaggregated Capex indicators

	TSO 489	Mean TCB21	Median TCB21	Mean Peers	Median Peers
UCC.pipe.pipe.km	21089	21145	15366		
UCC.comp.comp.pc	19366411	16313073	12780900		
UCC.pipe.pipevol	2026	1867	1809		

Disaggregated Opex indicators

The disaggregated Opex metrics (notation and formulae in A.9) put a subset of the operating cost, e.g maintenance cost (M) and planning (P) in relation to the physical assets in previous tables. Note that the disaggregation is not valid down to asset level, i.e. opex-maintenance cost is not differentiated for maintenance of different asset groups (pipelines, connection points,compressors, ...).

Table 2.12: Disaggregated Opex indicators

	TSO 489	Mean TCB21	Median TCB21	Mean Peers	Median Peers
UCO.p.inv.tot	0.08	0.04	0.00		
UCO.m.pipe.km.tot	3730.76	3332.35	2360.97		
UCO.m.comp.power	57.18	4309.15	57.18		
UCO.m.ng.opex	124.77	116.98	87.59		
UCO.m.connectionpoints	36072.44	67780.13	31542.74		

Staff cost indicators

The personnel cost is studied in relative terms (e.g. staff cost per FTE, before any LCI correction) and in absolute terms (e.g. total personnel cost for in-scope functions (TMP). We also provide two productivity ratios: FTE-personnel per grid-unit (NormGrid and pipeline length). Notation and formulae provided in A.10)

Table 2.13: Staff cost indicators

	TSO 489	Mean TCB21	Median TCB21	Mean Peers	Median Peers
pers.cost.fte	27090.207	55008.127	27090.207		
pers.cost.tmp	31803903.000	19471557.654	8140288.066		
pers.fte.ng	0.003	0.009	0.005		
pers.fte.pipe.km	0.096	0.205	0.137		

Chapter 3

Results

In the project, we have developed a series of final models G1445.V3, G4450.V3 for which variants with environmental correction factors have been applied, i.e., G1445.V3.env4, G4450.V3.env3.

3.1 DEA results

The interpretation is that using best practice, the benchmarking model estimates that GTS is able to provide the same services, i.e. keep the present levels of the cost drivers, at 100, 100, 100, 100% of the present total expenditure level, respectively. In other words, the model suggests a saving potential of between 0 % and 0 % of the controllable total expenditure for transport, maintenance and planning.

The models consider both investment efficiency and operating efficiency under a given set of environmental conditions. The material in this report may provide elements to explore other differences than those explicitly included in the model, to understand the scores and the operating practice of the gas transmission operators in Europe in 2020.

To evaluate the estimated efficiency of GTS, it is always relevant to compare to the efficiencies of the other TSOs in the TCB21 project, see the scores in Table 3.1 below. Structural comparability is assured by stringent activity decomposition, standardization of cost and asset reporting, harmonized capital costs and depreciation, elimination of country-specific costs related to taxes, land, buildings, and out-of-scope activities, correction for salary cost differences and national inflation as well as currency differences.

Table 3.1: Efficiency scores, DEA(ndrs.exo.ex.asep) year 2020

	Eff 489	Mean eff	Median eff	#peers	#asep.eff	#outliers
G1445.V3	1.000	0.846	0.942	9	0	5
G1445.V3.env4	1.000	0.843	0.942	9	0	5
G4450.V3	1.000	0.871	0.977	11	0	5
G4450.V3.env3	1.000	0.863	0.911	10	0	4

3.2 Scale efficiency

The productive efficiency depends on a multitude of factors, including the scale of operations. In DEA, the model can easily calculate these effects through the concept of different assumptions of returns to scale, see Methods and Calculations, Section 6.4.

$$DEA_{SE}(k) = \frac{DEA_{CRS}(k)}{DEA_{VRS}(k)} \tag{3.1}$$

The actual scale efficiency results for the gas transmission system operators in TCB21 are given in Table 3.2 and in Figs. 3.5 through 3.8 below for all final models. The detailed scores for GTS under different returns to scale assumptions (non-decreasing returns to scale, NDRS, constant returns to scale, CRS, and variable returns to scale, VRS) and without prior outlier detection are listed in 3.3 below.

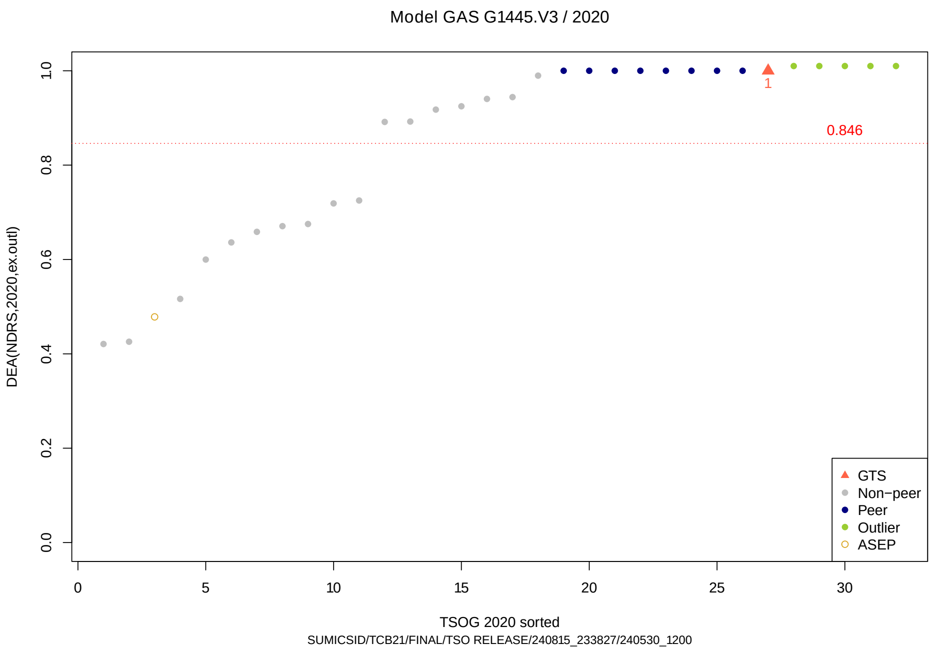

Figure 3.1: Final results for GTS in model G1445.V3 , 2020 , ndrs,.

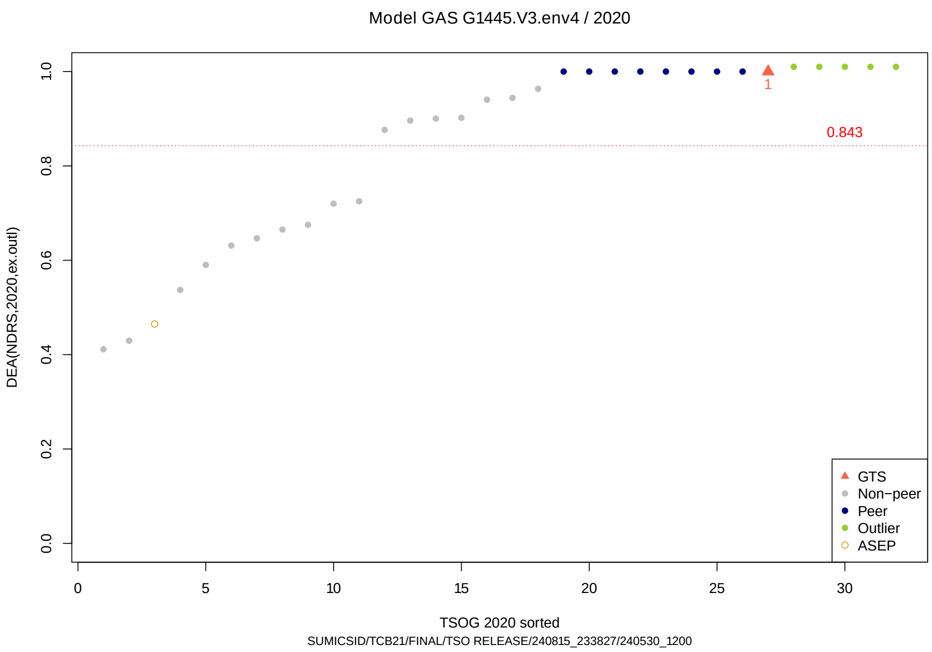

Figure 3.2: Final results for GTS in model G1445.V3.env4 , 2020 , ndrs,.

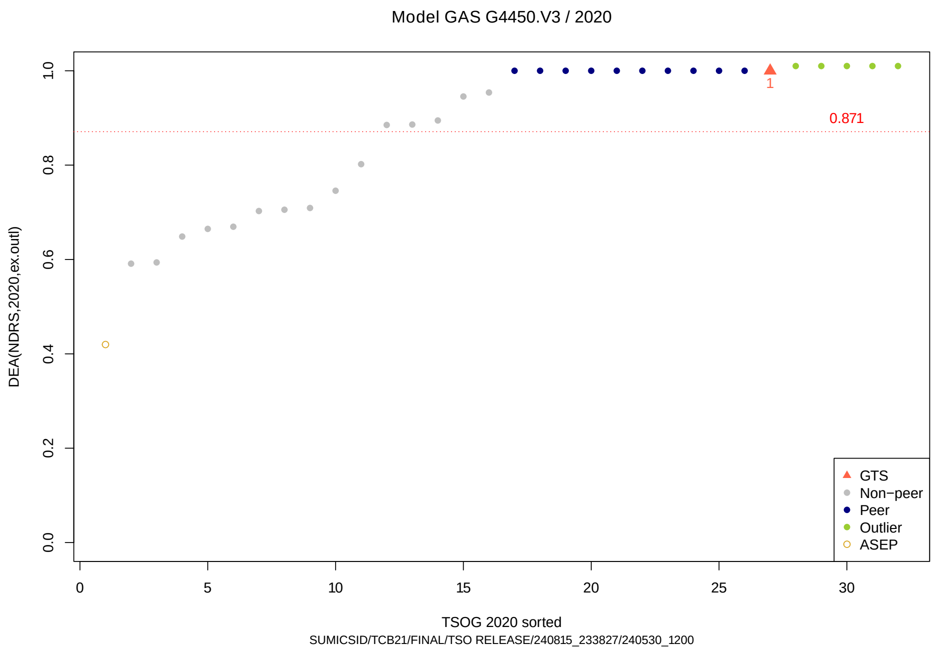

Figure 3.3: Final results for GTS in model G4450.V3 , 2020 , ndrs,.

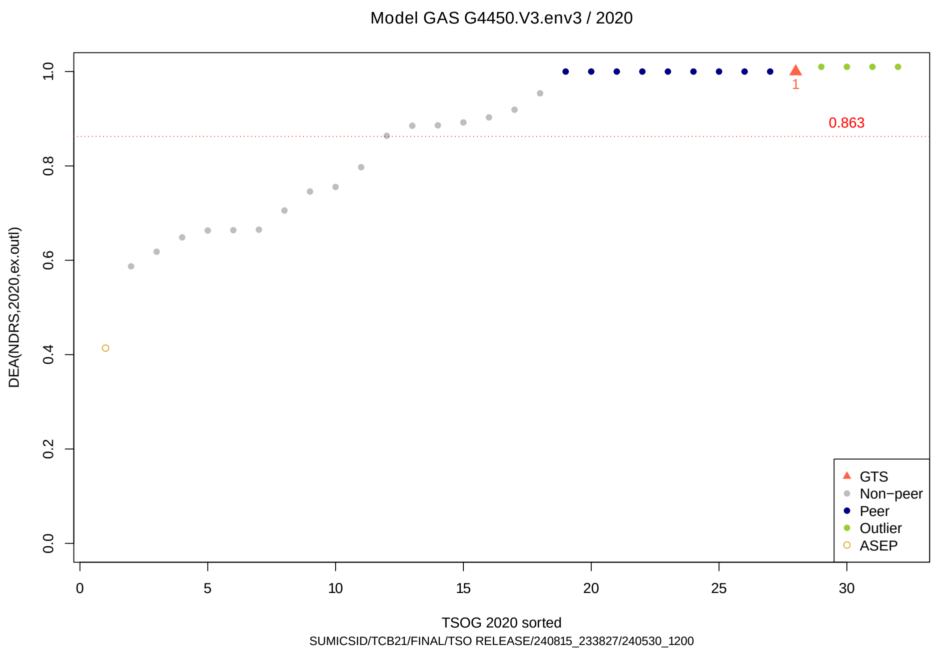

Figure 3.4: Final results for GTS in model G4450.V3.env3 , 2020 , ndrs,.

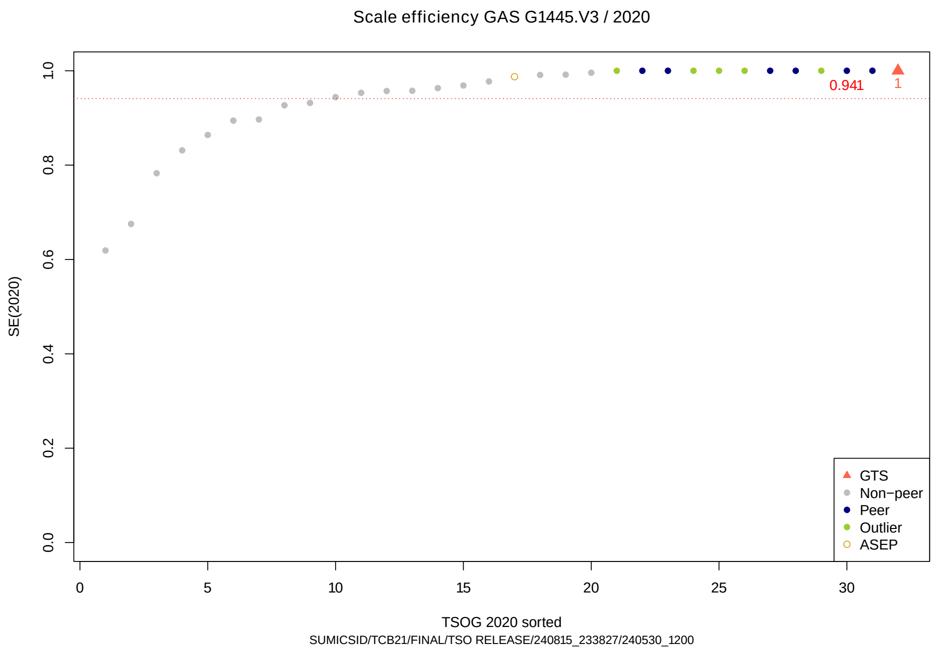

Figure 3.5: Scale efficiency G1445.V3 for GTS

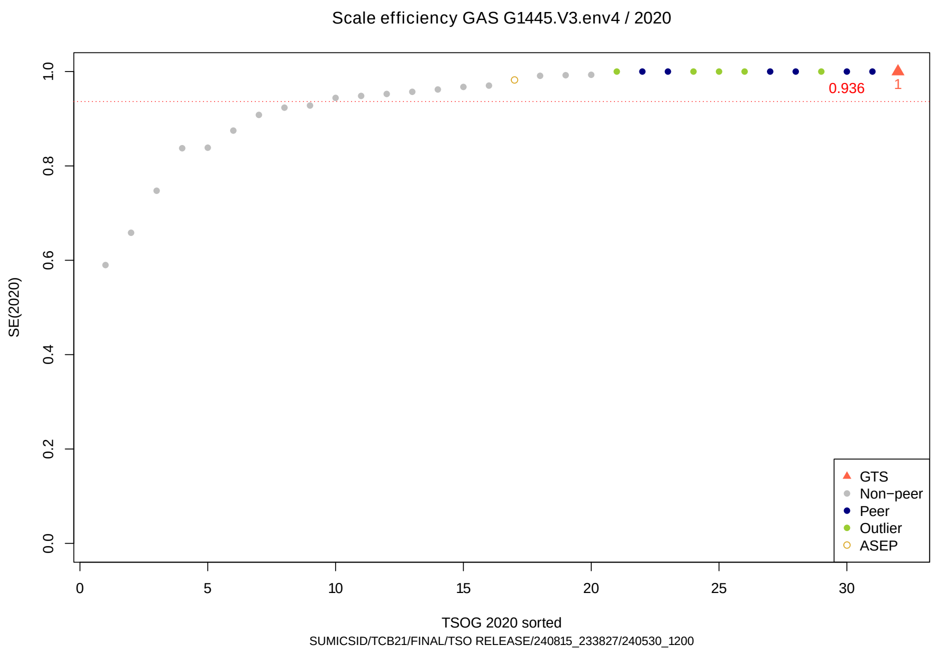

Figure 3.6: Scale efficiency G1445.V3.env4 for GTS

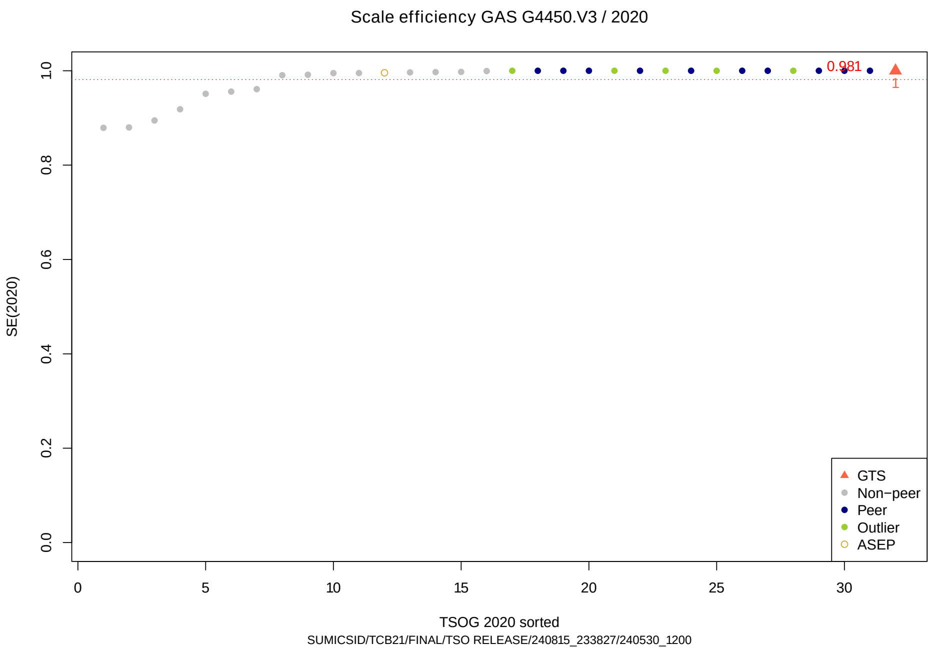

Figure 3.7: Scale efficiency G4450.V3 for GTS

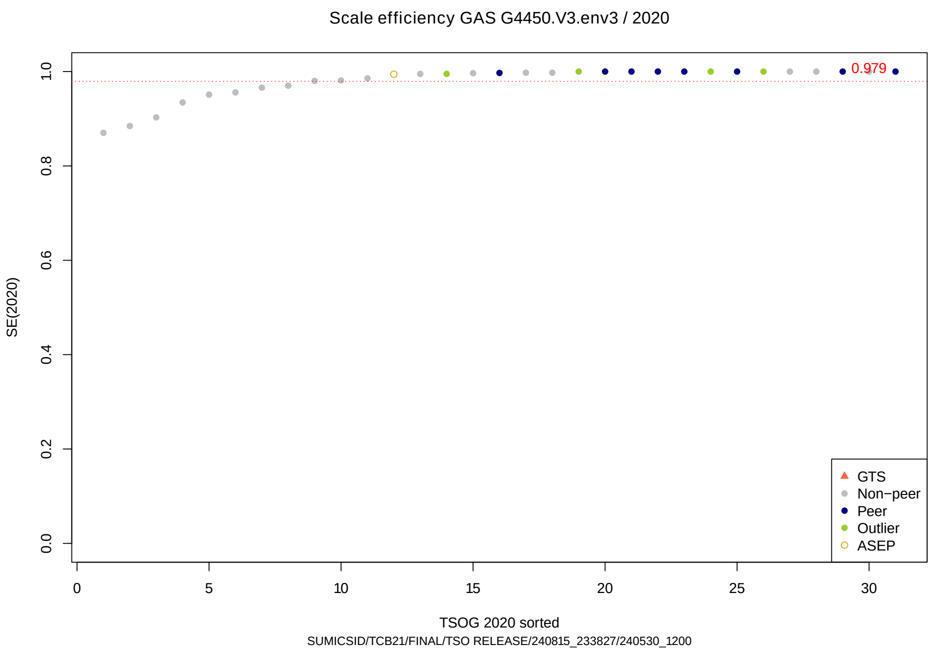

Figure 3.8: Scale efficiency G4450.V3.env3 for GTS

Table 3.2: Scale efficiency DEA(SE) GTS 2020 OS-pos: -1 <OS, 1 >OS, 0 OS

	SE-2020 489	OS-pos	Mean SE-2020	#SE-efficient	#>OS	#<OS
G1445.V3	1.000	0	0.941	12	4	16
G1445.V3.env4	1.000	0	0.936	12	4	16
G4450.V3	1.000	0	0.981	16	12	4
G4450.V3.env3	1.000	0				5

Table 3.3: DEA score: alternative RTS and exo, year 2020 GTS

	NDRS.exo 489	CRS.exo 489	VRS.exo 489	NDRS 489	CRS 489	VRS 489
G1445.V3	1.000	1.000	1.000	0.767	0.767	1.000
G1445.V3.env4	1.000	1.000	1.000	0.769	0.769	1.000
G4450.V3	1.000	1.000	1.000	0.939	0.939	1.000
G4450.V3.env3	1.000	1.000	1.000	0.939	0.939	1.000

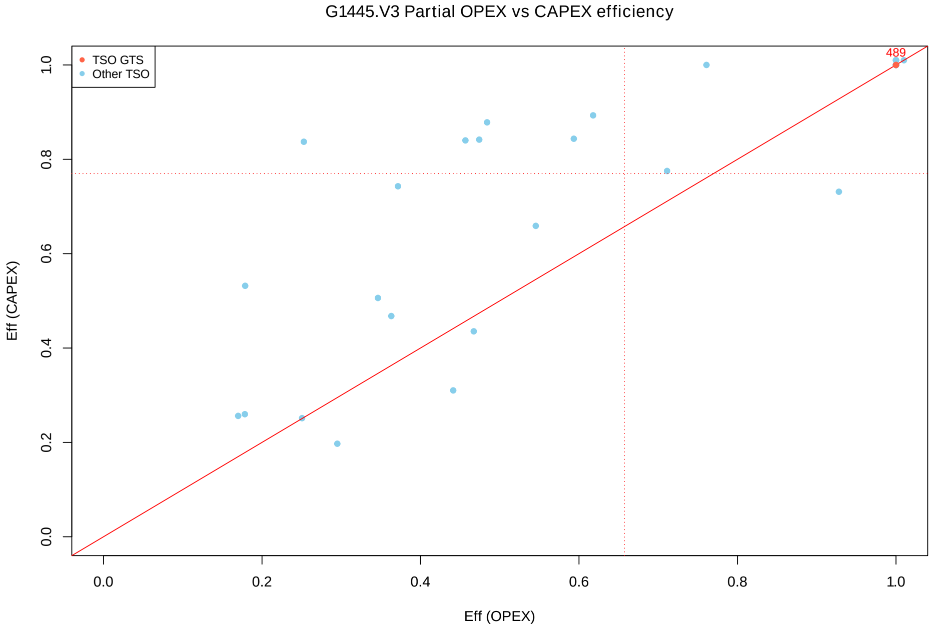

Figure 3.9: Partial OPEX and CAPEX efficiency in TCB21 (red dash=mean level). G1445.V3

3.3 Partial Opex-capex efficiency

As an alternative to Totex benchmarking, we present the partial DEA results for Opex and Capex, as discussed methodologically in the Note on Methods and Calculations, section 5.9. In short, the analysis uses a model where only one dimension, Opex or Capex, is considered controllable and subject to radial reduction to the frontier. Concretely, a partial Opex-DEA efficiency is interpreted as the proportion of Opex that could be saved at the same or lower level of Capex.

In Table 3.4 the partial Opex and Capex efficiencies for GTS are listed along mean scores for the TCB21 operators. The interesting comparisons are (i) whether GTS performs better or worse in partial benchmarking than in Totex benchmarking, and (ii) in which direction (opex or capex) does GTS perform significantly differently. The interpretations relate to the partial performance in opex and capex, respectively.

The partial scores for models G1445.V3 and G4450.V3 is shown in Figs. 3.9 - 3.14 for Eff(Opex) vs Eff(Capex), Eff(Opex) vs DEA(base) and Eff(Capex) vs DEA(base), respectively. Note that a single point in the graph may represent multiple operators with the same value, the graphs contain all participating operators.

Table 3.4: Partial DEA scores (NDRS, excl. outliers) year 2020

	DEA(Opex) 489	DEA(Capex) 489	Mean DEA(Opex)	Mean DEA(Capex)
G1445.V3	1.000	1.000	0.653	0.759
G1445.V3.env4	1.000	1.000	0.646	0.753
G4450.V3	1.010	1.000	0.776	0.887
G4450.V3.env3	1.010	1.000	0.774	0.882

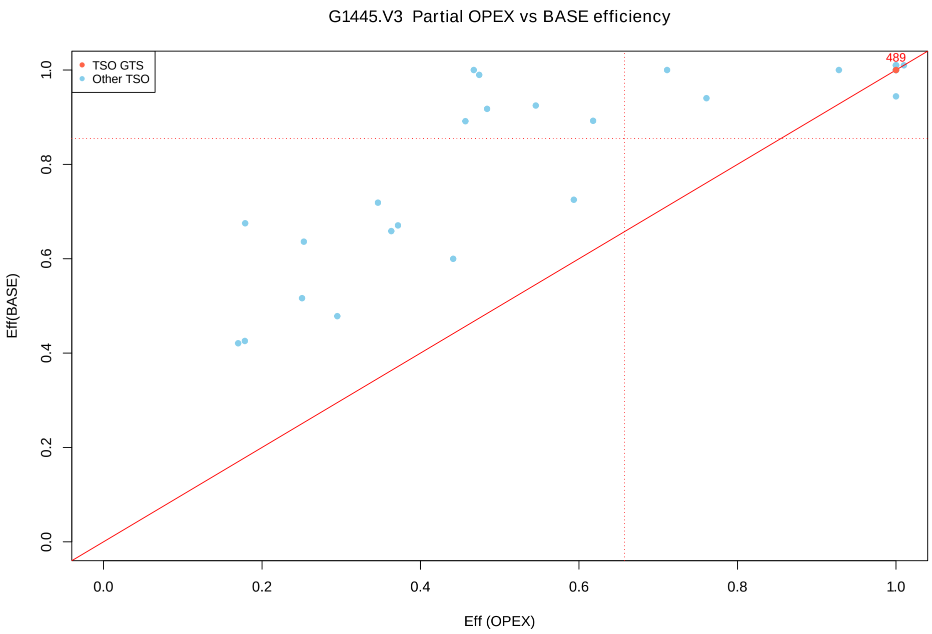

Figure 3.10: Partial OPEX vs TOTEX efficiency in TCB21 (red dashed line=mean). G1445.V3

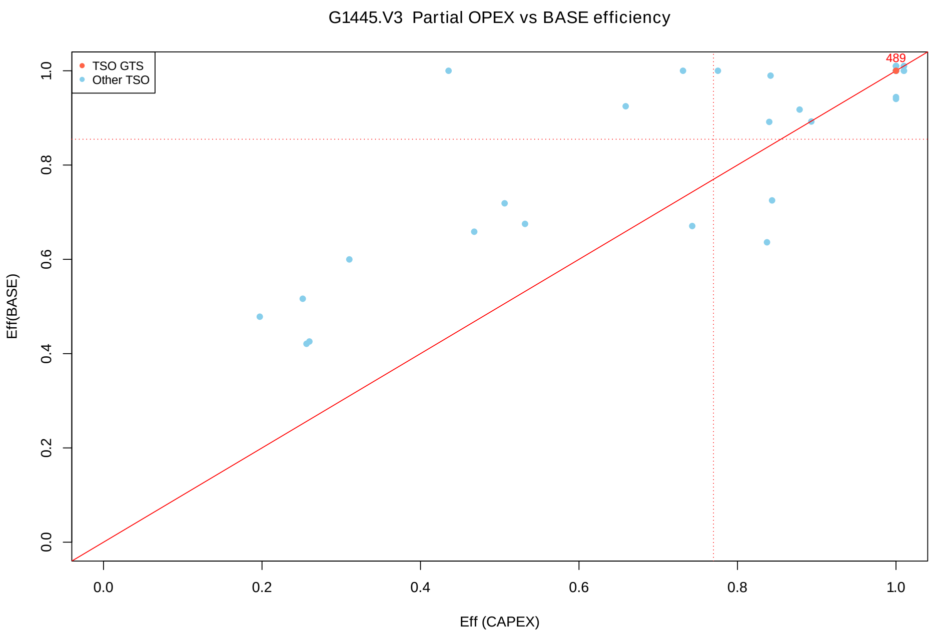

Figure 3.11: Partial CAPEX vs TOTEX efficiency in TCB21 (red dashed line=mean). G1445.V3

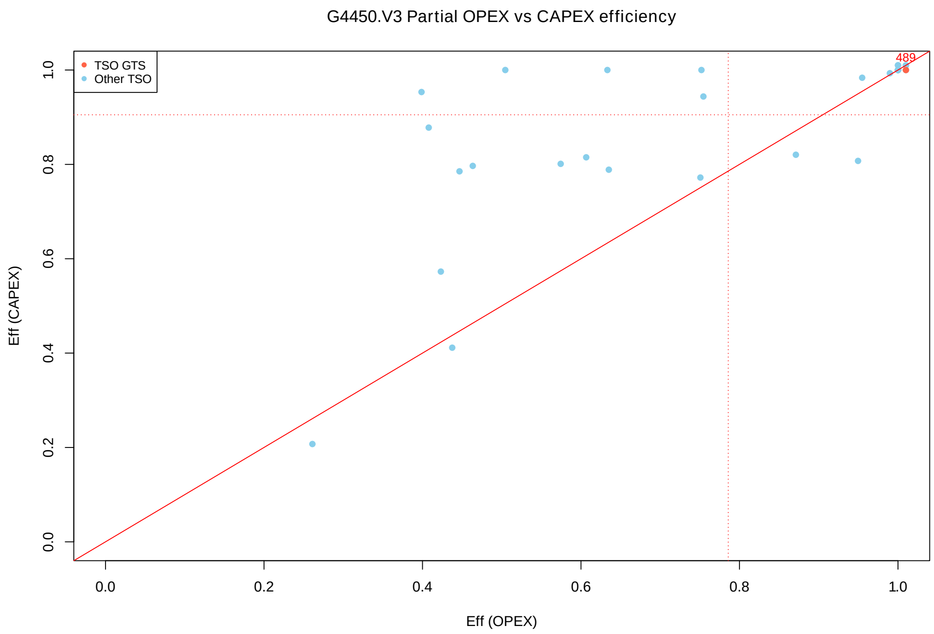

Figure 3.12: Partial OPEX and CAPEX efficiency in TCB21 (red dash=mean level). G4450.V3

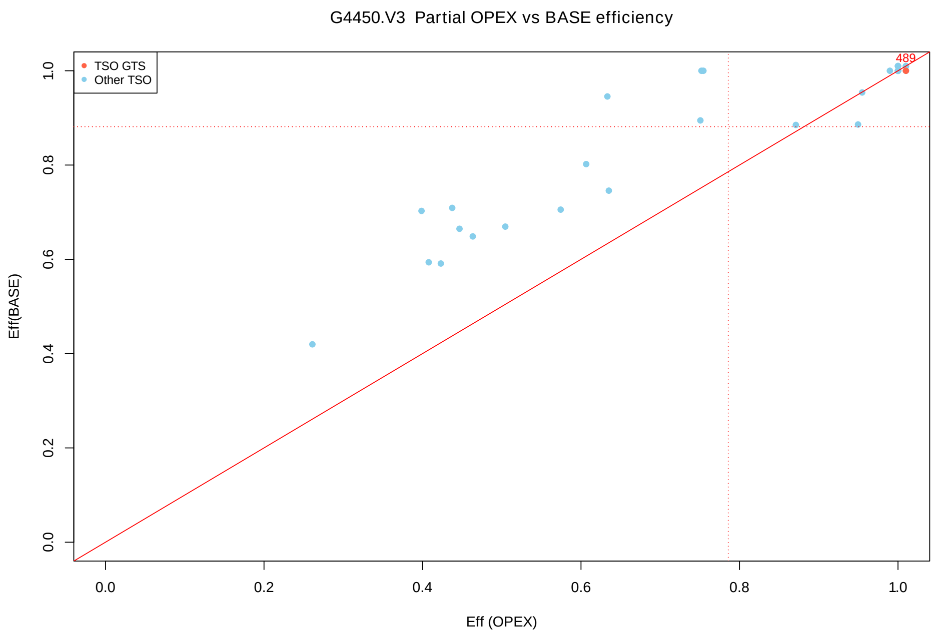

Figure 3.13: Partial OPEX vs TOTEX efficiency in TCB21 (red dashed line=mean). G4450.V3

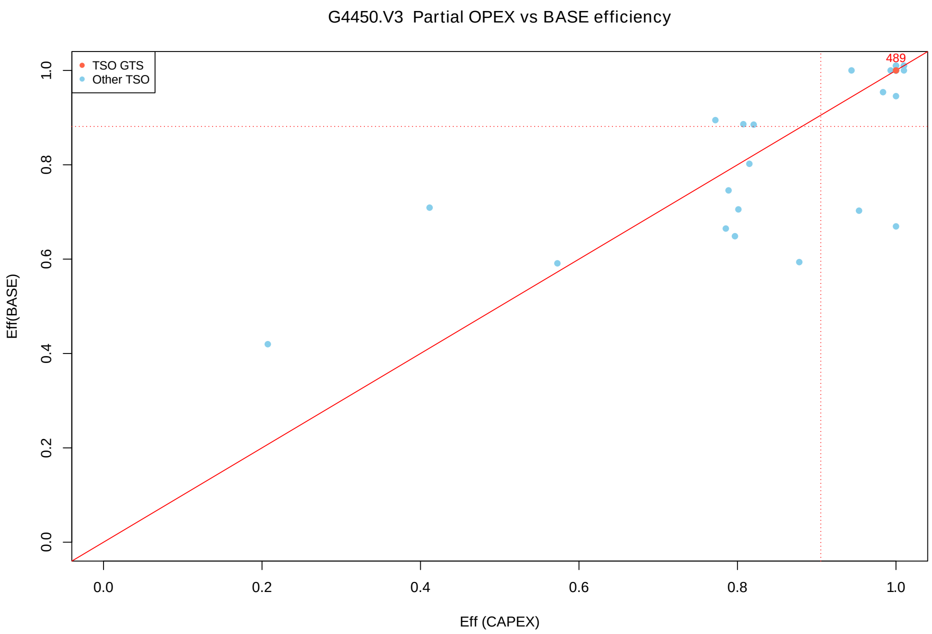

Figure 3.14: Partial CAPEX vs TOTEX efficiency in TCB21 (red dashed line=mean). G4450.V3

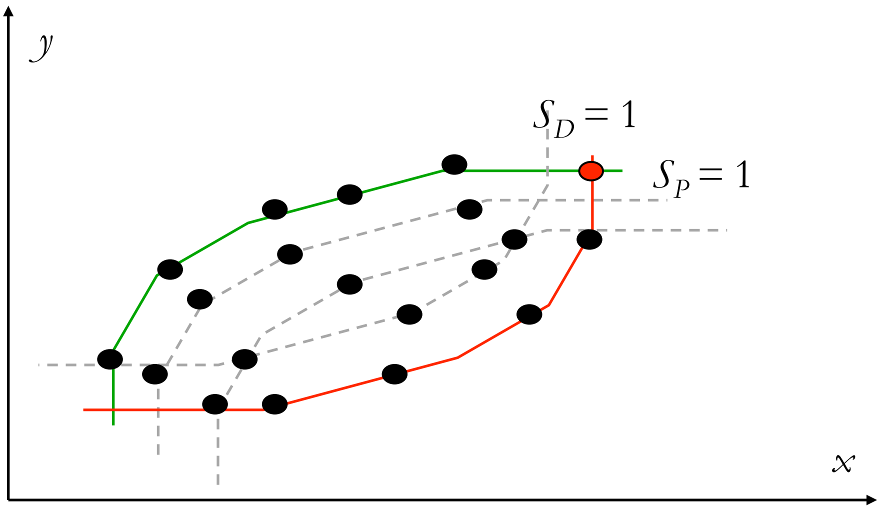

Figure 3.15: Peeling DEA

3.4 Peeling DEA

One approach to estimate the robustness of DEA-results is to use the Peeling DEA method (see Note on Method and Calculations, Section 5.10). In this method, the given model is solved successively in rounds where all fully efficient observations *peers* are removed. The model is then resolved with the remaining units until no observation remains in the set. Call the round in which a unit exits the *positive peel, SP*. Repeat the same exercise from the negative side, i.e., find the most inefficient units by looking at maximization of cost at the minimum of output. Call each successive layer removed the *negative peel,* S_N. A low postive S_P and a high S_N constitute evidence in terms of independent observations of efficiency. Likewise, a high S_P and a low S_N indicates evidence of inefficiency. We denote by $S_C = S_P + (\max S_N - S_N)$ the positive *shell count* S_C for a unit. The lower the S_C, the more certain the efficiency can be ascertained, and vice versa.

Some units with odd production profiles may show up as full efficient, i.e., $S_P = 1$ and in the same time fully anti-efficient, i.e., $S_N = 1$. These units have an extreme profile called *grey* as they are in the edges of the production space, see the red unit in Figure 3.15. For this reason, the detection of grey units is the third level of outlier detection in the project.

Below in Figs. 3.16 to 3.19 and in Tables 3.5 to 3.8 we provide the results for GTS in terms of S_P, S_N, S_C and the number of Grey units compared to the mean ranking in the sample.

Table 3.5: Peeling DEA scores (NDRS, excl. outliers) year 2020 G1445.V3

	SP	SN	SC	#Grey
GTS	2.00	2.00	3.00	0
mean TCB21	2.69	1.44	4.25	0

Table 3.6: Peeling DEA scores (NDRS, excl. outliers) year 2020 G1445.V3.env4

	SP	SN	SC	#Grey
GTS	2.00	2.00	3.00	0
mean TCB21	2.72	1.44	4.28	0

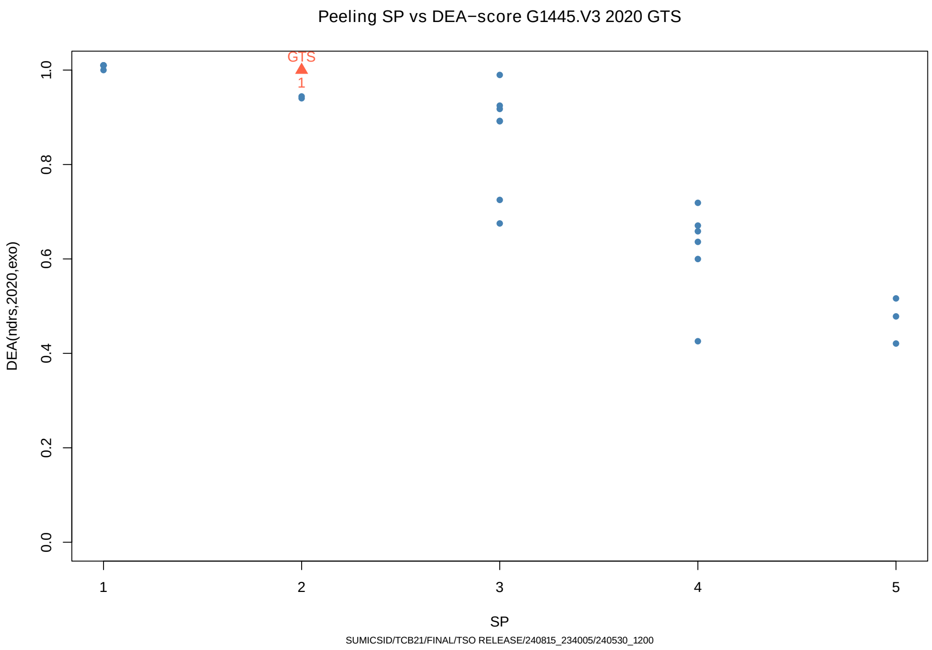

Figure 3.16: Peeling SP vs DEA(ndrs,exo,2020) G1445.V3 GTS

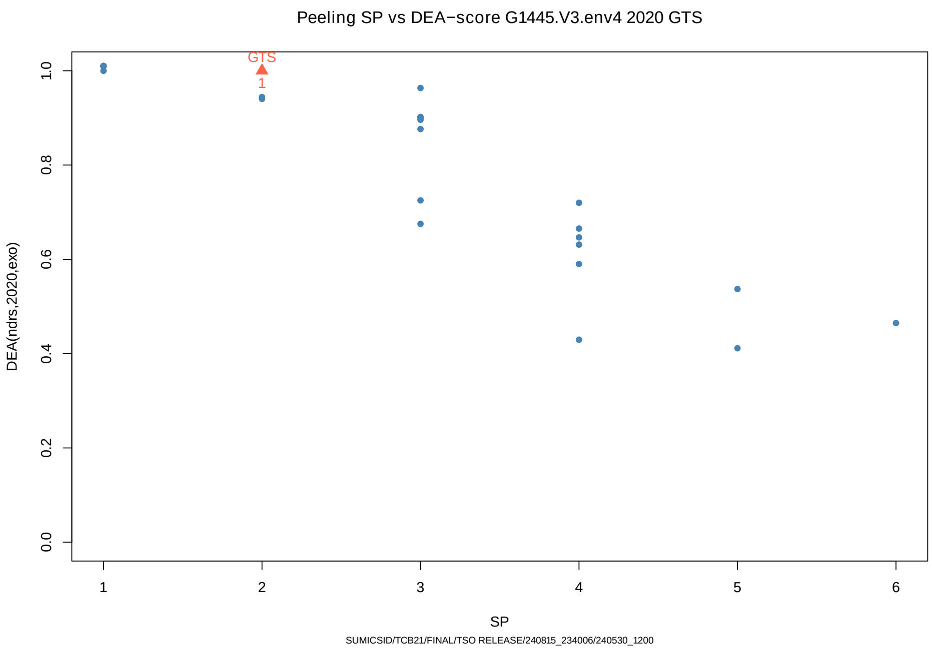

Figure 3.17: Peeling SP vs DEA(ndrs,exo,2020) G1445.V3.env4 GTS

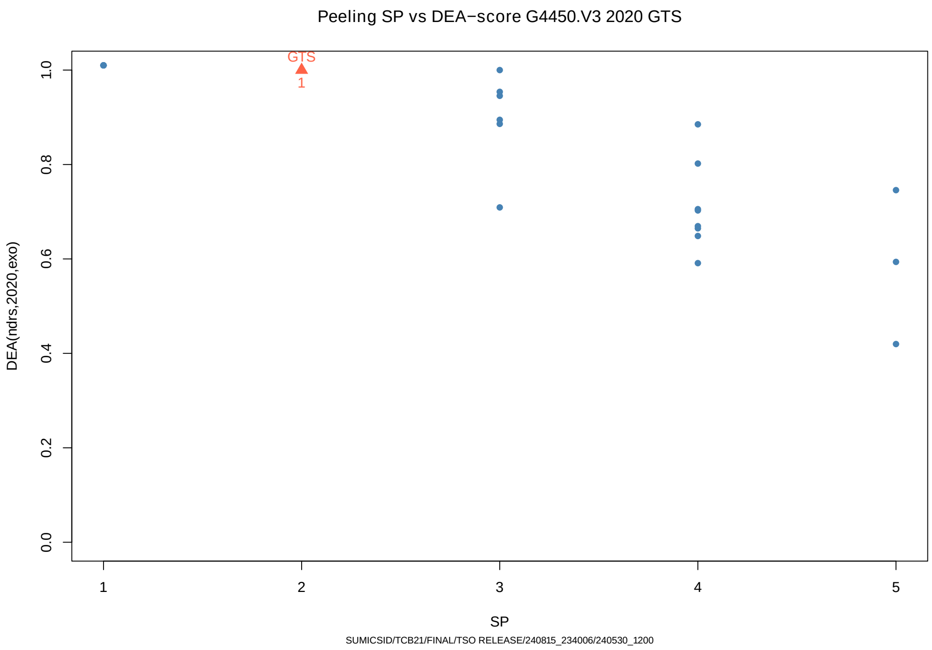

Figure 3.18: Peeling SP vs DEA(ndrs,exo,2020) G4450.V3 GTS

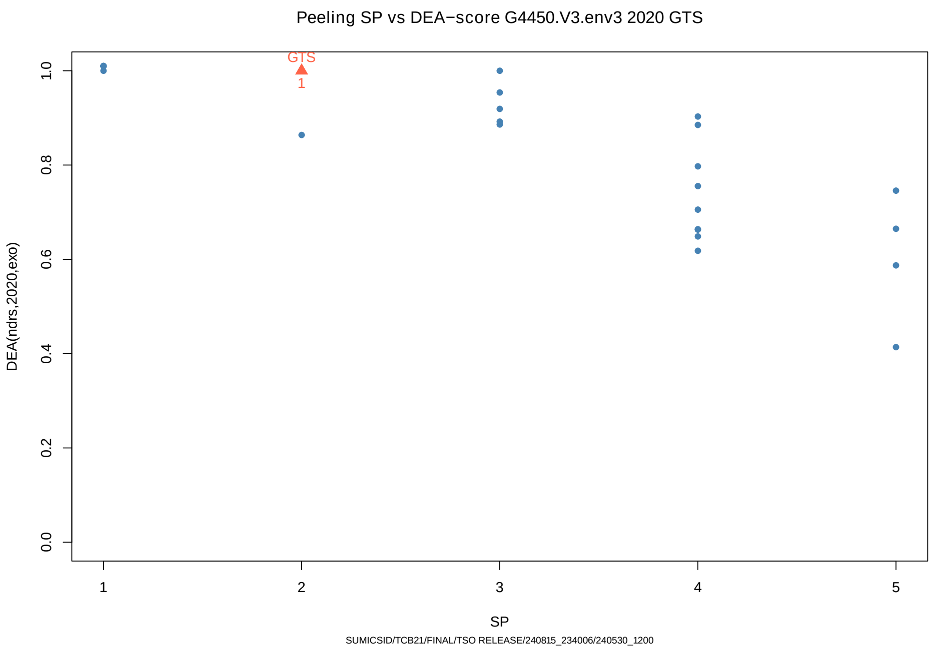

Figure 3.19: Peeling SP vs DEA(ndrs,exo,2020) G4450.V3.env3 GTS

Table 3.7: Peeling DEA scores (NDRS, excl. outliers) year 2020 G4450.V3

	SP	SN	SC	#Grey
GTS	2.00	3.00	2.00	0
mean TCB21	2.81	1.62	4.19	0

Table 3.8: Peeling DEA scores (NDRS, excl. outliers) year 2020 G4450.V3.env3

	SP	SN	SC	#Grey
GTS	2.00	3.00	2.00	0
mean TCB21	2.94	1.62	4.31	0

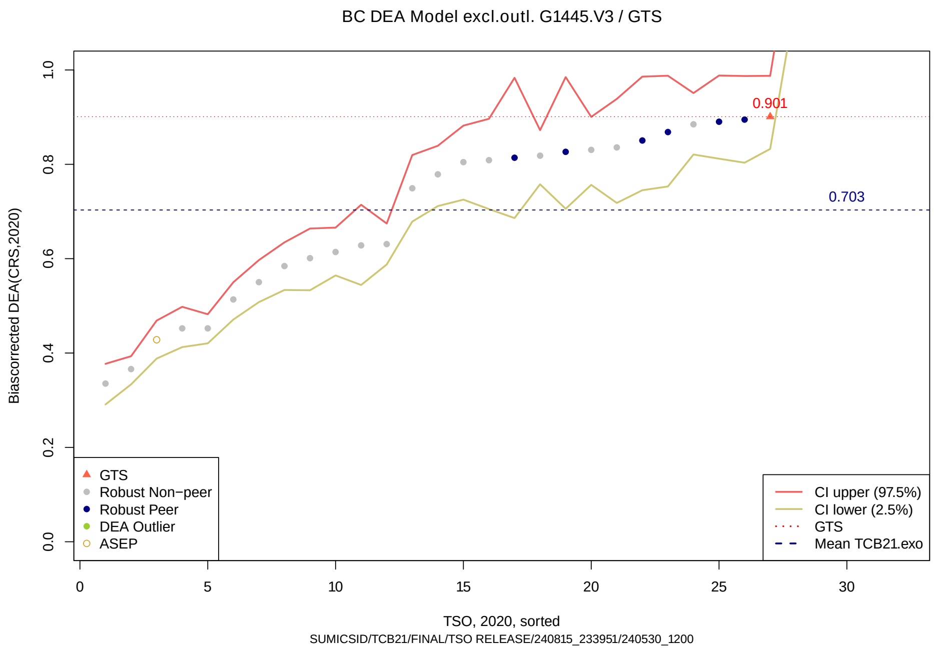

Figure 3.20: Bias-corrected DEA (RDEA.bc) G1445.V3

3.5 Robust DEA

DEA conventionally gives a deterministic point estimate without statistical properties. However, seminal work on bias-correction and bootstrapping in DEA from Simar and Wilson (1998) and Dario and Simar (2007) has developed a link to statistical estimations to enable the calculation of confidence intervals for DEA scores under CRS, bias-corrected scores, and point-estimates for bias by observation. For a further introduction, see Bogetoft and Otto (2011), Chap. 6.

DEA is a cautious evidence-based model that avoids extrapolation and a priori assumptions. The frontier is made uniquely by those observations that are in the set in a specific run. Intuitively, this resembles a local competition where some athletes are participating as qualifications for the Olympic Games. What if some competitors would fall sick the same day, or some outsider athletes unexpectedly would arrive? How can we be sure that a silver medalist is good enough to qualify? How stable are the rankings if the reference set changes?

Robust DEA (RDEA) provides answers for these questions by providing a statistical estimate for the range of scores that would be obtained if the observations in the dataset are seen as sampled from a larger population. Specifically, we address the question of *sampling bias* due to missing or added observations. We obtain upper and lower confidence intervals for the scores in the (asymptotically) full dataset. This implies that units that have special profiles tend to get overestimated efficiency since the chance is high that they may not have many valid comparators in the sample.

The confidence intervals below are for the bias corrected efficiency $\tilde{\theta}_k$ (RDEA.bc); to get confidence intervals for the uncorrected efficiency $\hat{\theta}_k$, add the biases (RDEA.bias) to both upper and lower values for the intervals: RDEA.bc.CIL, RDEA.bc.CIU. The dependent variable is as before dTotex.cb. In the RDEA.exo runs, the outliers from the models $\hat{\theta}_k(T)$ are removed, the results are therefore directly comparable with the results in section 3.1, although under CRS rather than NDRS. Robustness results for alternative models and variants were presented at project workshops WS3 and WS4 and in the Note on Model Specification. The respective results are listed in Table 3.9 for GTS and for the mean TSO in Table 3.10 below. The scores are also graphed in Figs. 3.20 to 3.27 below for each model.

Note that the RDEA.exo scores below do not include outliers (superefficient units) in Figs and Tables: the marker is missing from the graph and the score (set to 1.01) is excluded from the mean. Also, the "BC Peers" in the graphs are the peers in RDEA, not the peers in the respective DEA-runs presented as main results.

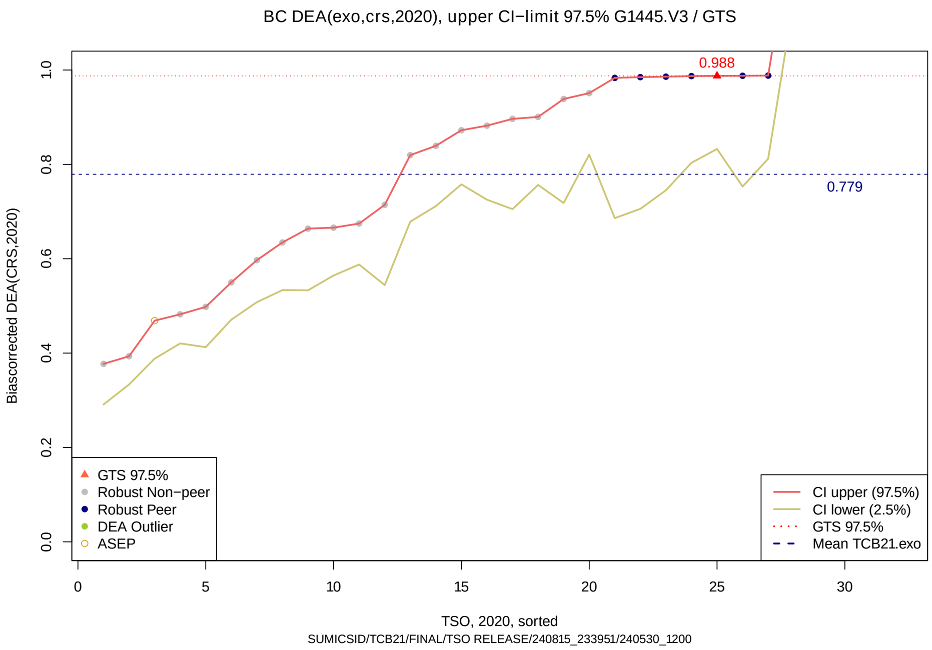

Figure 3.21: CI:Upper limit Bias-corrected DEA (RDEA.bc.CIU) G1445.V3

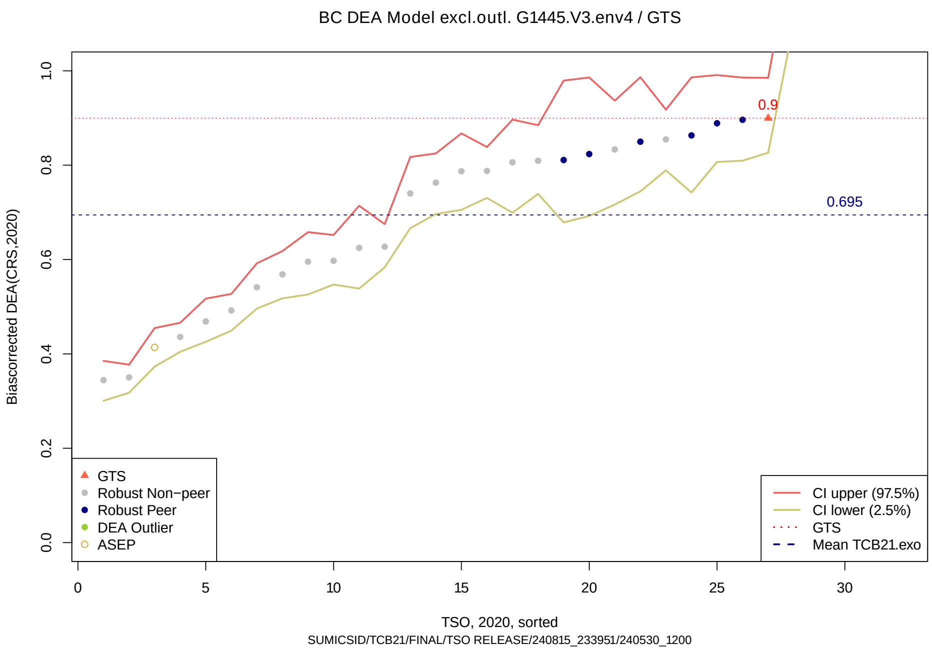

Figure 3.22: Bias-corrected DEA (RDEA.bc) G1445.V3.env4

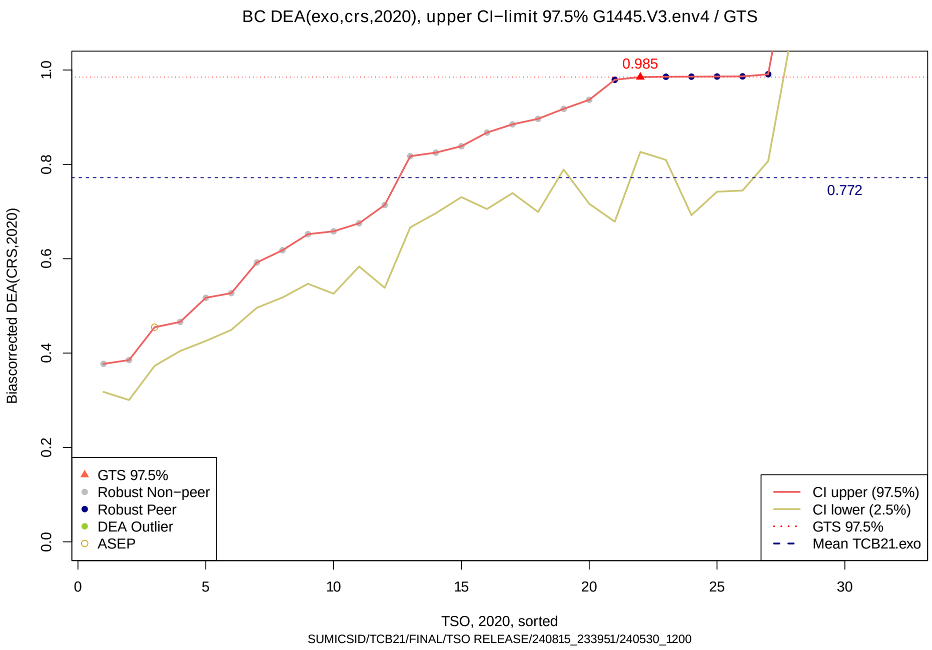

Figure 3.23: CI:Upper limit Bias-corrected DEA (RDEA.bc.CIU) G1445.V3.env4

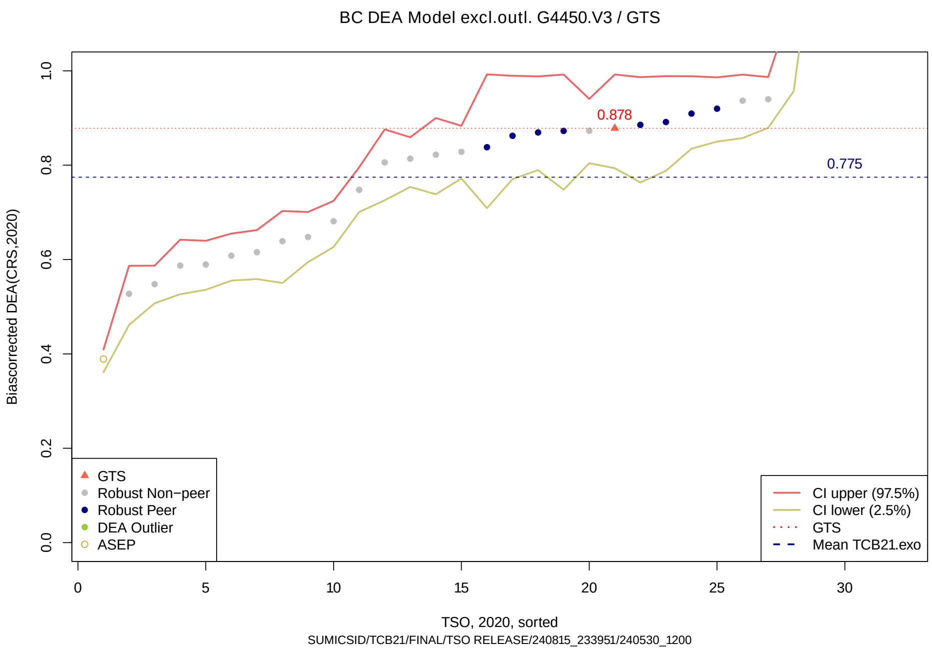

Figure 3.24: Bias-corrected DEA (RDEA.bc) G4450.V3

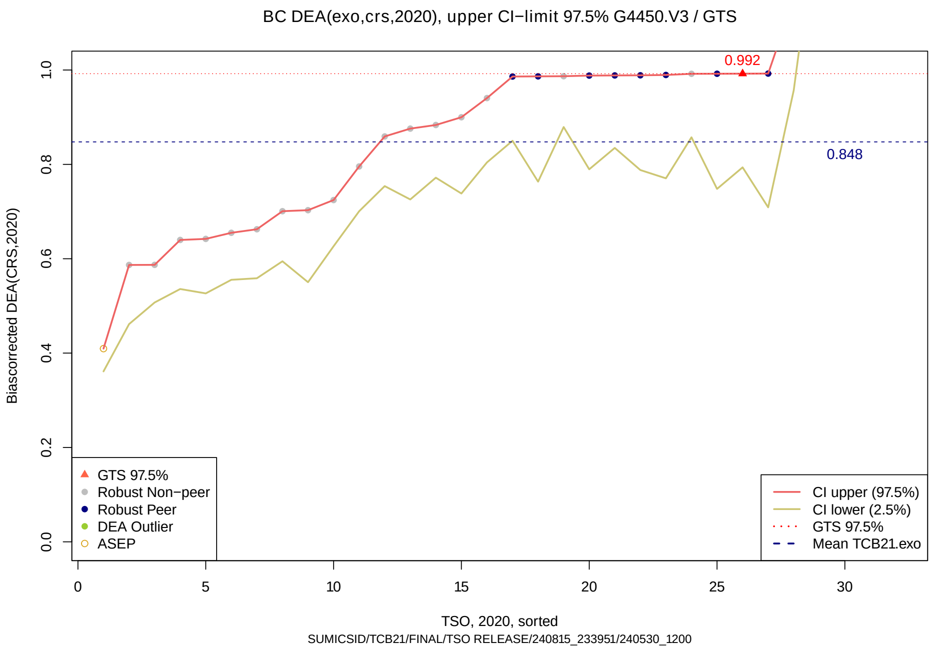

Figure 3.25: CI:Upper limit Bias-corrected DEA (RDEA.bc.CIU) G4450.V3

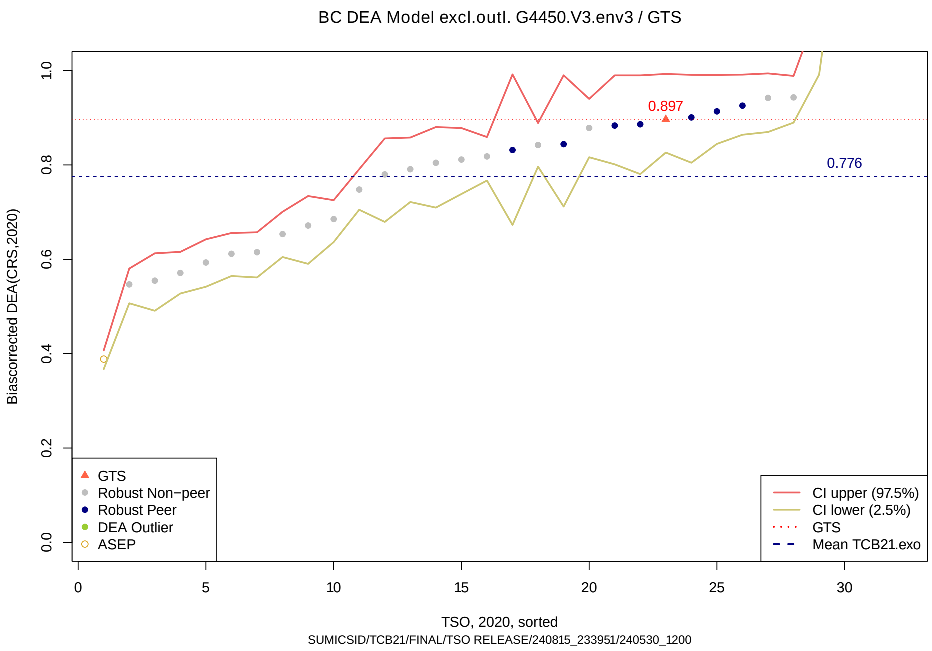

Figure 3.26: Bias-corrected DEA (RDEA.bc) G4450.V3.env3

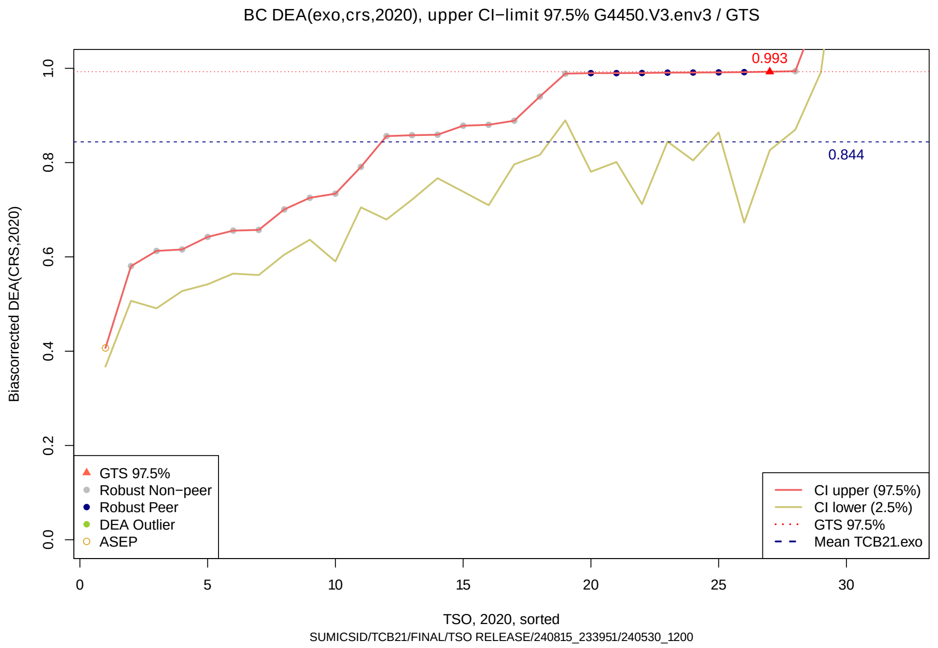

Figure 3.27: CI:Upper limit Bias-corrected DEA (RDEA.bc.CIU) G4450.V3.env3

Table 3.9: RDEA.exo scores,year 2020, GTS

	RDEA.bc.CIL.489	RDEA.bc.489	RDEA.bc.CIU.489	RDEA.bias.489
G1445.V3	0.833	0.901	0.988	0.099
G1445.V3.env4	0.826	0.900	0.985	0.100
G4450.V3	0.794	0.878	0.992	0.122
G4450.V3.env3	0.826	0.897	0.993	0.103

Table 3.10: Mean RDEA.exo scores,year 2020, gas

	RDEA.bc.CIL	RDEA.bc	RDEA.bc.CIU	RDEA.bias
G1445.V3	0.631	0.703	0.779	0.085
G1445.V3.env4	0.621	0.695	0.772	0.086
G4450.V3	0.700	0.775	0.848	0.081
G4450.V3.env3	0.705	0.776	0.844	0.075

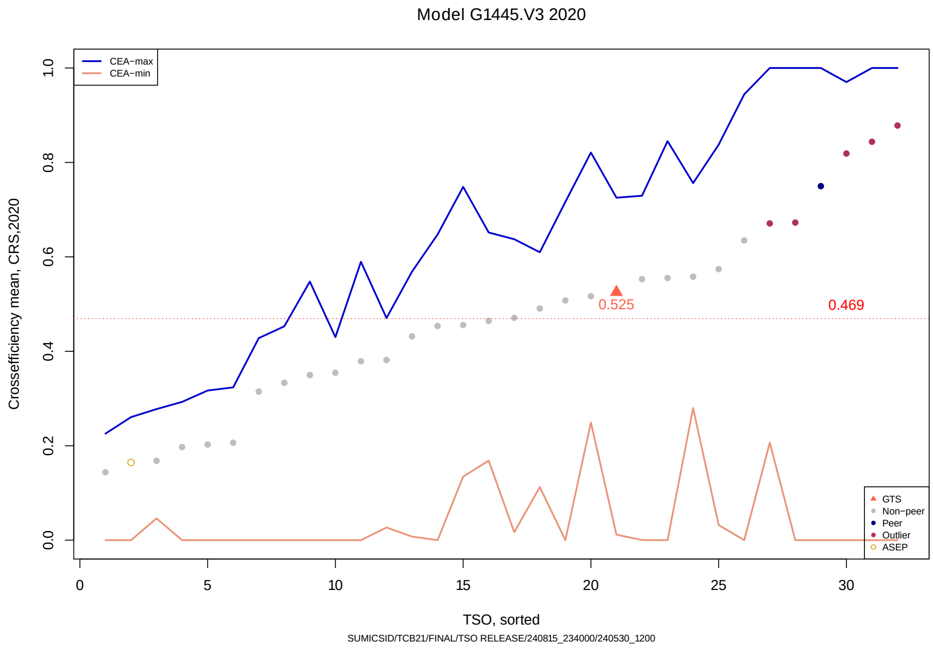

Figure 3.28: CEA results (ave, max, min), G1445.V3 crs ,2020.

3.6 Crossefficiency CEA

The results in DEA are determined by default through an open weighting of the inputs and output, i.e., we assume no a priori prices, values or relations in the respective classes of inputs and outputs. This assumption is very cautious as the model would assign the highest possible value to output(s) that are comparatively better represented for any given operator. The individual evaluations, also called *dual output-weights*, valid only for a single operator and not intervening in the conventional DEA.

In Crossefficiency analysis (CEA) we challenge this assumption by assigning successively the weights of all other $n-1$ operators to the given operator assessed. The CEA-score is then obtained as the mean score for the weights of all operators and not only its own. This approach guarantees robustness to extreme output-weights and also gives insights into possible clusters of operators.

The results for CEA (under CRS and 2020) for all final models are presented in Table 3.11 below. The results are given for the average output weights (CEA-ave) and for the maximum output weights that are exogenous (i.e. not from the unit at hand), along with mean and median results for the 2020 TCB21 operators.

Table 3.11: CEA scores (CRS)2020

	CEA-ave 489	CEA-max 489	Mean CEA-ave	Median CEA-ave	Mean CEA-max
G1445.V3	0.53	0.73	0.47	0.47	0.65
G1445.V3.env4	0.52	0.72	0.46	0.46	0.65
G4450.V3	0.72	0.98	0.52	0.48	0.72
G4450.V3.env3	0.72	1.00	0.52	0.48	0.79

The detailed results for each model are given in Figs. 3.28 through 3.31 below, where in addition to CEA-ave and CEA-max, we also provide CEA-min, which is the most disfavorable output weights for GTS given by any operator in the reference set.

The differences between the individual DEA dual weights for GTS and the mean of the weights for the operators (including GTS) is illustrated in Figs. 3.32 through 3.35. Note that no weight restrictions are applied, thus a TSO may assign a zero-valued output weight.

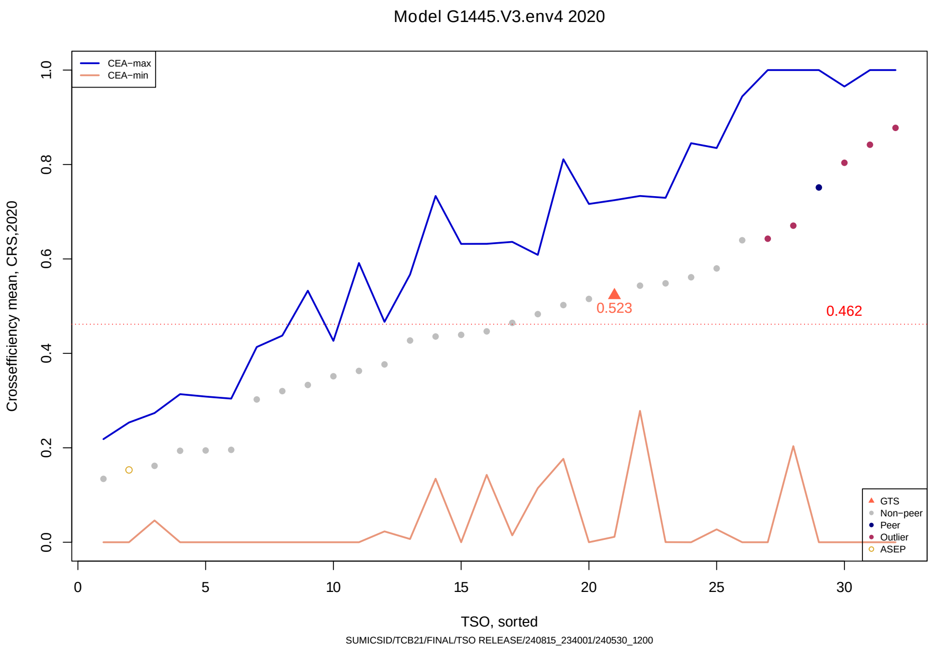

Figure 3.29: CEA results (ave, max, min), G1445.V3.env4 crs ,2020.

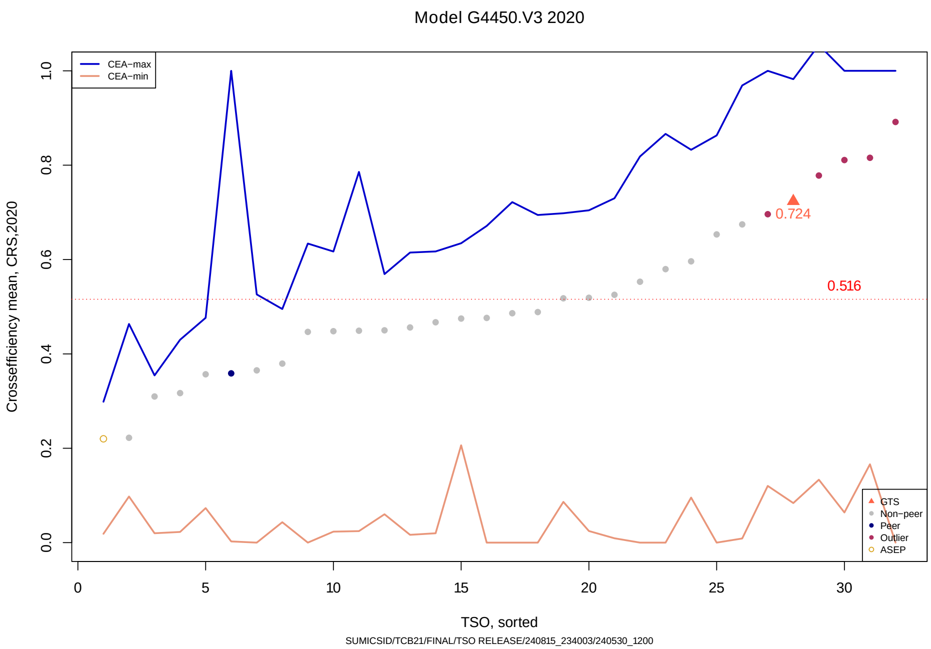

Figure 3.30: CEA results (ave, max, min), G4450.V3 crs ,2020.

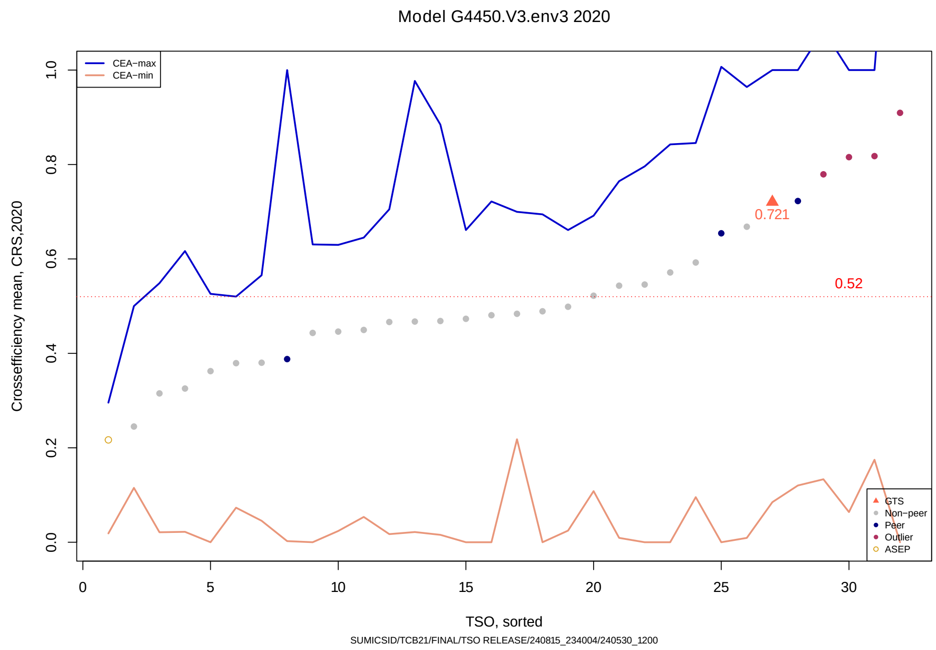

Figure 3.31: CEA results (ave, max, min), G4450.V3.env3 crs ,2020.

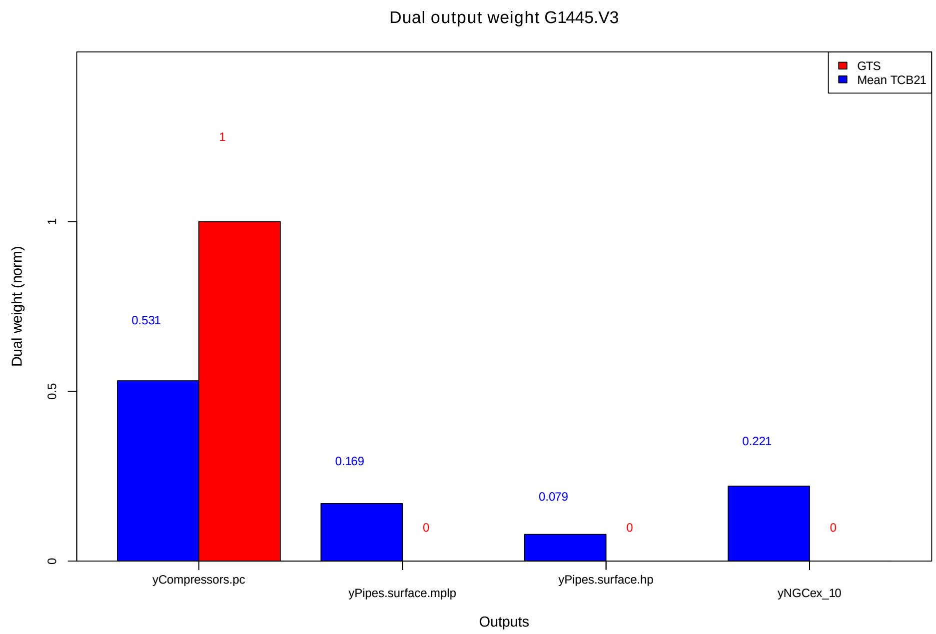

Figure 3.32: Dual weights CEA (mean and TSO), G1445.V3 crs, 2020.

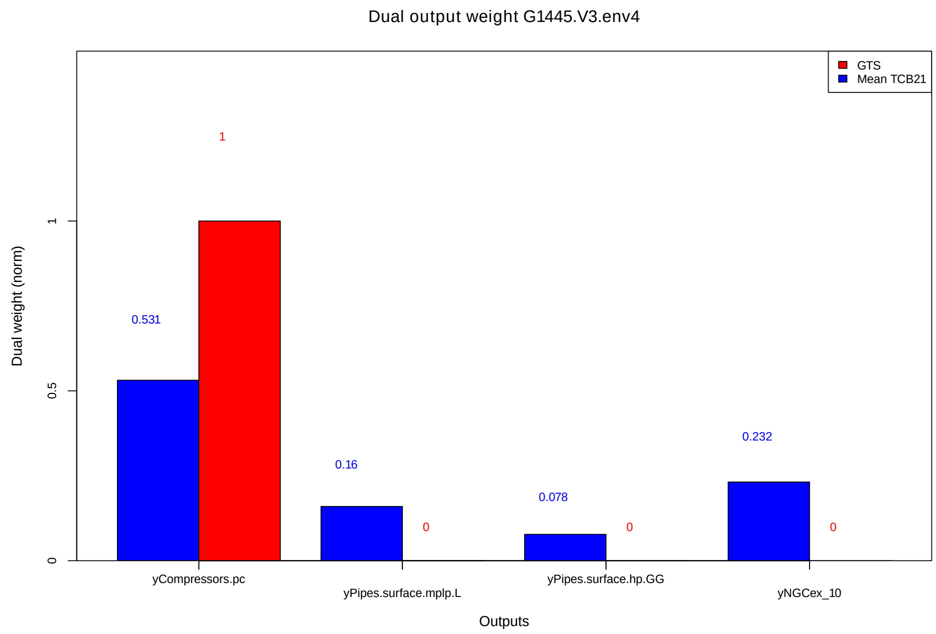

Figure 3.33: Dual weights CEA (mean and TSO), G1445.V3.env4 crs, 2020.

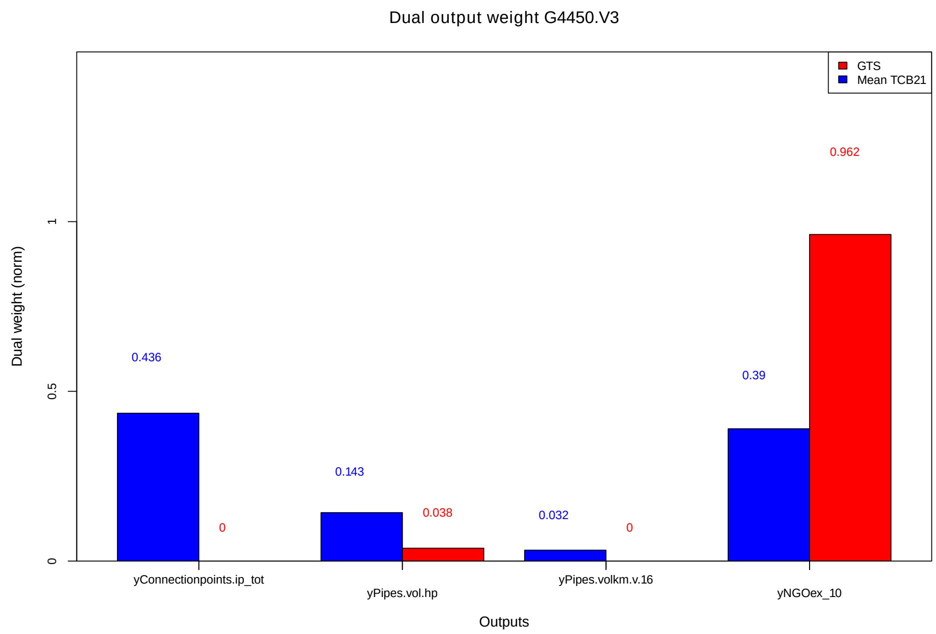

Figure 3.34: Dual weights CEA (mean and TSO), G4450.V3 crs, 2020.

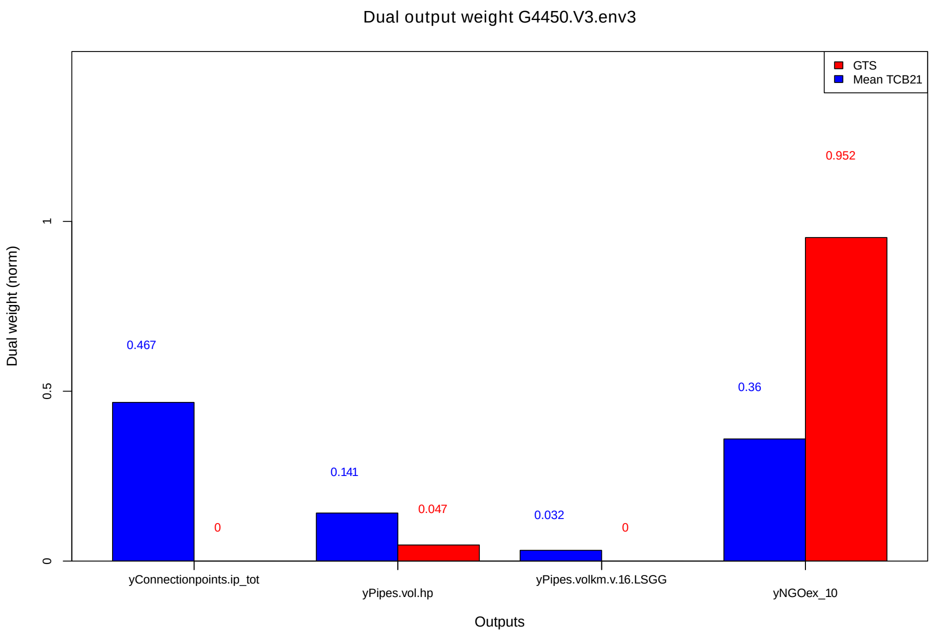

Figure 3.35: Dual weights CEA (mean and TSO), G4450.V3.env3 crs, 2020.

Chapter 4

Sensitivity analysis

The calculated cost functions are proportional to a number of parameters, e.g. the NormGrid weights. However, since a frontier benchmarking is an investigation into relative, not absolute, changes, the scales of the inputs and outputs are not important. The relevant evaluation in this context is whether a change in a technical parameter would lead to changes in the relative ranking or level of the benchmarked units. To investigate this aspect, following the Method Note and WS5, the following model parameters have been varied and the resulting changes in the efficiency score for GTS are illustrated in the following graphs.

Tested parameters

1. Interest rate,
2. Age assumptions for standardized life time,
3. Salary corrections for capitalized labor in investments,
4. Impact of different labour cost indexes (LCI),
5. Impact of different inflation indexes (PI),
6. Overhead allocation rules
7. Environmental correction factors

4.1 Interest rate

In the following analysis we change the real interest rate over a range from 0.05% to 5%, listing the individual score as well as mean score (DEA(ndrs,exo, 2020)), using the same outliers as for the default setting. The impact is qualitatively illustrated in Figs. 4.1 to 4.4 below. The detail of the results are also given in Appendix Tables A.11 to A.14 per model.

4.2 Standardized age assumptions

The following analysis looks at the impact on the score of the assumptions regarding the standardized life time per asset. For simplicity, we have reduced the simulation to two alternative cases, Age_{low} and Age_{high}, respectively with correspondingly about 10 years shorter and longer lifetimes. The exact parameters are reproduced in Table 4.1 below. See Figs. 4.5 to 4.8 for graphs. The impact on the individual scores for GTS and the mean score (DEA(ndrs,exo,2020)) is listed per model in in Appendix Tables A.15 to A.18.

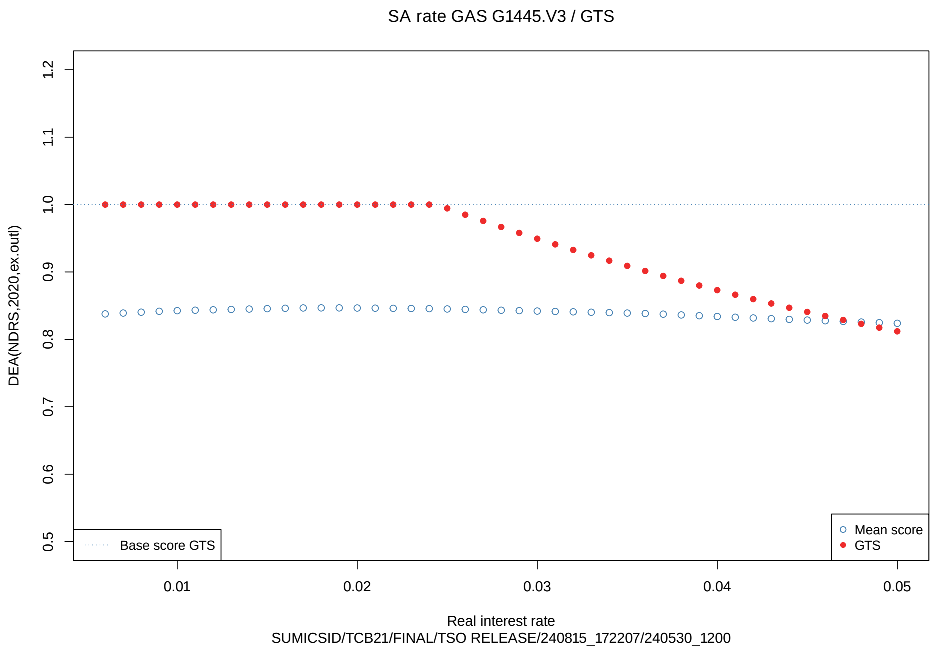

Figure 4.1: DEA(ndrs,exo,2020) scores for GTS varying the interest rate from 0.5% to 5%, G1445.V3

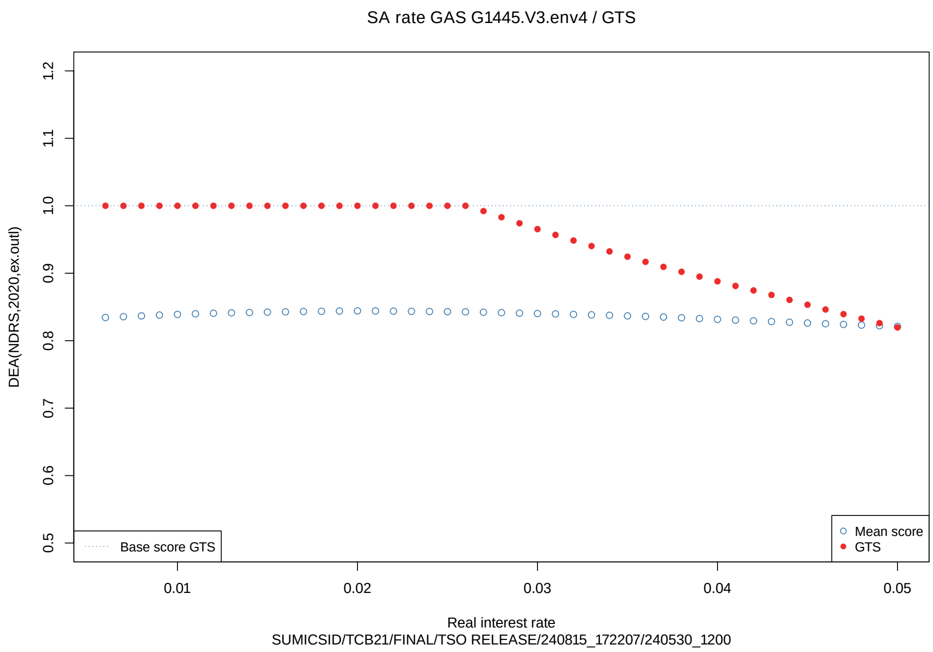

Figure 4.2: DEA(ndrs,exo,2020) scores for GTS varying the interest rate from 0.5% to 5%, G1445.V3.env4

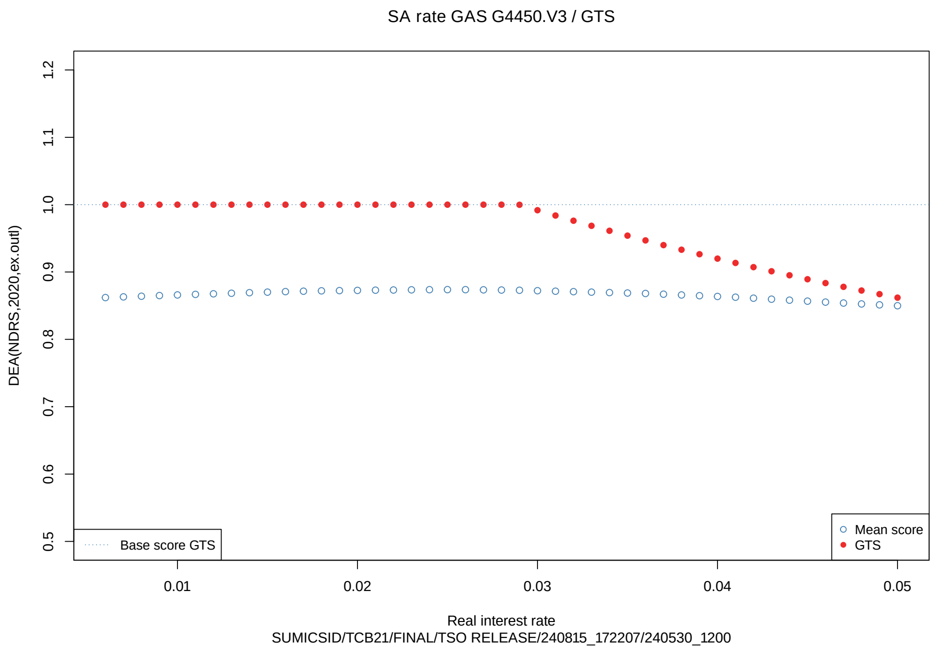

Figure 4.3: DEA(ndrs,exo,2020) scores for GTS varying the interest rate from 0.5% to 5%, G4450.V3

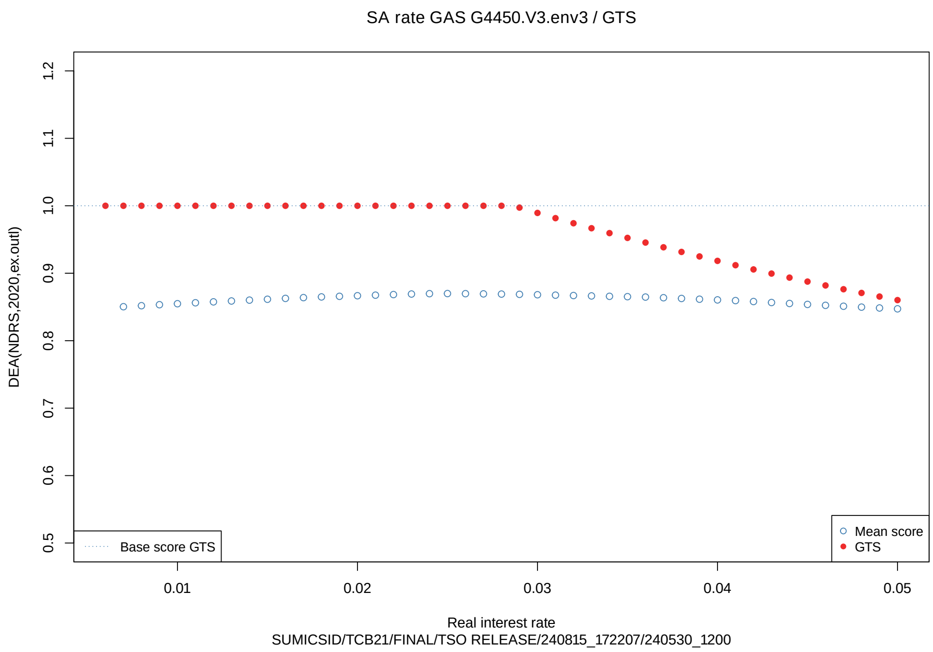

Figure 4.4: DEA(ndrs,exo,2020) scores for GTS varying the interest rate from 0.5% to 5%, G4450.V3.env3

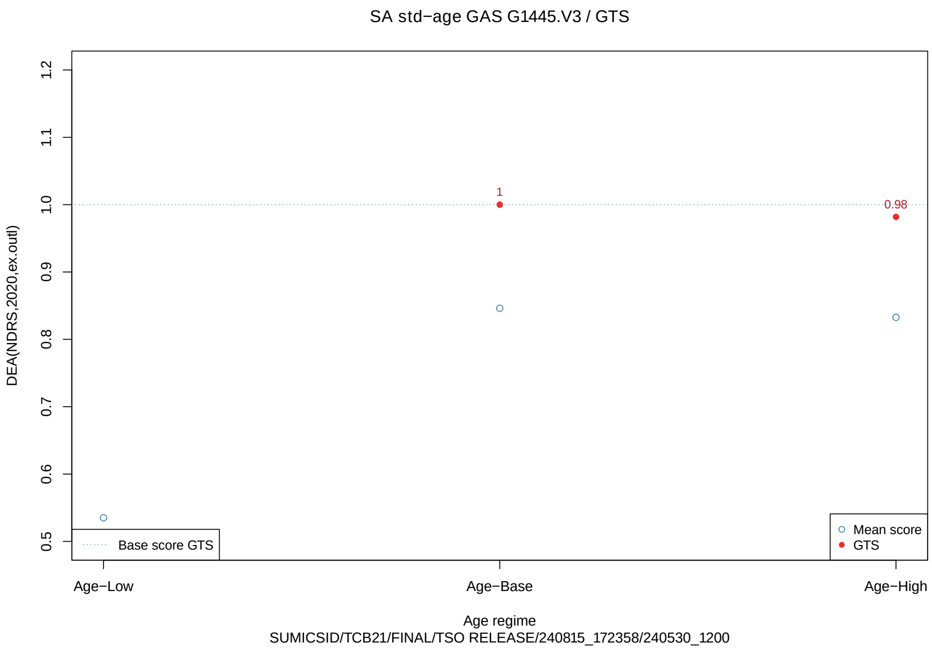

Figure 4.5: DEA(ndrs,exo,2020) score for GTS under alternative standard age regimes, G1445.V3

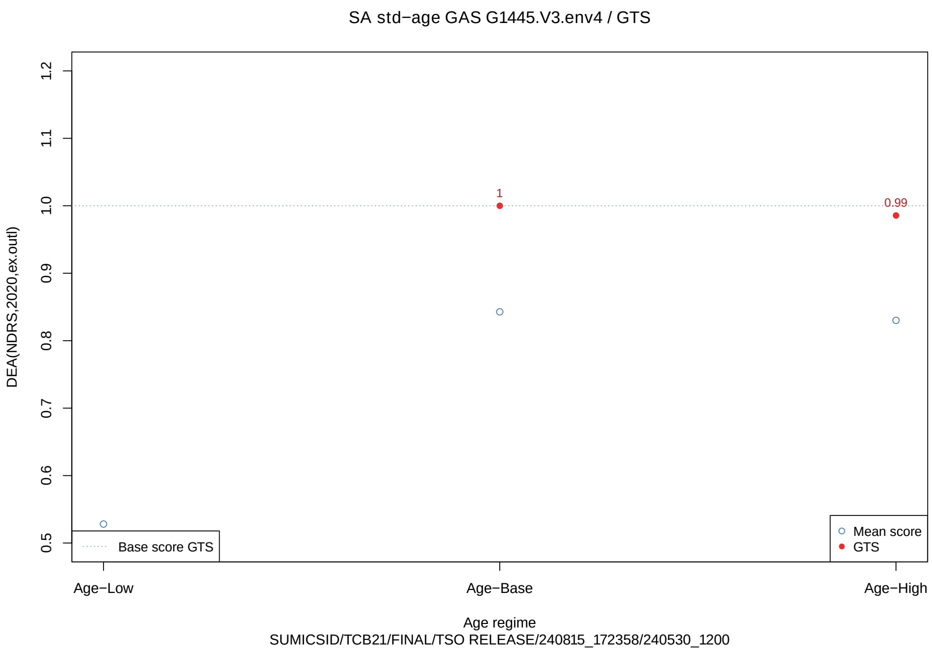

Figure 4.6: DEA(ndrs,exo,2020) score for GTS under alternative standard age regimes, G1445.V3.env4

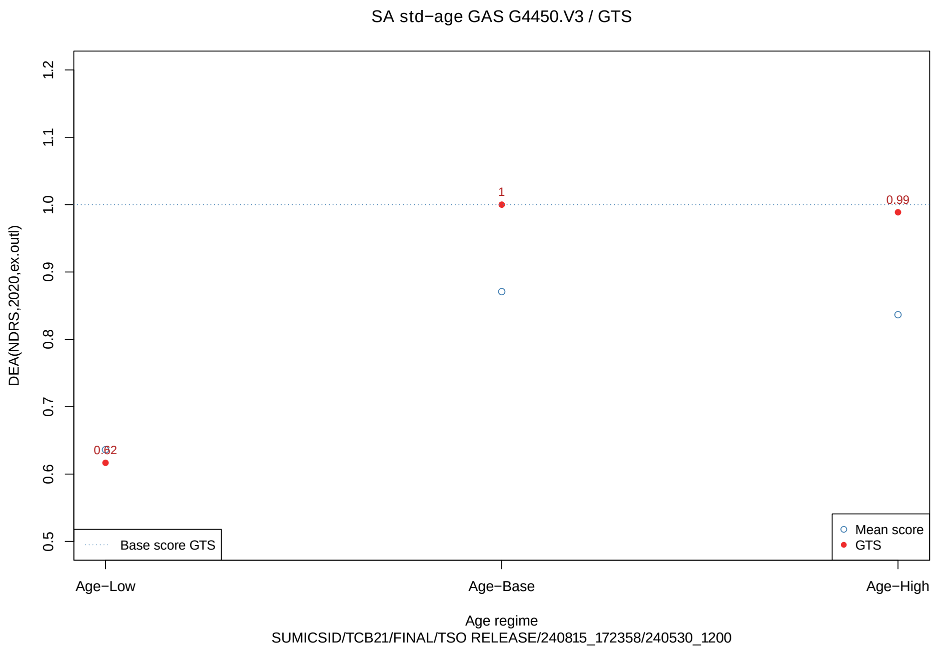

Figure 4.7: DEA(ndrs,exo,2020) score for GTS under alternative standard age regimes, G4450.V3

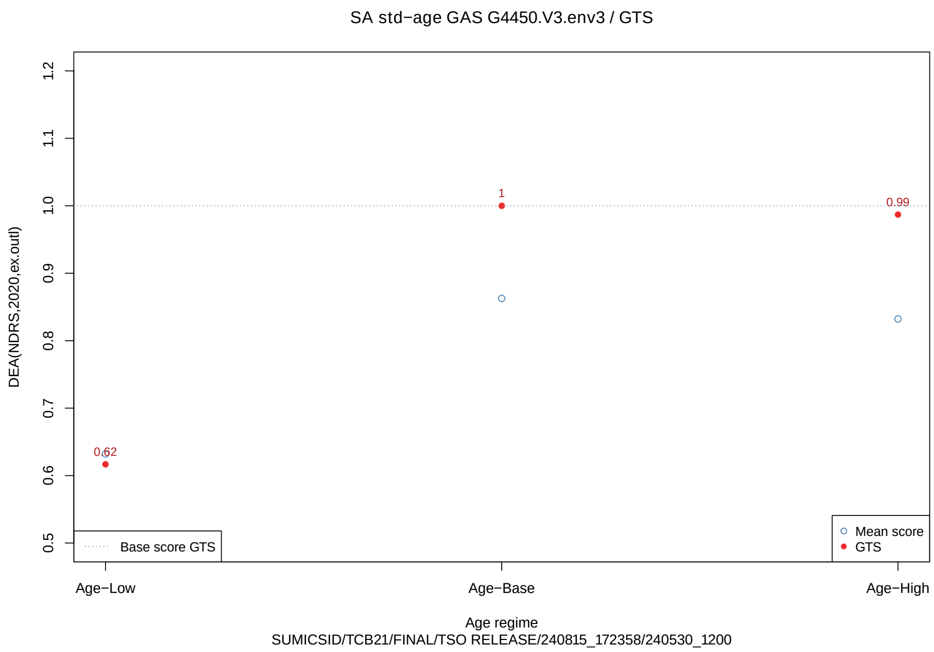

Figure 4.8: DEA(ndrs,exo,2020) score for GTS under alternative standard age regimes, G4450.V3.env3

Table 4.1: Techno-economic life SA (years)

Asset	Base case	Age-Low	Age-High
Pipelines	60	40	70
Regulators	30	20	40
Compressors	30	20	40
Connection points	30	20	40
Metering stations	30	20	40
Control centers	20	20	40
Inpipes	20	20	30
Odorisation	20	20	30
Gaschromat	10	10	20
Delivery station	30	20	40
Equipment	10	10	20

4.3 Impact of labour cost indexes (LCI)

Analysis presented in the Note on Method and Calculations indicates that the preferred labour cost index (LCI) for the gas sector is LCI-UTIL. The impact is qualitatively illustrated in Figs. 4.9 to 4.12 below. The detail of the results are given in Appendix A.7 in Tables A.19 to A.22 per model.

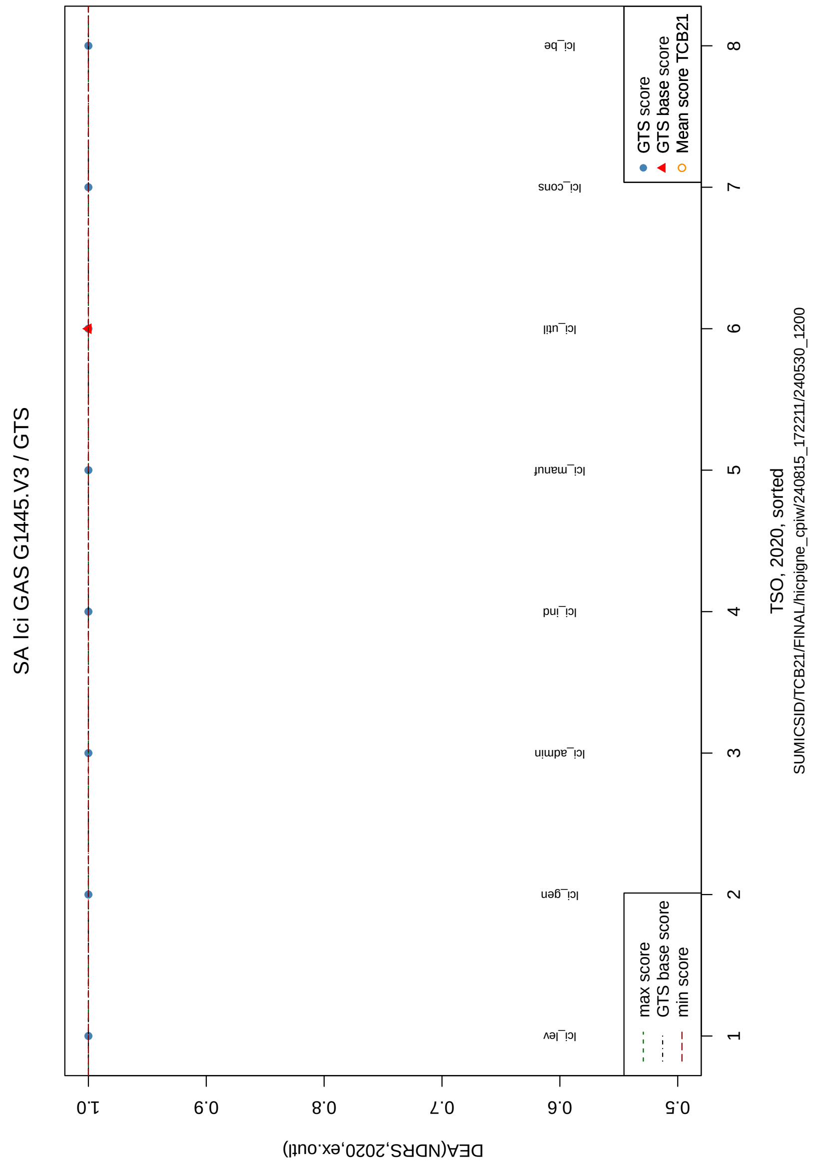

Figure 4.9: DEA(ndrs,exo,2020) score for alternative LCI in G1445.V3 for GTS

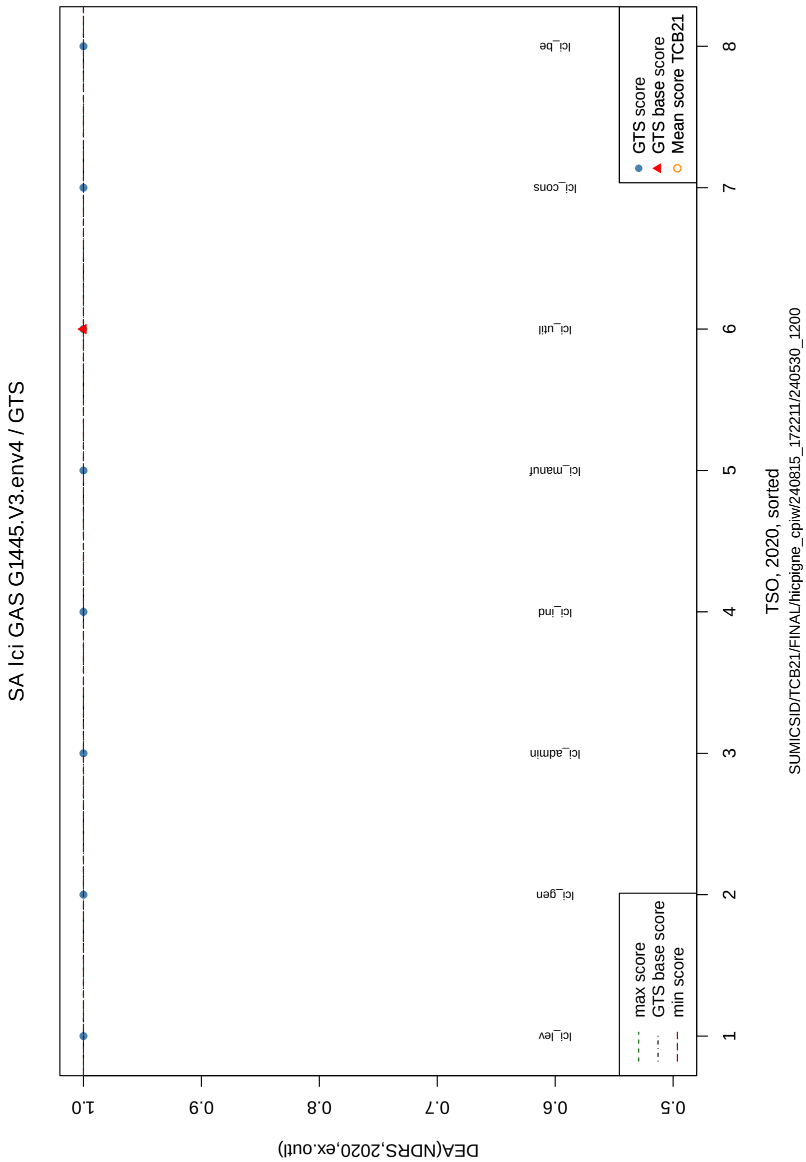

Figure 4.10: DEA(ndrs,exo,2020) score for alternative LCI in G1445.V3.env4 for GTS

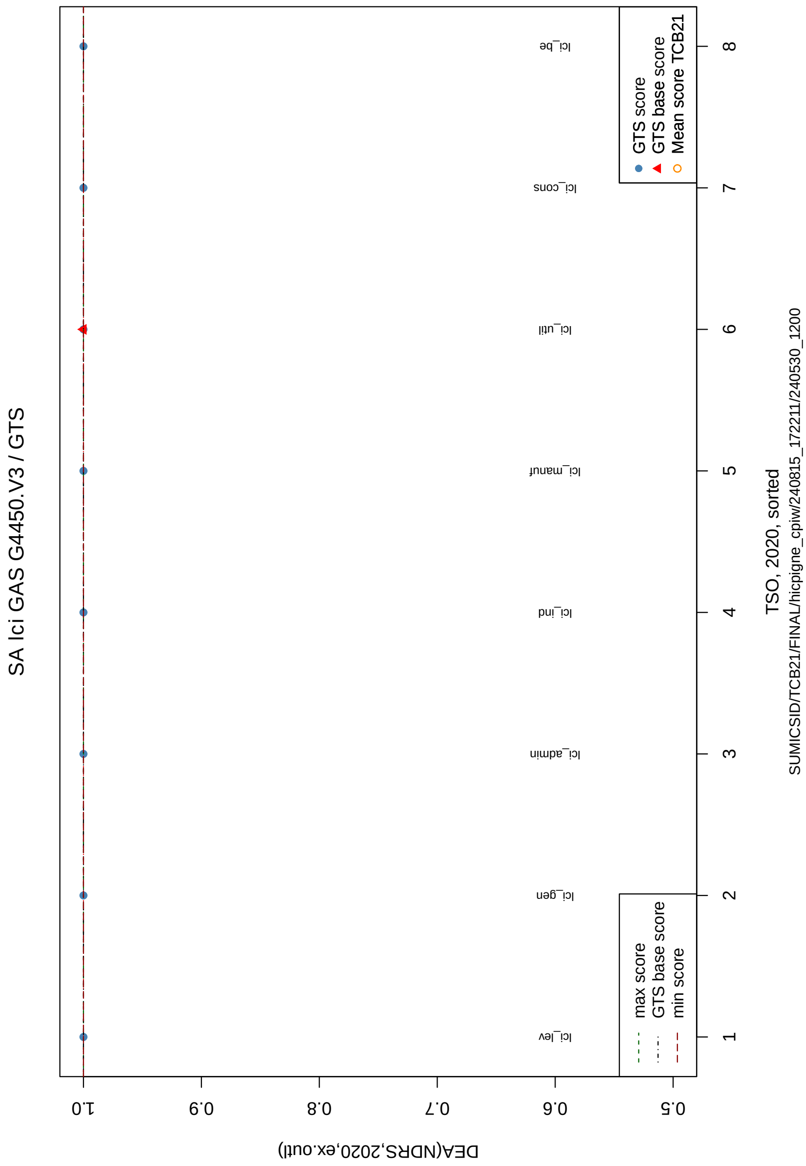

Figure 4.11: DEA(ndrs,exo,2020) score for alternative LCI in G4450.V3 for GTS

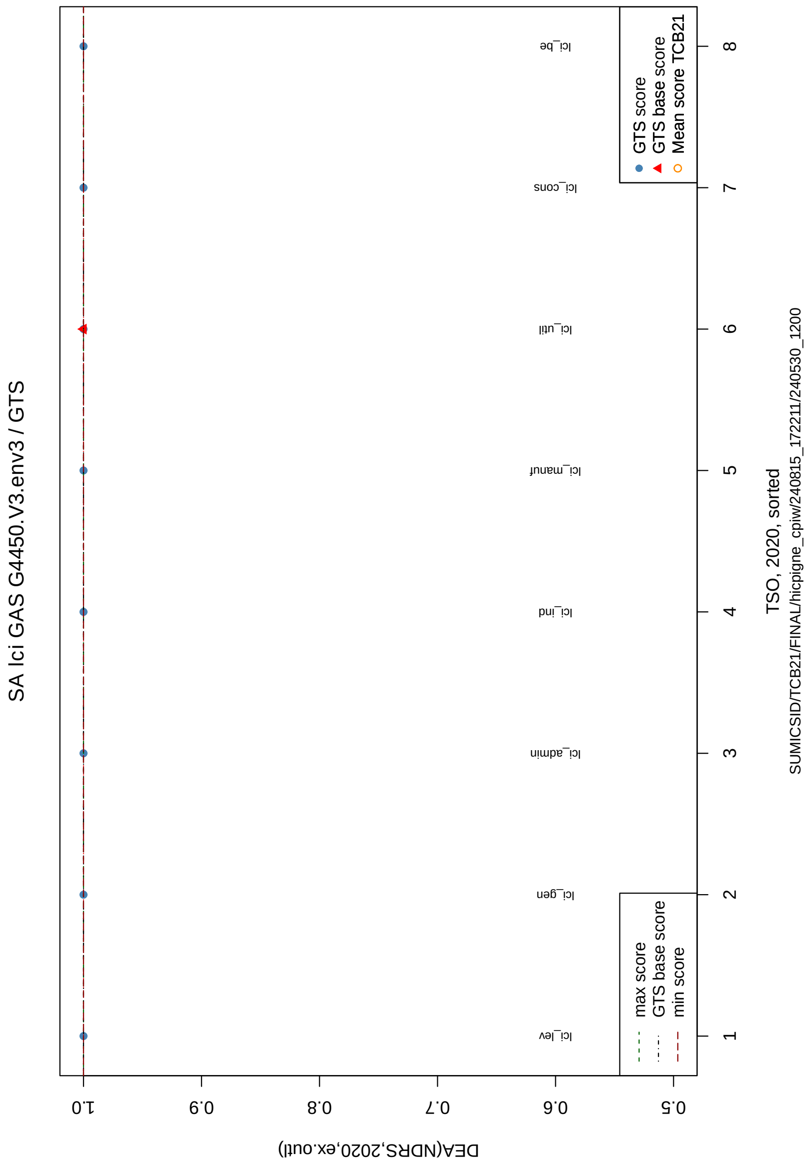

Figure 4.12: DEA(ndrs,exo,2020) score for alternative LCI in G4450.V3.env3 for GTS

4.4 Salary corrections for capitalized labor in investments

In the base model, there is no adjustment for labour cost differences in investments. The impact of this assumption is investigated in this section per model, varying the basis for local LCI adjustements of historic investments from 0 to 50 percent of the nominal investment value. The impact is qualitatively illustrated in Figs. 4.13 to 4.16 below. The detail of the results are given Appendix A.8 in Tables A.23 to A.26 per model.

The formula for adjustment is the following.

$$Capex_{it}^{adj} = Capex_{it}(1 - \psi(1 - mean_t(\frac{LCI_{EU}}{LCI_{k(i)t}}))) \tag{4.1}$$

where $Capex_{it}$ is the real annuity capex for operator i in year t, LCI_{kt} is the labor cost index for country k in year t, $k(i)$ is the country for operator i, and ψ is the capex-laborcost share. The notation denotes the proportion for adjustment ψ, i.e., $\psi = 0.25 = 25$ percent of nominal investment is adjusted.

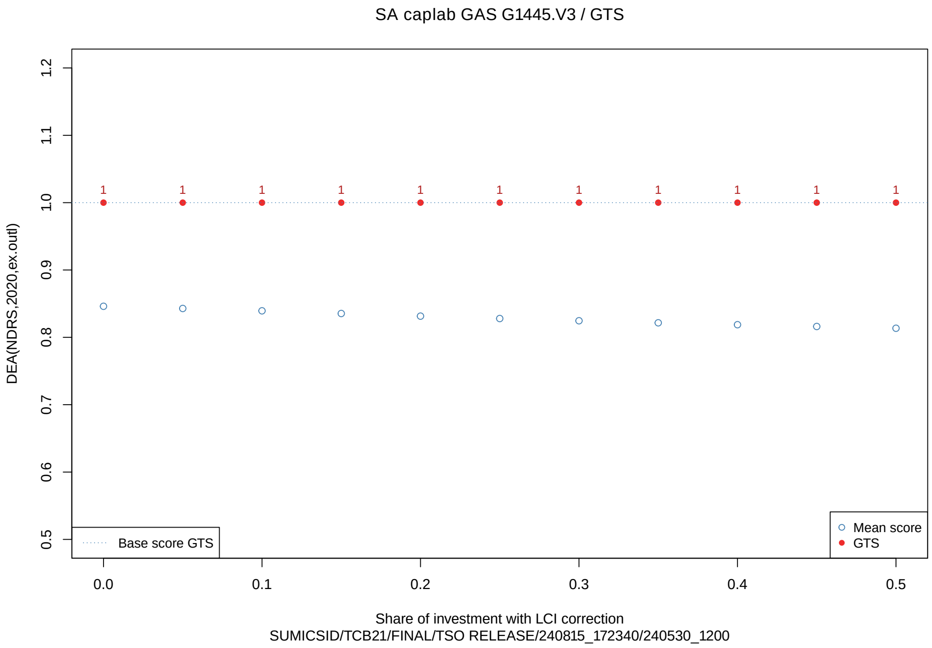

Figure 4.13: DEA(ndrs,exo,2020) score as function of share of LCI-adjusted capex in G1445.V3 , GTS and mean for TCB21.

4.5 Impact of inflation indexes (PI)

Analysis presented in the Note on Method and Calculations indicates that the preferred price index (PI) for the gas sector is HICPIGNE(WB-CPI). However, there are a series of eligible PI tested in Figs. 4.17 to 4.20 below. The detail of the results are given in Appendix A.9 in Tables A.27 to A.30 per model.

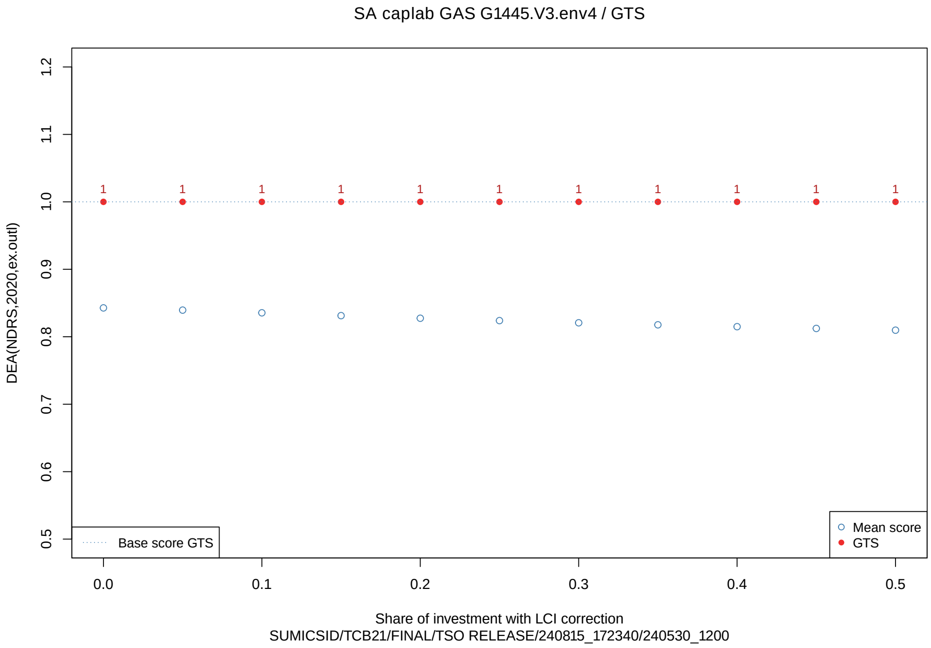

Figure 4.14: DEA(ndrs,exo,2020) score as function of share of LCI-adjusted capex in G1445.V3.env4 , GTS and mean for TCB21.

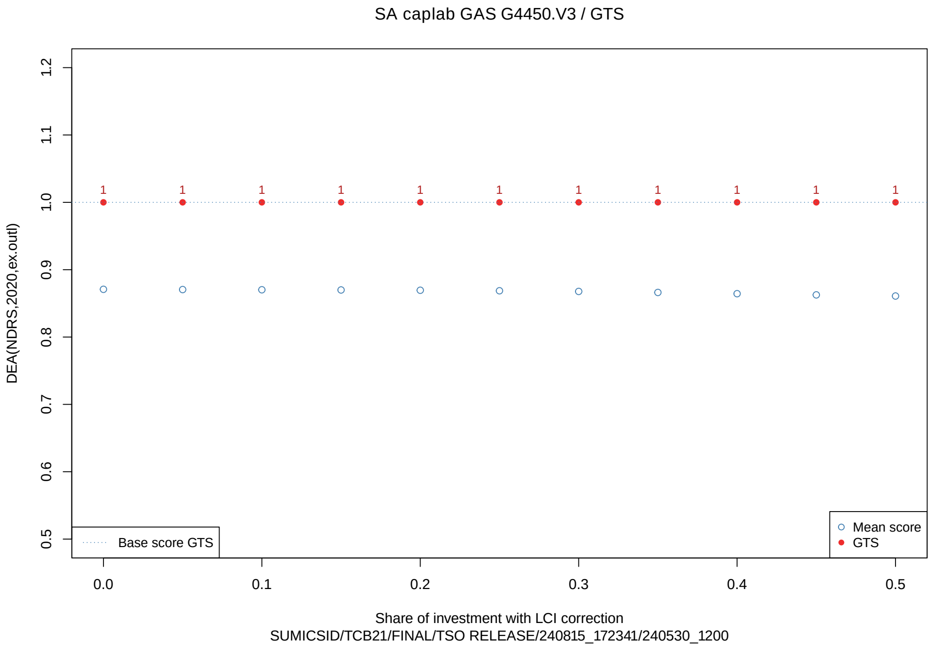

Figure 4.15: DEA(ndrs,exo,2020) score as function of share of LCI-adjusted capex in G4450.V3 , GTS and mean for TCB21.

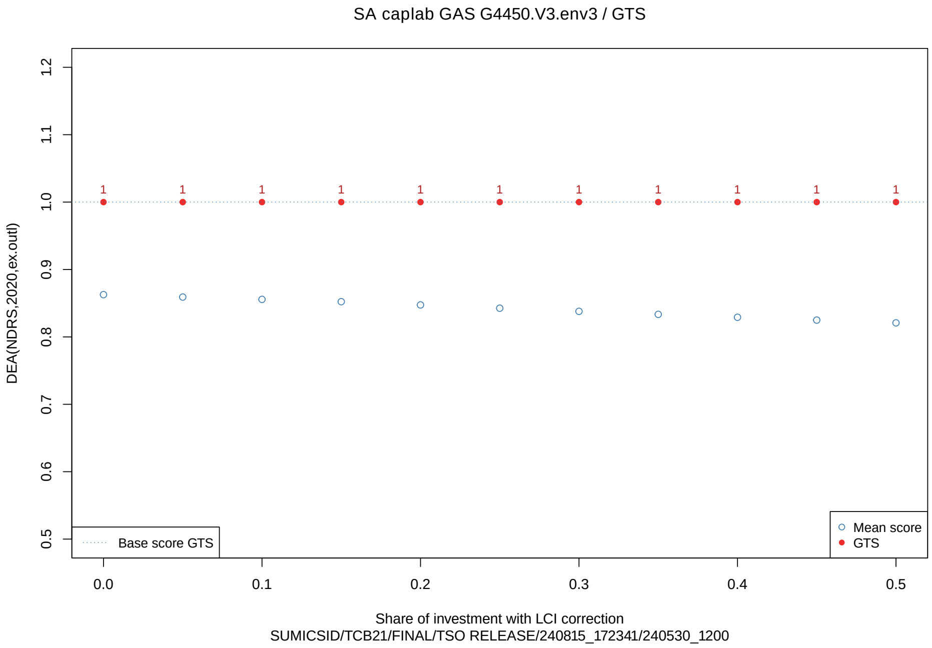

Figure 4.16: DEA(ndrs,exo,2020) score as function of share of LCI-adjusted capex in G4450.V3.env3 , GTS and mean for TCB21.

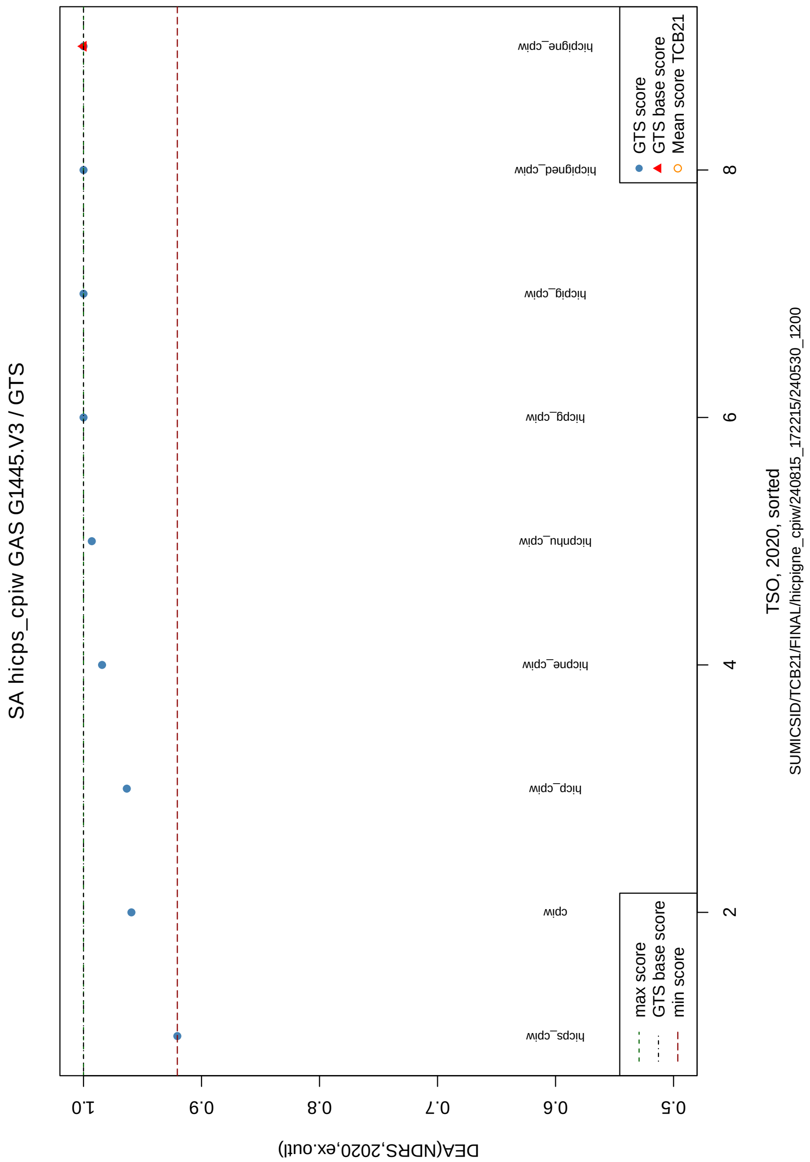

Figure 4.17: DEA(ndrs,exo,2020) score for alternative inflation indexes in G1445.V3 for GTS .

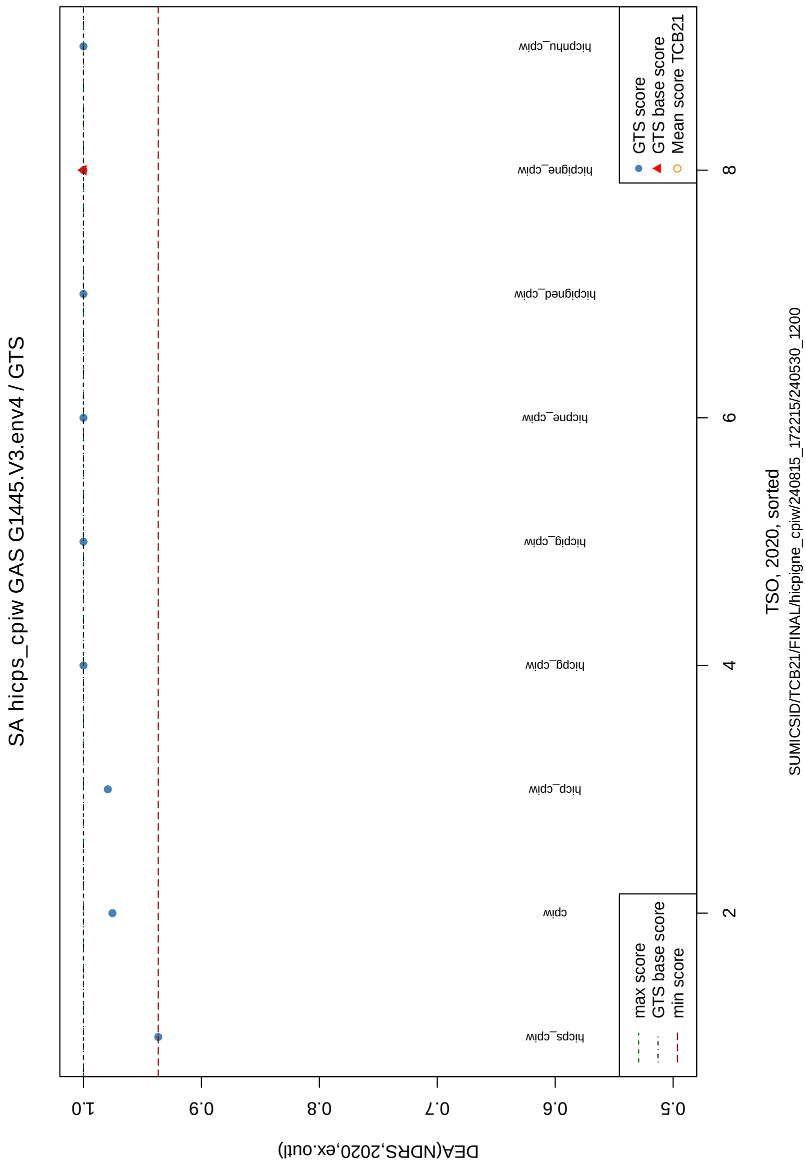

Figure 4.18: DEA(ndrs,exo,2020) score for alternative inflation indexes in G1445.V3.env4 for GTS .

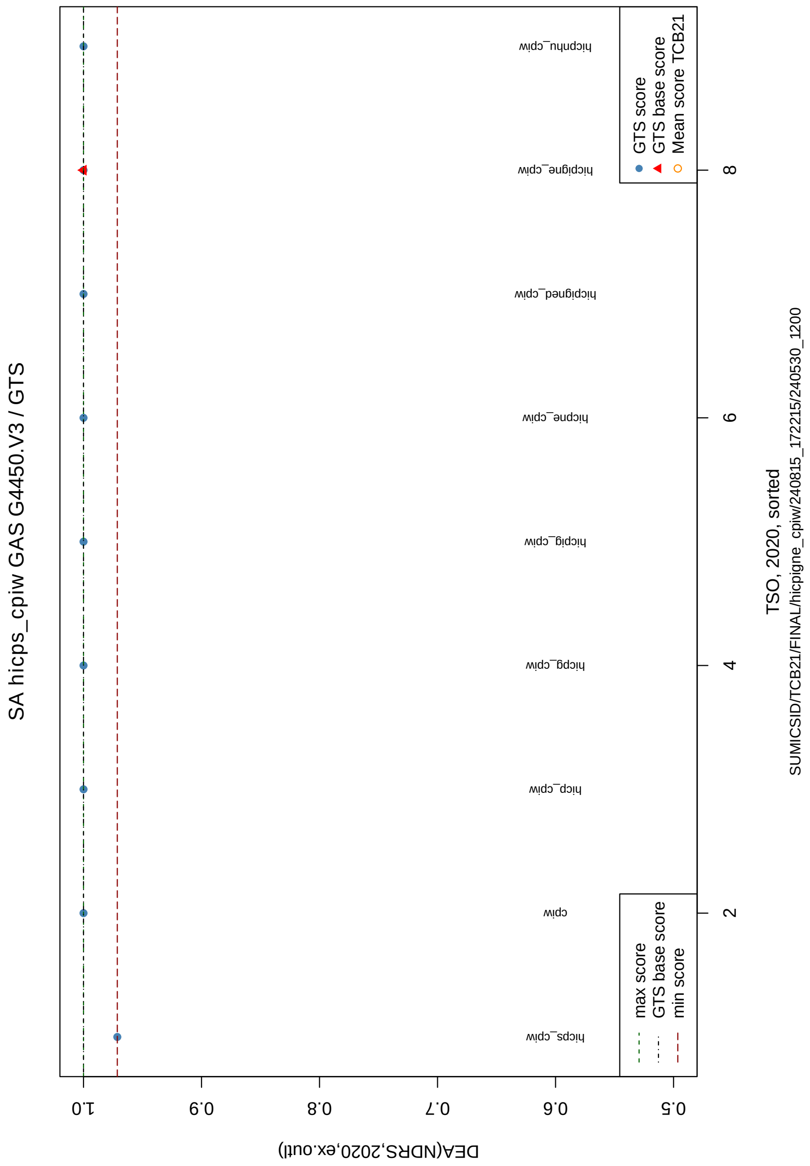

Figure 4.19: DEA(ndrs,exo,2020) score for alternative inflation indexes in G4450.V3 for GTS .

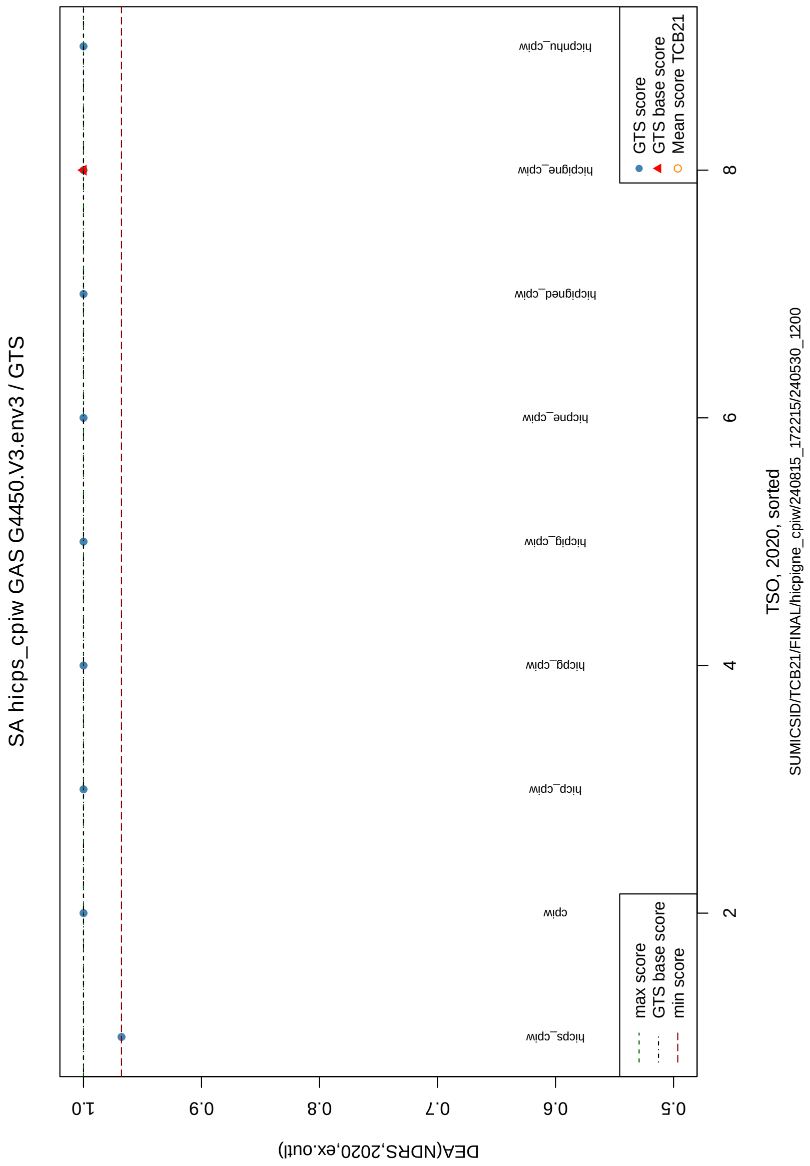

Figure 4.20: DEA(ndrs,exo,2020) score for alternative inflation indexes in G4450.V3.env3 for GTS .

4.6 Overhead allocation rules

Indirect cost for support is allocated to the benchmarked cost using a cost-based allocation with some deductions. The sensitivity of this assumption is tested in Appendix A.10 below using the DEA(ndrs.exo.2020) scores. The impact is qualitatively illustrated in Figs. 4.21 to 4.24 below. The detail of the results are given Appendix A.10 in Tables A.31 to A.34 per model.

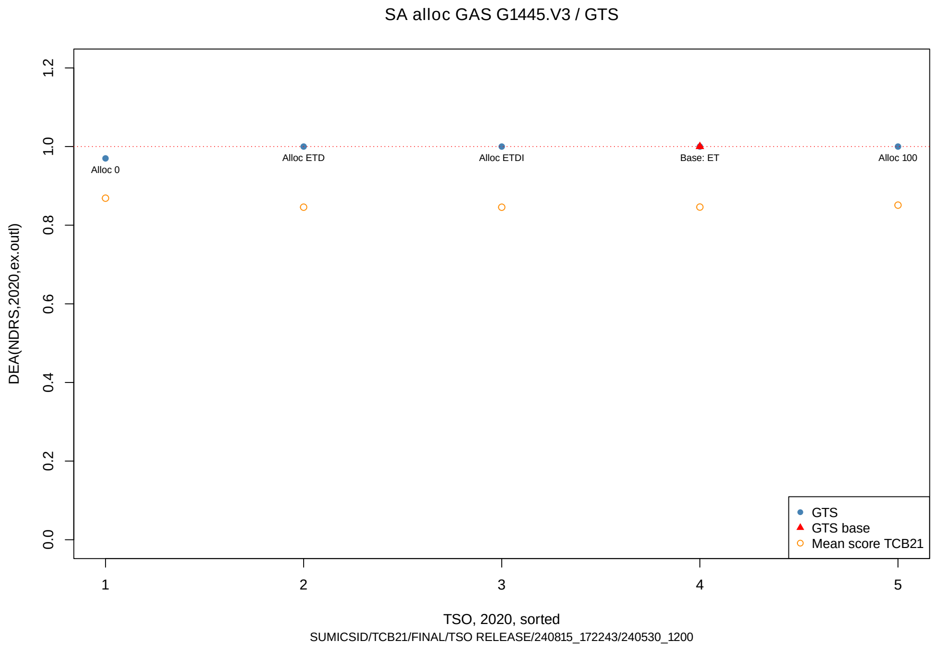

Figure 4.21: DEA(ndrs,exo,2020) scores for GTS under alternative overhead allocation regimes, G1445.V3

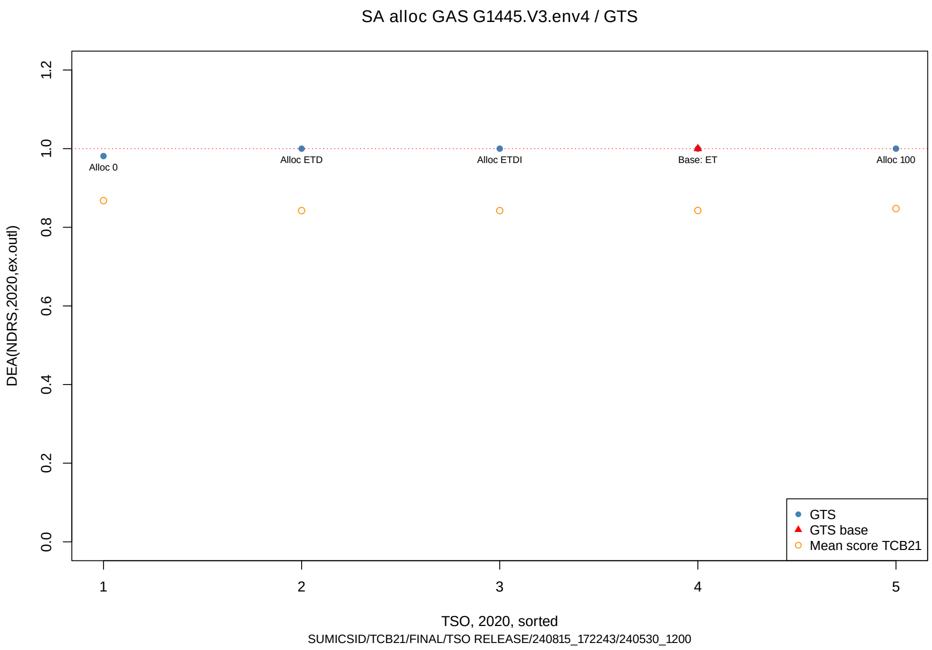

Figure 4.22: DEA(ndrs,exo,2020) scores for GTS under alternative overhead allocation regimes, G1445.V3.env4

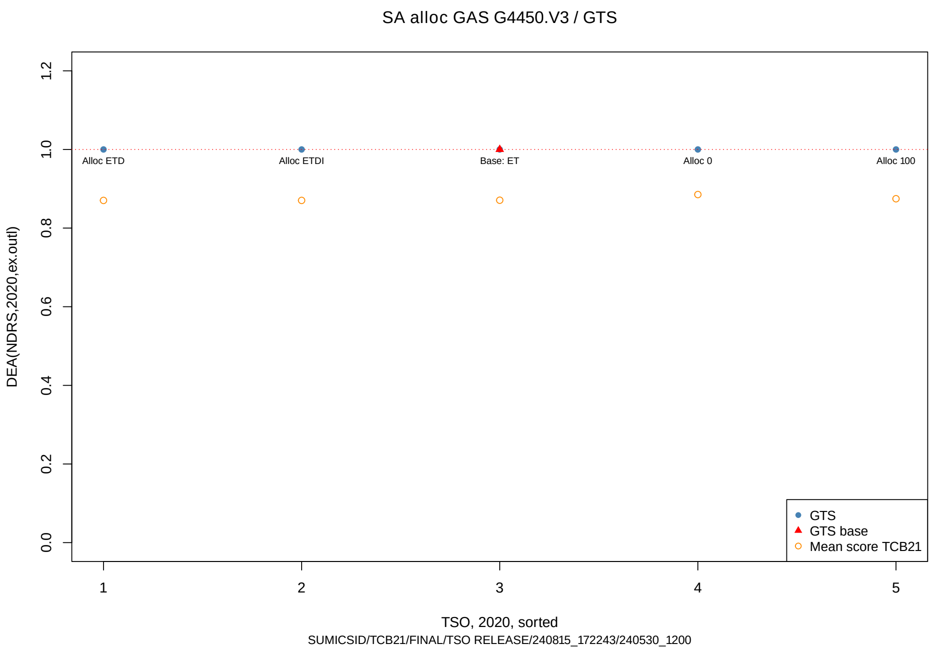

Figure 4.23: DEA(ndrs,exo,2020) scores for GTS under alternative overhead allocation regimes, G4450.V3

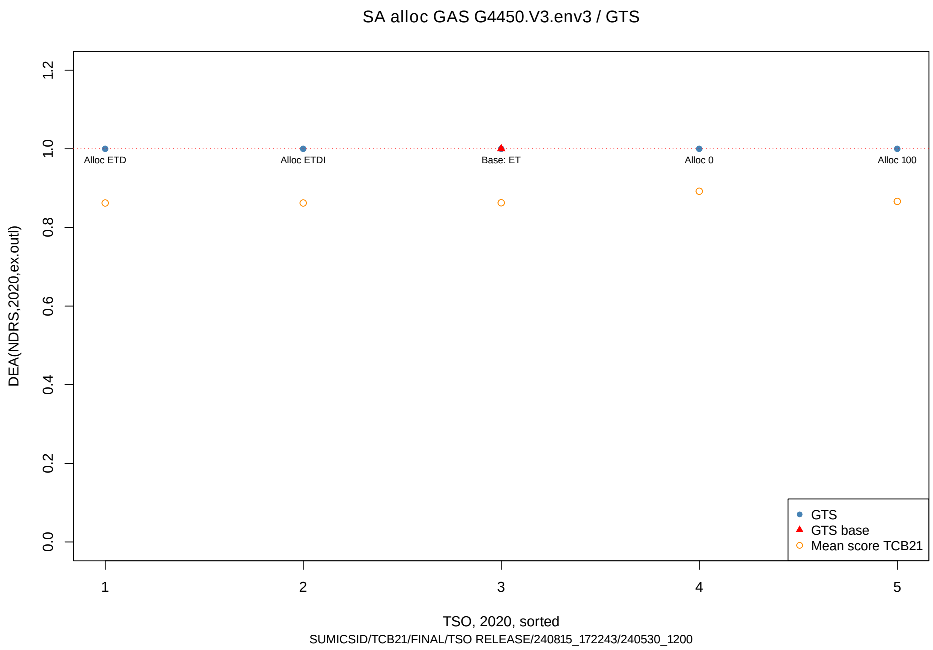

Figure 4.24: DEA(ndrs,exo,2020) scores for GTS under alternative overhead allocation regimes, G4450.V3.env3

4.7 Environmental correction factors

For each model, a variant using environmental correction factors expressing the complexity of network installations and operations in different environments related to landuse, slope, top- and subsoil structure, wind, humidity and wetness conditions(see list of notation in Table 4.2 below). The factors are applied to the relevant output elements, e.g., the wind-complexity only applies to overhead-line outputs in electricity, not to cables or transformers.

The factors are chosen based on their explanatory power in the Model Specification Note. The impact is qualitatively illustrated in Figs. 4.25 to 4.26 below. The detailed impact is listed in Appendix A.11 in Tables A.35 to A.36 below.

The change is the ratio of the score for the alternative environmental correction Z to the base score for the environmental variant of the corresponding environmental model, i.e.:

$$change.Z = \frac{DEA(ndrs, 2020, Z)}{Base.DEA.env(ndrs, 2020)} \tag{4.2}$$

The operators 'max' and 'min' denote the maximum and minimum corresponding ratios, respectively.

The notation in the name (X.Y) indicates the correction applied to term1 (X) and term 2 (Y), respectively. A zero (0) denotes no correction term. For the model specifications, see Tables 2.2 to 2.5.

Table 4.2: Notation for environmental factors.

Acronym	Definition
L	Landuse impact
S	Slope
GG	Top- and Subsoil Gravel
V	Volume of stone

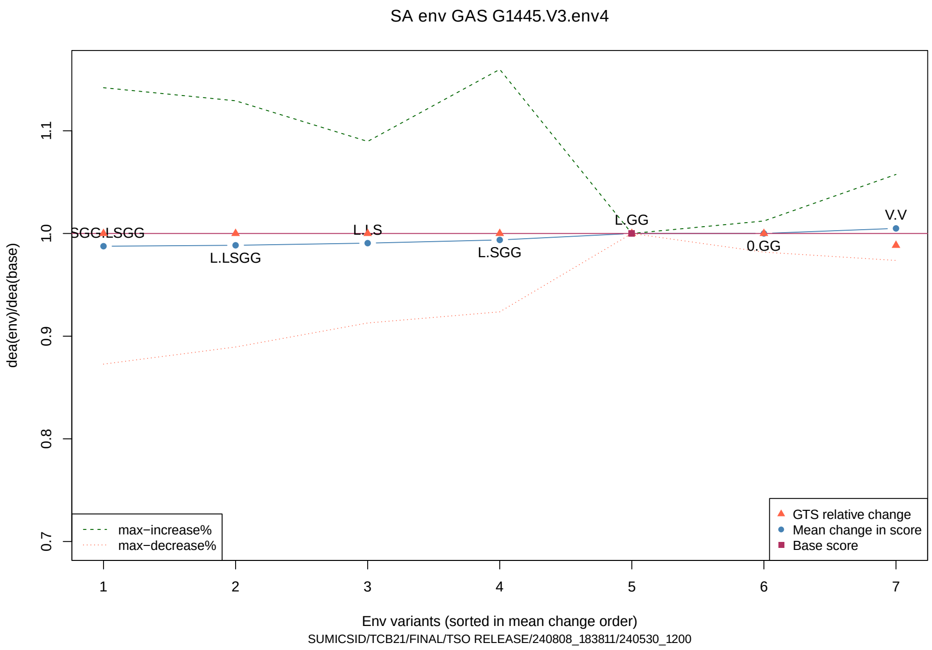

Figure 4.25: Relative change in DEA(ndrs,exo,2020) score for alternative environmental correction factors in G1445.V3.env4 for GTS and TCB21 operators.

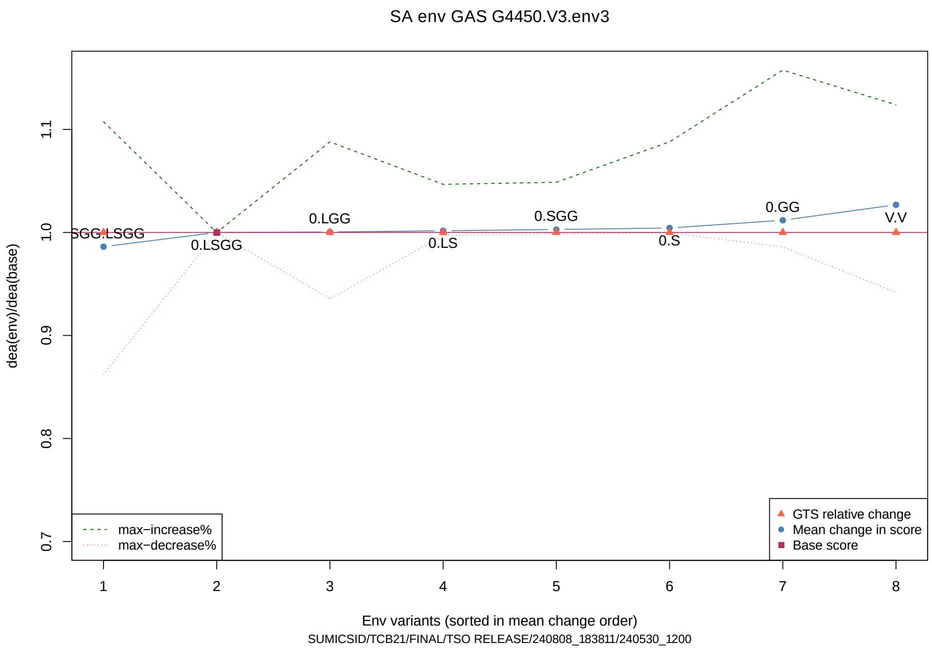

Figure 4.26: Relative change in DEA(ndrs,exo,2020) score for alternative environmental correction factors in G4450.V3.env3 for GTS and TCB21 operators.

Chapter 5

Cost development

In this chapter the dynamic cost development for GTS compared to that for the gas operators in TCB21 is analyzed by cost type for the benchmarked activities T,M,P. The cost development indexed at 2016 for Totex, Capex and Opex for GTS, its peers and the mean gas operator are listed in 5.1 below. All results are inflation-adjusted and adjusted for LCI. The cumulative change in this section refers to the ratio below between a year t and the initial year 2016:

$$dev.Totex_t = \frac{Totex_t}{Totex_{2016}} \tag{5.1}$$

In a serie of graphs we show the relative cost development to grid growth, see Figs 5.1 to 5.5 below. The line for GTS is drawn as red line, the peers (all models) are navyblue and the mean results are in grey. Grid growth is measured as NormGrid. All cost data are adjusted for inflation using 2020 as base year, the analysis thus concerns real cost development.

This information is useful to consider specific sources of efficiency and in-efficiency compared to the comparators, considering the earlier analyses for profile, age and sensitivity.

Table 5.1: Cost development (index=2016)

	2016	2017	2018	2019	2020
dev.Totex GTS	1.000	1.008	1.020	0.973	0.980
dev.Capex GTS	1.000	1.009	1.035	1.041	1.044
dev.Opex GTS	1.000	1.007	0.984	0.806	0.820
dev.Totex.peers	1.000	1.008	1.020	0.973	0.980
dev.Totex.mean.tcb21	1.000	1.017	1.059	1.077	1.177
grid.growth GTS	1.000	1.000	1.000	1.000	1.000
grid.growth.mean.tcb21	1.000	1.000	1.001	1.004	1.031

Figure 5.1: Development of totex for GTS 2016-2020.

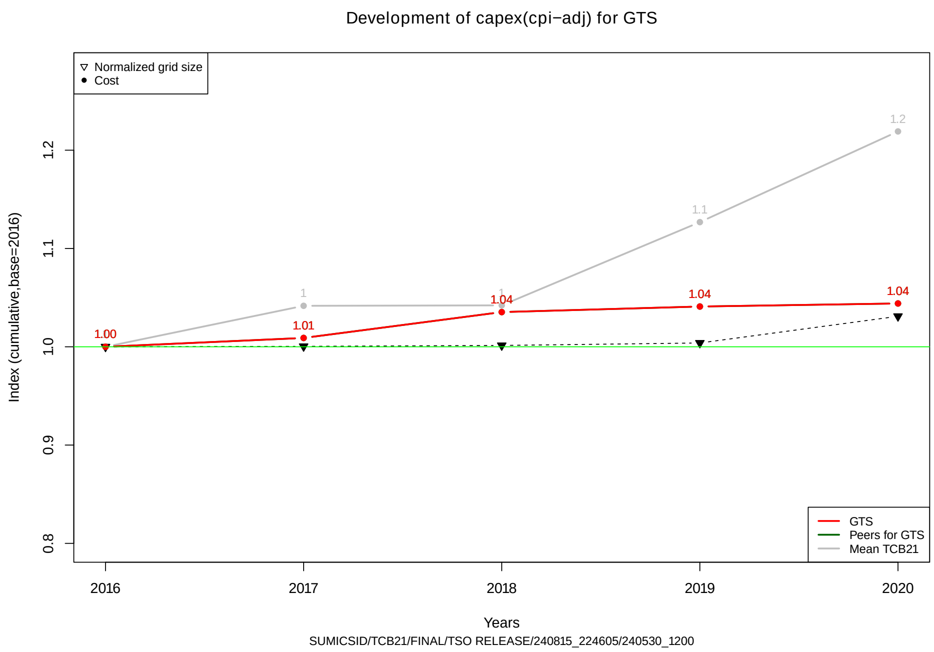

Figure 5.2: Development of capex for GTS 2016-2020.

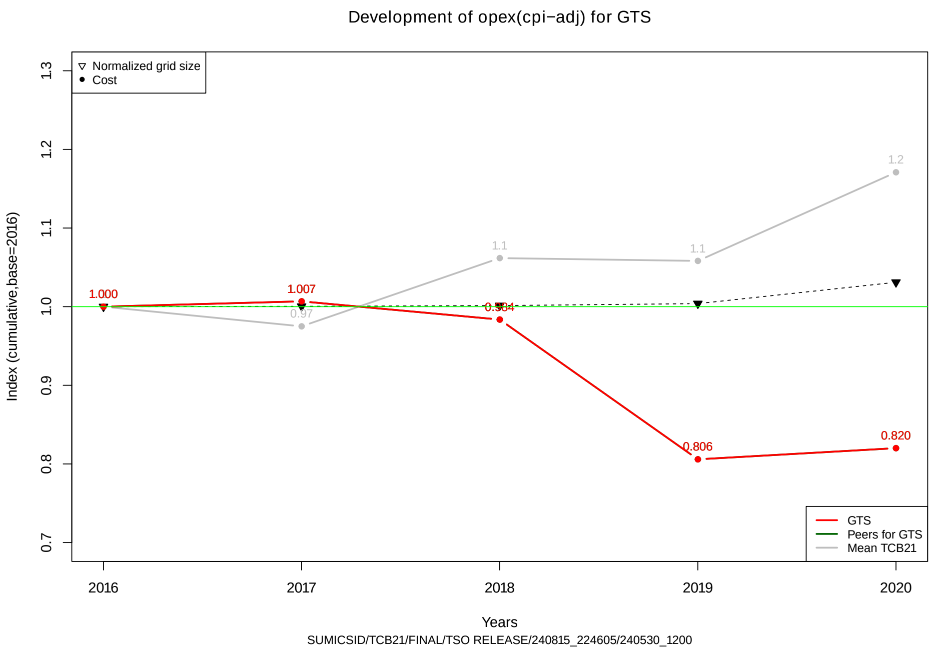

Figure 5.3: Development of opex for GTS 2016-2020.

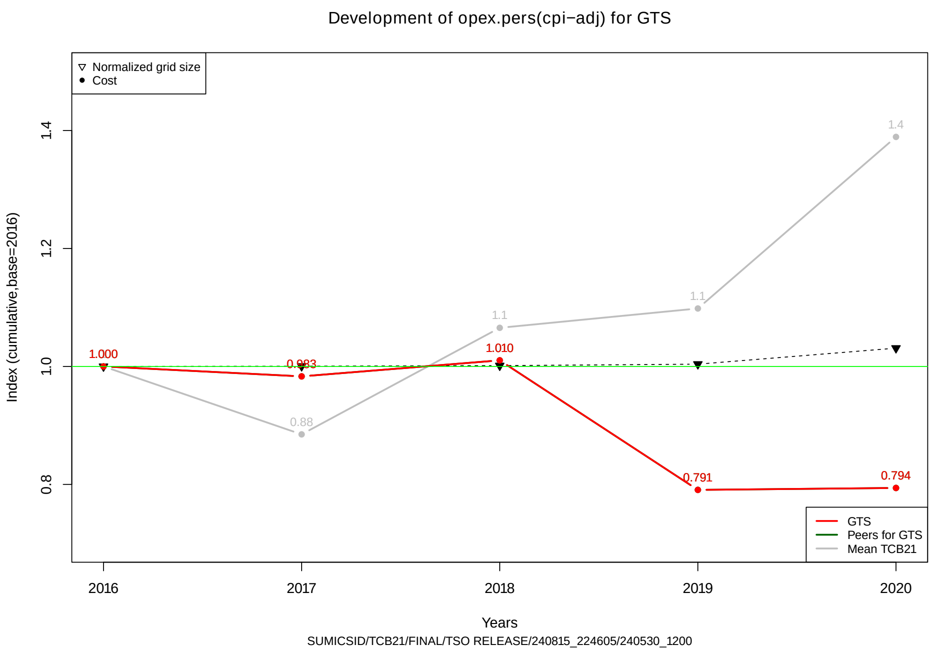

Figure 5.4: Development of opex.pers for GTS 2016-2020.

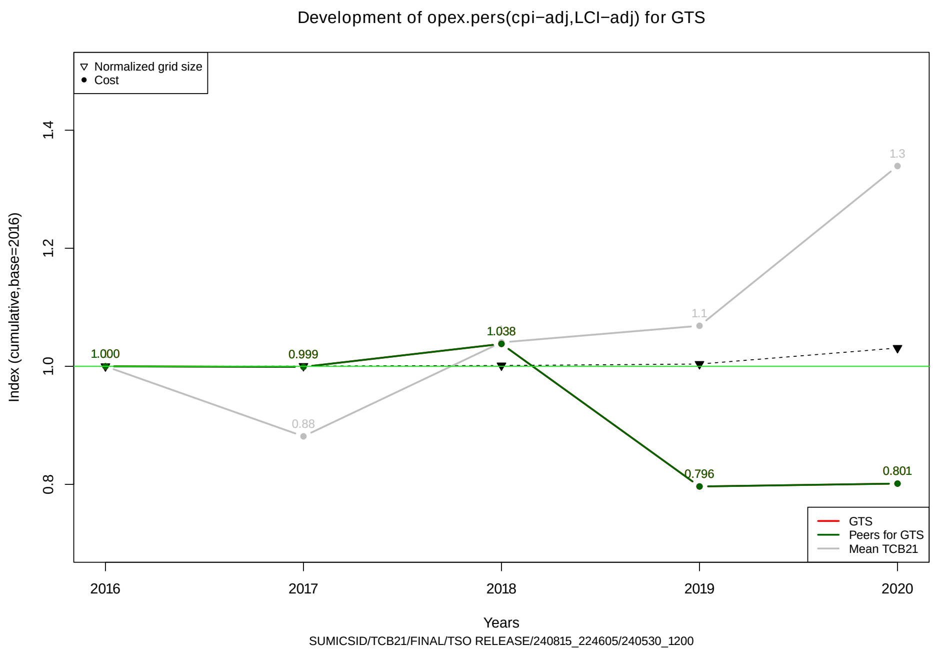

Figure 5.5: Development of opex.pers.lci for GTS 2016-2020.

Appendix A

Appendix

A.1 Parameters and reference values

The settings in Table A.1 are used in the calculations for the efficiency with the numerical parameters in Table A.2. The choice of these parameters is discussed further in the notes on Method and Model Specification, respectively.

Table A.1: Key settings.

parameter.names	parameter.values
Run date	15/08/2024
Real interest rate	0.016
CAPEX Exchange rate EUR 2020	1
OPEX Exchange rate EUR 2020	1
Inflation index:	hicpigne_cpiw
Labor cost index:	plci_util

Table A.2: Key parameters.

parameter.names	parameter.values
Labor cost index 2016	1.37
Labor cost index 2017	1.32
Labor cost index 2018	1.30
Labor cost index 2019	1.32
Labor cost index 2020	1.34
Overhead allocation TMP	0.56
Overhead allocation S	0.17
Overhead allocation X	0.03
Overhead allocation TO	0.05
Overhead allocation O	0.18
Investment life Pipelines	60.00
Investment life Regulators	30.00
Investment life Compressors	30.00
Investment life Connection points	30.00
Investment life Metering stations	30.00
Investment life Control centers	20.00
Investment life Inpipes	20.00
Investment life Odorisation	20.00
Investment life Gaschromat	10.00
Investment life Delivery station	30.00
Investment life Equipment	10.00

A.2 Notation for indicators

Table A.3: Notation KPI for staff cost shares

variable	formula
OpexShare.TMP	xOpex(TMP)/xTotex(TMP)
OpexShare.S	xOpex(S)/xTotex(TMP)
OpexShare.X	xOpex(X)/xTotex(TMP)
OpexShare.TO	xOpex(TO)/xTotex(TMP)
OpexShare.SF	xOpex(SF)/xTotex(TMP)
OpexShare.O	xOpex(O)/xTotex(TMP)
OpexShare.I	xOpex(I)/xTotex(TMP)
OpexShare.totex.all	xOpex(all.fcn)/xTotex(all.fcn)
PersShare.opex.nosalind	xOpex(pers,no.indircost,no.LCI)/xOpex(TMP,no.indircost,no.LCI)
PersShare.opex.salind	xOpex(pers,no.indircost,LCI)/xOpex(TMP,no.indircost,LCI)
PersShare.totex.nosalind	xOpex(pers,no.indircost,LCI)/xTotex(TMP,no.indircost,no.LCI)
PersShare.totex.salind	xOpex(pers,no.indircost,LCI)/xTotex(TMP,no.indircost,LCI)
IndirShare.totex	xOpex(I)/xTotex(TMP,no.indircost)

Table A.4: Notation Aggregate Totex indicators

variable	formula
UCT.pipe.km	xTotex/yPipes.tot
UCT.comp.pc	xTotex/yCompressors.pc
UCT.pipevol	xTotex/yPipes.vol.tot
UCT.ng	xTotex/yNGa

Table A.5: Notation Aggregate Opex indicators

variable	formula
UCO.pipe.km	xOpex/yPipes.tot
UCO.comp.pc	xOpex/yCompressors.pc
UCO.pipevol	xOpex/yPipes.vol.tot
UCO.ng.opex	xOpex/yNGO

Table A.6: Notation Aggregate Capex indicators

variable	formula
UCC.pipe.km	xCapex/yPipes.tot
UCC.comp.pc	xCapex/yCompressors.pc
UCC.pipevol	xCapex/yPipes.vol.tot
UCC.ng.capex	xCapex/yNGC

Table A.7: Notation Technical indicators and ratios

variable	formula
comp.power.pipe.km	yCompressors.power.tot/yPipes.tot
metering.stations.pipe.km	yMeters.tot/yPipes.tot
cp.comp.pipe.km	yConnectionpoints.tot/yPipes.tot
cp.comp.power	yConnectionpoints.tot/yCompressors.power.tot
comp.pc.new	yCompressors.pc(new,2016-2020)
comp.power.new	yCompressors.power(new,2016-2020)
pipe.km.new	yPipes.tot(new,2016-2020)

Table A.8: Notation Disaggregated Capex indicators

variable	formula
UCC.pipe.pipe.km	xCapex(pipelines)/yPipes.tot
UCC.comp.comp.pc	xCapex(compressors)/yCompressors.pc
UCC.pipe.pipevol	xCapex(pipelines)/yPipes.vol.tot

Table A.9: Notation Disaggregated Opex indicators

variable	formula
UCO.p.inv.tot	xOpex(P)/mean(xCapex(new inv-2016-2020))
UCO.m.pipe.km.tot	xOpex(M) /yPipes.tot
UCO.m.comp.power	xOpex(M)/yCompressors.power.tot
UCO.m.ng.opex	xOpex(M) /yNGO
UCO.m.connectionpoints	xOpex(M)/yConnectionpoints.tot

Table A.10: Notation Staff cost indicators

variable	formula
pers.cost.fte	xCost(pers,excl LCI)/Pers(fte)
pers.cost.tmp	xCost(pers, TMP)
pers.fte.ng	Pers(fte)/yNGC
pers.fte.pipe.km	Pers(fte)/yPipes_tot

A.3 UC graphs

The unit cost (UC) measures in the following graphs are defined for a TSO k and a year y as follows:

$$UC_{totex}(k,y) = xTotex(k,y)/yNGa(k,y)$$
$$UC_{opex}(k,y) = xOpex(k,y)/yNGa(k,y)$$
$$UC_{capex}(k,y) = xCapex(k,y)/yNGa(k,y)$$

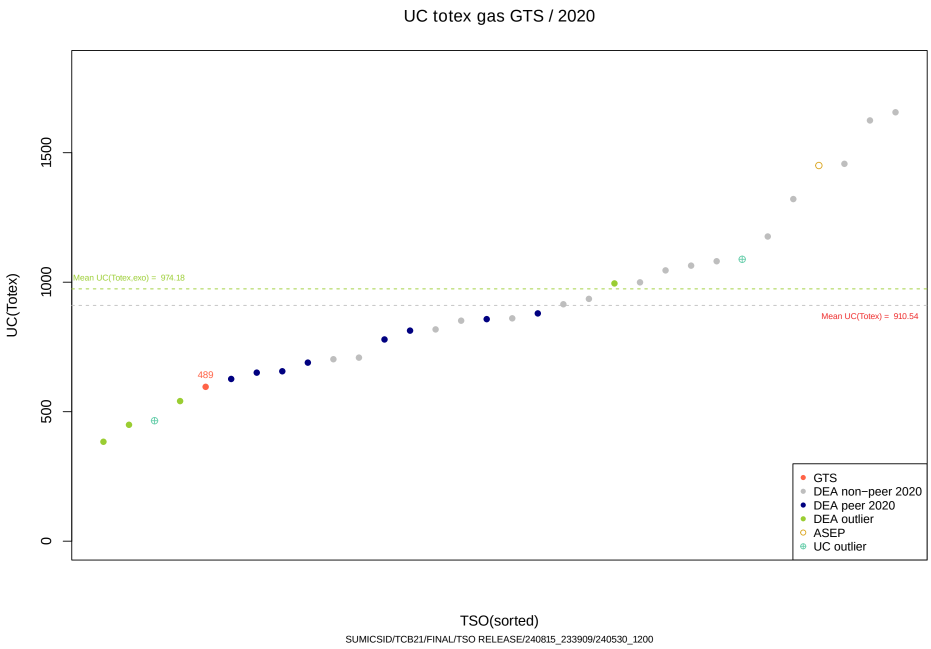

Figure A.1: Unit cost (UC) Totex.

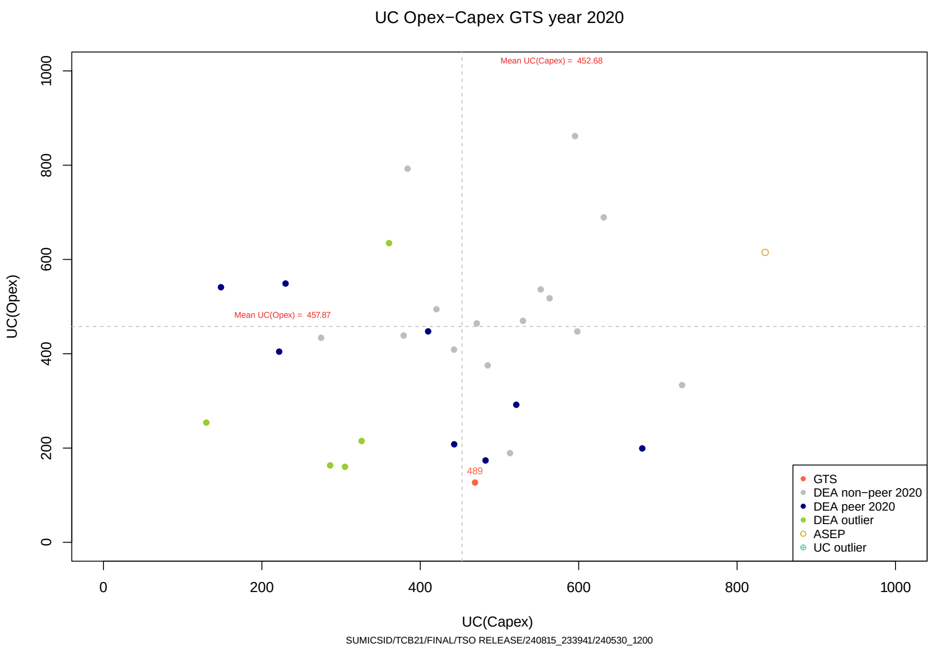

Figure A.2: Unit cost UC(Opex) vs UC(Capex).

A.4 Labour cost indexes

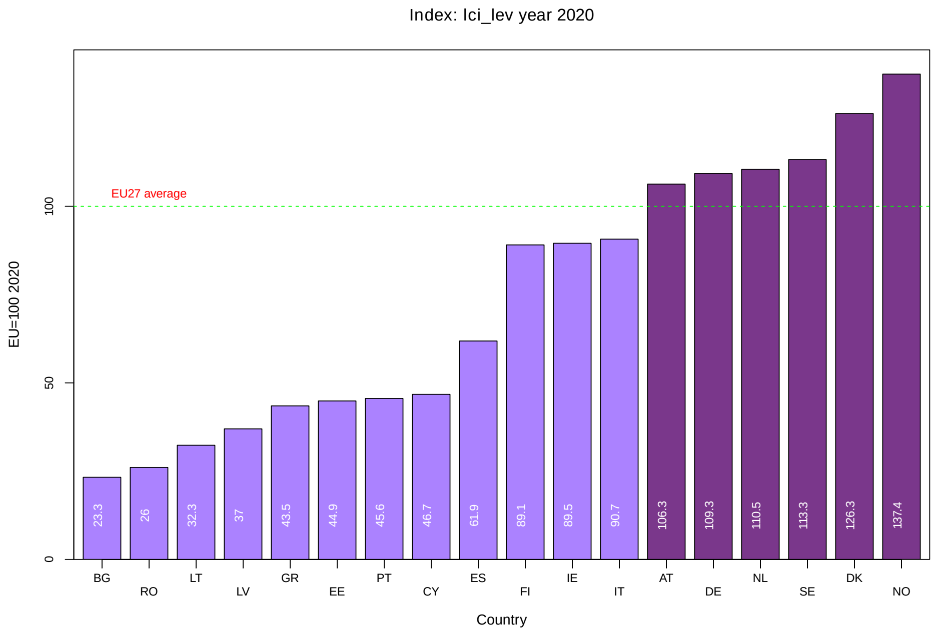

Figure A.3: Labour cost index LCI-LEV 2020 by country.

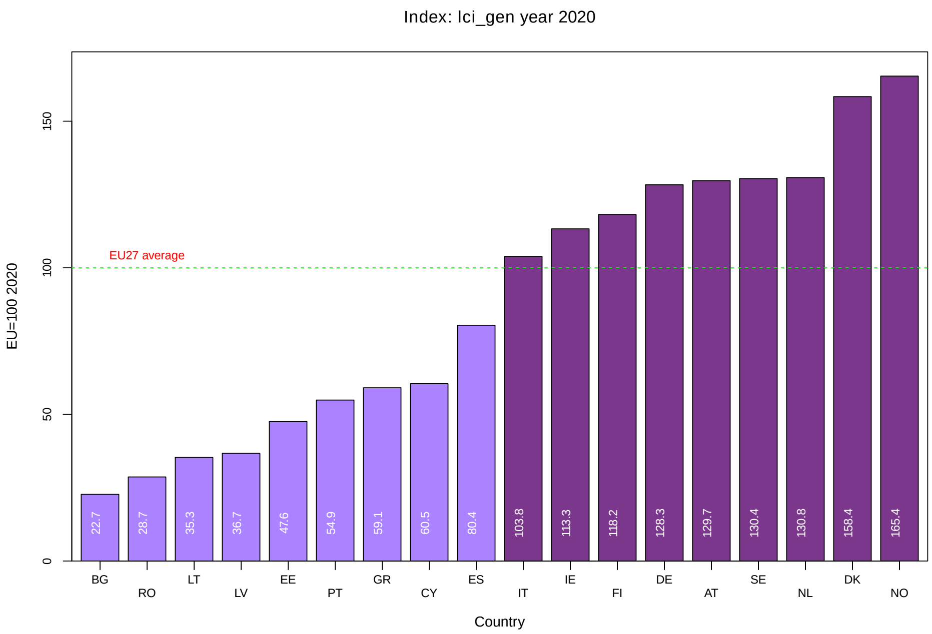

Figure A.4: Labour cost index LCI-GEN 2020 by country.

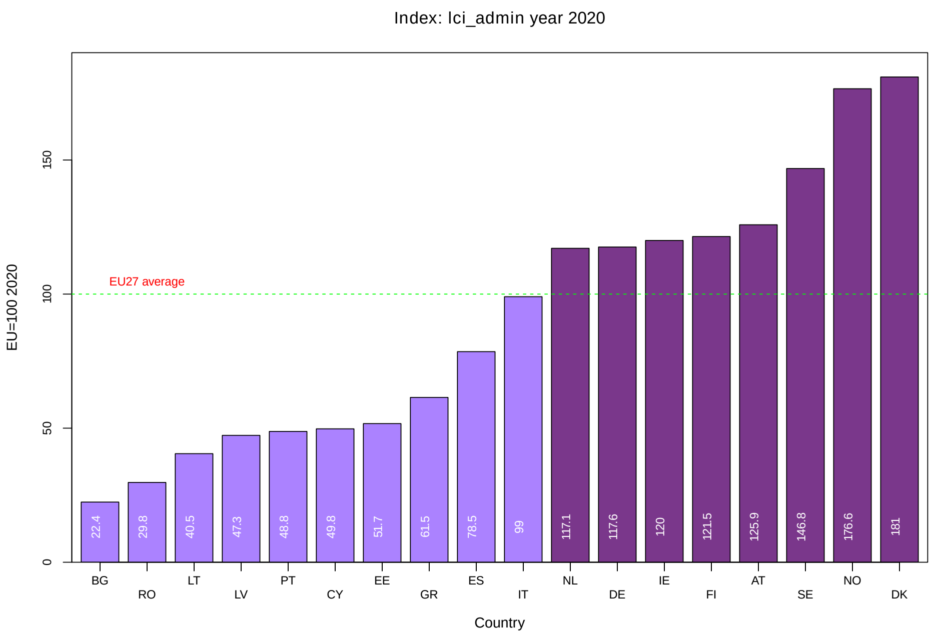

Figure A.5: Labour cost index LCI-ADMIN 2020 by country.

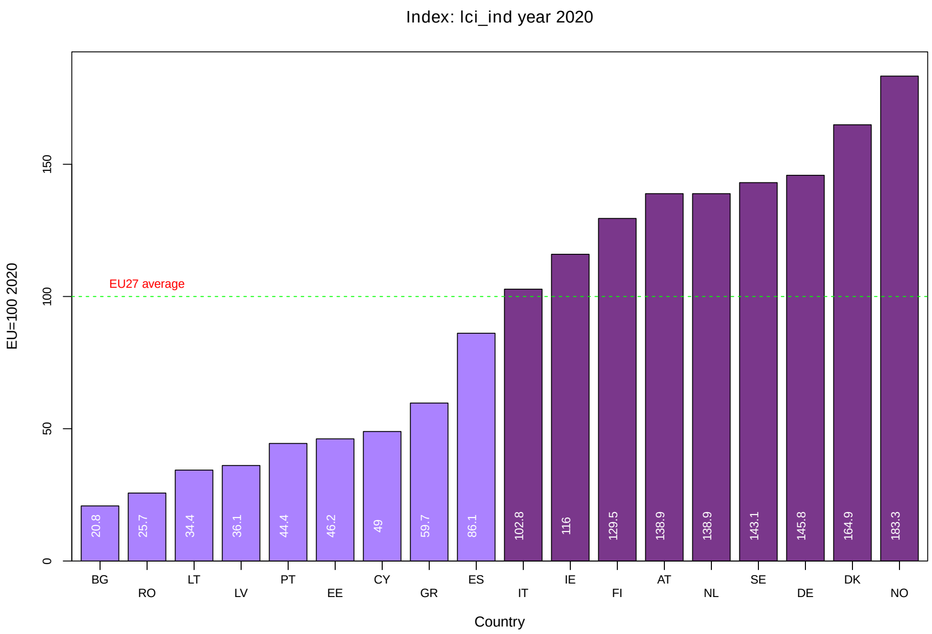

Figure A.6: Labour cost index LCI-IND 2020 by country.

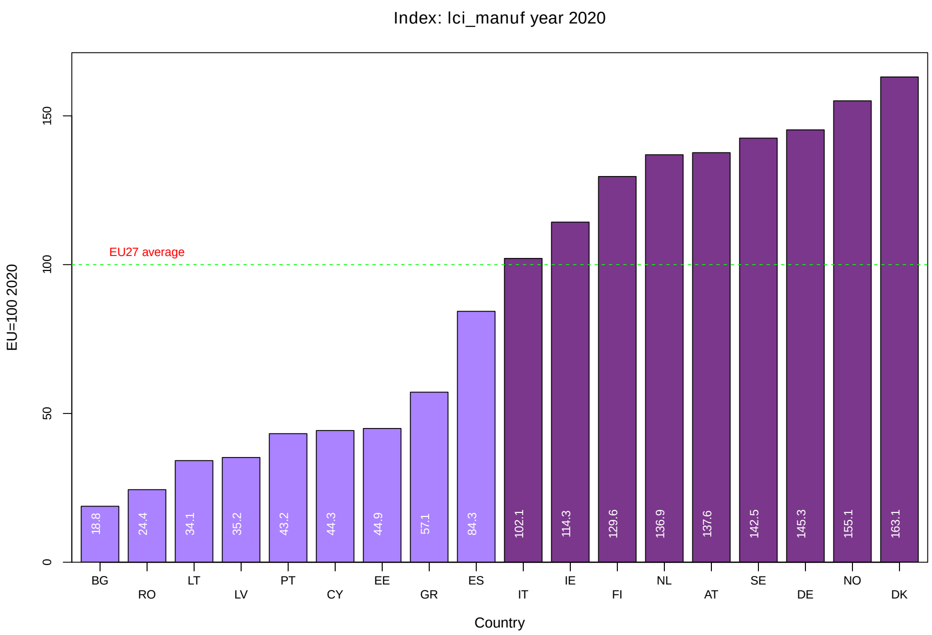

Figure A.7: Labour cost index LCI-MANUF 2020 by country.

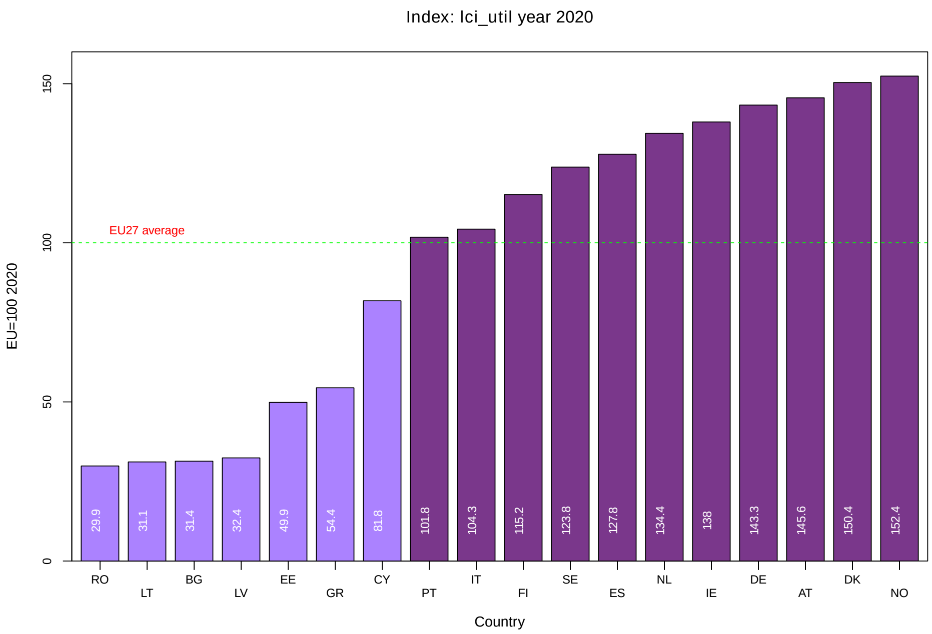

Figure A.8: Labour cost index LCI-UTIL 2020 by country.

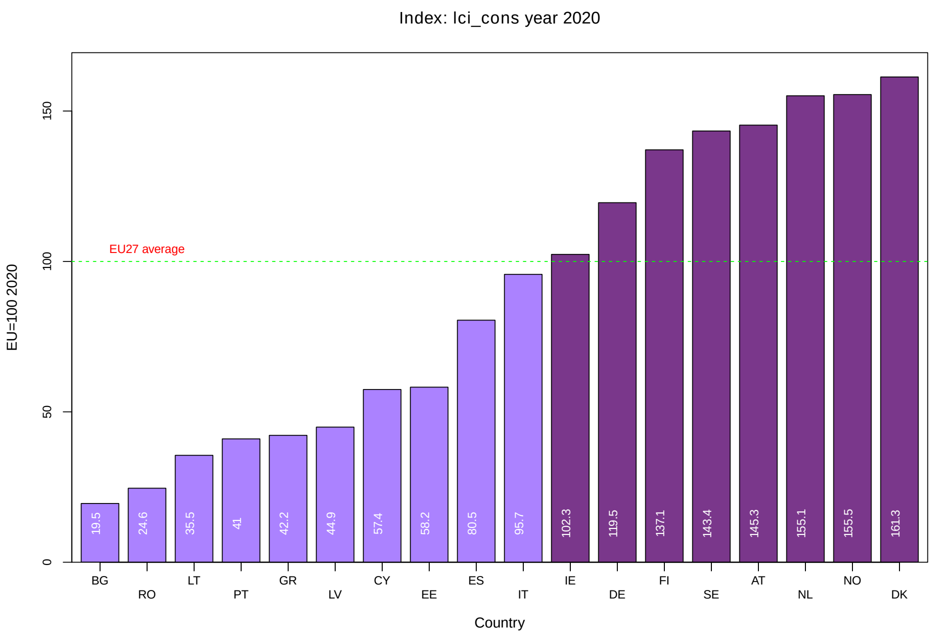

Figure A.9: Labour cost index LCI-CONS 2020 by country.

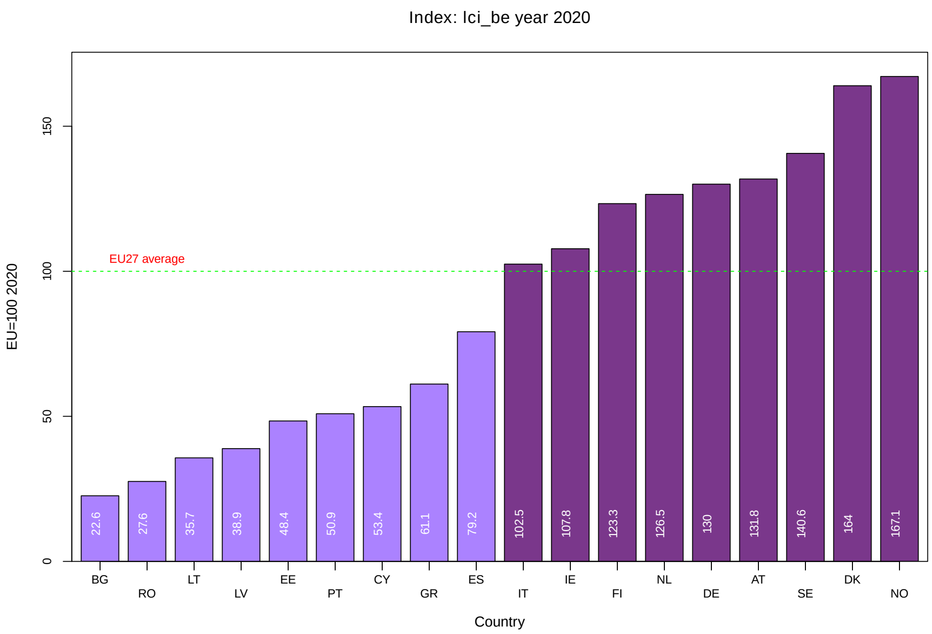

Figure A.10: Labour cost index LCI-BE 2020 by country.

A.5 Sensitivity analysis: interest rate

Table A.11: Sensitivity analysis rate model G1445.V3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
0.006	1.000	0.838
0.007	1.000	0.839
0.008	1.000	0.840
0.009	1.000	0.842
0.01	1.000	0.843
0.011	1.000	0.843
0.012	1.000	0.844
0.013	1.000	0.844
0.014	1.000	0.845
0.015	1.000	0.846
0.016	1.000	0.846
0.017	1.000	0.847
0.018	1.000	0.847
0.019	1.000	0.847
0.02	1.000	0.847
0.021	1.000	0.846
0.022	1.000	0.846
0.023	1.000	0.846
0.024	1.000	0.846
0.025	0.994	0.845
0.026	0.985	0.844
0.027	0.976	0.844
0.028	0.967	0.843
0.029	0.958	0.843
0.03	0.949	0.842
0.031	0.941	0.841
0.032	0.933	0.841
0.033	0.925	0.840
0.034	0.917	0.840
0.035	0.909	0.839
0.036	0.902	0.838
0.037	0.894	0.837
0.038	0.887	0.836
0.039	0.880	0.835
0.04	0.873	0.834
0.041	0.866	0.833
0.042	0.860	0.832
0.043	0.853	0.831
0.044	0.847	0.830
0.045	0.841	0.829
0.046	0.835	0.828
0.047	0.829	0.827
0.048	0.823	0.826
0.049	0.817	0.825
0.05	0.812	0.824

Table A.12: Sensitivity analysis rate model G1445.V3.env4 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
0.006	1.000	0.834
0.007	1.000	0.836
0.008	1.000	0.837
0.009	1.000	0.838
0.01	1.000	0.839
0.011	1.000	0.840
0.012	1.000	0.841
0.013	1.000	0.841
0.014	1.000	0.842
0.015	1.000	0.842
0.016	1.000	0.843
0.017	1.000	0.843
0.018	1.000	0.844
0.019	1.000	0.844
0.02	1.000	0.844
0.021	1.000	0.844
0.022	1.000	0.844
0.023	1.000	0.844
0.024	1.000	0.843
0.025	1.000	0.843
0.026	1.000	0.843
0.027	0.992	0.842
0.028	0.983	0.841
0.029	0.974	0.841
0.03	0.965	0.840
0.031	0.957	0.840
0.032	0.948	0.839
0.033	0.940	0.838
0.034	0.932	0.838
0.035	0.925	0.837
0.036	0.917	0.836
0.037	0.909	0.835
0.038	0.902	0.834
0.039	0.895	0.833
0.04	0.888	0.832
0.041	0.881	0.831
0.042	0.874	0.829
0.043	0.868	0.828
0.044	0.860	0.827
0.045	0.853	0.826
0.046	0.846	0.825
0.047	0.839	0.824
0.048	0.833	0.823
0.049	0.826	0.822
0.05	0.820	0.821

Table A.13: Sensitivity analysis rate model G4450.V3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
0.006	1.000	0.862
0.007	1.000	0.863
0.008	1.000	0.864
0.009	1.000	0.865
0.01	1.000	0.866
0.011	1.000	0.867
0.012	1.000	0.868
0.013	1.000	0.868
0.014	1.000	0.869
0.015	1.000	0.870
0.016	1.000	0.871
0.017	1.000	0.871
0.018	1.000	0.872
0.019	1.000	0.872
0.02	1.000	0.873
0.021	1.000	0.873
0.022	1.000	0.873
0.023	1.000	0.874
0.024	1.000	0.874
0.025	1.000	0.874
0.026	1.000	0.874
0.027	1.000	0.874
0.028	1.000	0.873
0.029	1.000	0.873
0.03	0.992	0.872
0.031	0.984	0.872
0.032	0.976	0.871
0.033	0.969	0.870
0.034	0.961	0.869
0.035	0.954	0.869
0.036	0.947	0.868
0.037	0.940	0.867
0.038	0.933	0.866
0.039	0.926	0.865
0.04	0.920	0.864
0.041	0.913	0.863
0.042	0.907	0.861
0.043	0.901	0.860
0.044	0.895	0.858
0.045	0.889	0.857
0.046	0.884	0.855
0.047	0.878	0.854
0.048	0.873	0.853
0.049	0.867	0.851
0.05	0.862	0.850

Table A.14: Sensitivity analysis rate model G4450.V3.env3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
0.006	1.000	
0.007	1.000	0.850
0.008	1.000	0.852
0.009	1.000	0.853
0.01	1.000	0.855
0.011	1.000	0.856
0.012	1.000	0.858
0.013	1.000	0.859
0.014	1.000	0.860
0.015	1.000	0.861
0.016	1.000	0.863
0.017	1.000	0.864
0.018	1.000	0.865
0.019	1.000	0.866
0.02	1.000	0.867
0.021	1.000	0.868
0.022	1.000	0.868
0.023	1.000	0.869
0.024	1.000	0.870
0.025	1.000	0.870
0.026	1.000	0.870
0.027	1.000	0.869
0.028	1.000	0.869
0.029	0.997	0.869
0.03	0.989	0.868
0.031	0.982	0.868
0.032	0.974	0.867
0.033	0.967	0.866
0.034	0.959	0.866
0.035	0.952	0.865
0.036	0.945	0.865
0.037	0.938	0.864
0.038	0.932	0.863
0.039	0.925	0.862
0.04	0.918	0.860
0.041	0.912	0.859
0.042	0.906	0.858
0.043	0.899	0.857
0.044	0.893	0.855
0.045	0.888	0.854
0.046	0.882	0.852
0.047	0.876	0.851
0.048	0.871	0.850
0.049	0.865	0.848
0.05	0.860	0.847

A.6 Standardized age assumptions

Table A.15: Sensitivity analysis std-age model G1445.V3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
Age-Low	0.410	0.535
Age-Base	1.000	0.846
Age-High	0.982	0.833

Table A.16: Sensitivity analysis std-age model G1445.V3.env4 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
Age-Low	0.430	0.528
Age-Base	1.000	0.843
Age-High	0.986	0.830

Table A.17: Sensitivity analysis std-age model G4450.V3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
Age-Low	0.617	0.636
Age-Base	1.000	0.871
Age-High	0.989	0.837

Table A.18: Sensitivity analysis std-age model G4450.V3.env3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
Age-Low	0.617	0.632
Age-Base	1.000	0.863
Age-High	0.987	0.832

A.7 Impact of labour cost indexes (LCI)

Table A.19: Sensitivity analysis lci model G1445.V3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
lci_lev	1.000	0.842
lci_gen	1.000	0.845
lci_admin	1.000	0.844
lci_ind	1.000	0.849
lci_manuf	1.000	0.847
lci_util	1.000	0.846
lci_cons	1.000	0.844
lci_be	1.000	0.846

Table A.20: Sensitivity analysis lci model G1445.V3.env4 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
lci_lev	1.000	0.840
lci_gen	1.000	0.843
lci_admin	1.000	0.842
lci_ind	1.000	0.846
lci_manuf	1.000	0.844
lci_util	1.000	0.843
lci_cons	1.000	0.841
lci_be	1.000	0.845

Table A.21: Sensitivity analysis lci model G4450.V3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
lci_lev	1.000	0.863
lci_gen	1.000	0.866
lci_admin	1.000	0.863
lci_ind	1.000	0.864
lci_manuf	1.000	0.863
lci_util	1.000	0.871
lci_cons	1.000	0.856
lci_be	1.000	0.865

Table A.22: Sensitivity analysis lci model G4450.V3.env3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
lci_lev	1.000	0.860
lci_gen	1.000	0.863
lci_admin	1.000	0.863
lci_ind	1.000	0.863
lci_manuf	1.000	0.862
lci_util	1.000	0.863
lci_cons	1.000	0.855
lci_be	1.000	0.864

A.8 Salary corrections for capitalized labor in investments

The notation denotes the proportion for adjustment ψ, i.e., $\psi = 0.25 = 25$ percent of nominal investment is adjusted.

Table A.23: Sensitivity analysis caplab model G1445.V3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
0	1.000	0.846
0.05	1.000	0.843
0.1	1.000	0.839
0.15	1.000	0.835
0.2	1.000	0.832
0.25	1.000	0.828
0.3	1.000	0.825
0.35	1.000	0.822
0.4	1.000	0.819
0.45	1.000	0.816
0.5	1.000	0.814

Table A.24: Sensitivity analysis caplab model G1445.V3.env4 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
0	1.000	0.843
0.05	1.000	0.839
0.1	1.000	0.836
0.15	1.000	0.831
0.2	1.000	0.827
0.25	1.000	0.824
0.3	1.000	0.821
0.35	1.000	0.818
0.4	1.000	0.815
0.45	1.000	0.812
0.5	1.000	0.810

Table A.25: Sensitivity analysis caplab model G4450.V3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
0	1.000	0.871
0.05	1.000	0.870
0.1	1.000	0.870
0.15	1.000	0.870
0.2	1.000	0.869
0.25	1.000	0.869
0.3	1.000	0.868
0.35	1.000	0.866
0.4	1.000	0.864
0.45	1.000	0.863
0.5	1.000	0.861

Table A.26: Sensitivity analysis caplab model G4450.V3.env3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
0	1.000	0.863
0.05	1.000	0.859
0.1	1.000	0.856
0.15	1.000	0.852
0.2	1.000	0.847
0.25	1.000	0.843
0.3	1.000	0.838
0.35	1.000	0.833
0.4	1.000	0.829
0.45	1.000	0.825
0.5	1.000	0.821

A.9 Impact of inflation indexes (PI)

Table A.27: Sensitivity analysis cpi model G1445.V3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
cpiw	0.959	0.851
hicp_cpiw	0.963	0.851
hicpg_cpiw	1.000	0.853
hicpig_cpiw	1.000	0.852
hicpne_cpiw	0.984	0.850
hicpigned_cpiw	1.000	0.844
hicpigne_cpiw	1.000	0.846
hicpnhu_cpiw	0.993	0.852
hicps_cpiw	0.921	0.847

Table A.28: Sensitivity analysis cpi model G1445.V3.env4 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
cpiw	0.975	0.849
hicp_cpiw	0.979	0.849
hicpg_cpiw	1.000	0.850
hicpig_cpiw	1.000	0.850
hicpne_cpiw	1.000	0.849
hicpigned_cpiw	1.000	0.841
hicpigne_cpiw	1.000	0.843
hicpnhu_cpiw	1.000	0.850
hicps_cpiw	0.937	0.846

Table A.29: Sensitivity analysis cpi model G4450.V3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
cpiw	1.000	0.875
hicp_cpiw	1.000	0.874
hicpg_cpiw	1.000	0.869
hicpig_cpiw	1.000	0.868
hicpne_cpiw	1.000	0.877
hicpigned_cpiw	1.000	
hicpigne_cpiw	1.000	0.871
hicpnhu_cpiw	1.000	0.874
hicps_cpiw	0.971	0.874

Table A.30: Sensitivity analysis cpi model G4450.V3.env3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
cpiw	1.000	0.871
hicp_cpiw	1.000	0.870
hicpg_cpiw	1.000	0.864
hicpig_cpiw	1.000	0.862
hicpne_cpiw	1.000	0.873
hicpigned_cpiw	1.000	0.848
hicpigne_cpiw	1.000	0.863
hicpnhu_cpiw	1.000	0.869
hicps_cpiw	0.968	0.869

A.10 Overhead allocation rules

Table A.31: Sensitivity analysis alloc model G1445.V3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
Alloc ETD	1.000	0.846
Alloc ETDI	1.000	0.846
Base: ET	1.000	0.846
Alloc 0	0.970	0.869
Alloc 100	1.000	0.851

Table A.32: Sensitivity analysis alloc model G1445.V3.env4 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
Alloc ETD	1.000	0.842
Alloc ETDI	1.000	0.842
Base: ET	1.000	0.843
Alloc 0	0.981	0.868
Alloc 100	1.000	0.848

Table A.33: Sensitivity analysis alloc model G4450.V3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
Alloc ETD	1.000	0.870
Alloc ETDI	1.000	0.870
Base: ET	1.000	0.871
Alloc 0	1.000	0.885
Alloc 100	1.000	0.875

Table A.34: Sensitivity analysis alloc model G4450.V3.env3 GTS

	DEA.ndrs.exo.20 GTS	Mean.DEA.ndrs.exo.20
Alloc ETD	1.000	0.862
Alloc ETDI	1.000	0.862
Base: ET	1.000	0.863
Alloc 0	1.000	0.892
Alloc 100	1.000	0.866

A.11 Environmental correction factors

The change is the ratio of the score for the alternative environmental correction Z to the base score for the environmental variant of the corresponding environmental model, i.e.:

$$change.Z = \frac{DEA(ndrs, 2020, Z)}{Base.DEA.env(ndrs, 2020)}$$

The operators 'max' and 'min' denote the maximum and minimum corresponding ratios, respectively.

The notation in the name (X.Y) indicates the correction applied to term1 (X) and term 2 (Y), respectively. A zero (0) denotes no correction term. For the model specifications, see Tables 2.2 to 2.5.

Table A.35: Sensitivity analysis env model G1445.V3.env4 GTS

	GTS score	GTS change	mean.change	max.change	min.change
G1445.V3.env4	1.000	1.000	1.000	1.000	1.000
G1445.V3.env.0.GG	1.000	1.000	1.000	1.012	0.982
G1445.V3.env.L.LS	1.000	1.000	0.991	1.090	0.913
G1445.V3.env.L.LSGG	1.000	1.000	0.988	1.129	0.889
G1445.V3.env.LSGG.LSGG	1.000	1.000	0.988	1.142	0.873
G1445.V3.env.L.SGG	1.000	1.000	0.994	1.160	0.924
G1445.V3.env.V.V	0.988	0.988	1.005	1.057	0.974

Table A.36: Sensitivity analysis env model G4450.V3.env3 GTS

	GTS score	GTS change	mean.change	max.change	min.change
G4450.V3.env3	1.000	1.000	1.000	1.000	1.000
G4450.V3.env.LSGG.LSGG	1.000	1.000	0.986	1.108	0.862
G4450.V3.env.0.LS	1.000	1.000	1.002	1.047	0.997
G4450.V3.env.0.LGG	1.000	1.000	1.000	1.088	0.936
G4450.V3.env.0.S	1.000	1.000	1.004	1.088	1.000
G4450.V3.env.0.SGG	1.000	1.000	1.003	1.049	0.999
G4450.V3.env.0.GG	1.000	1.000	1.012	1.158	0.986
G4450.V3.env.V.V	1.000	1.000	1.027	1.124	0.942