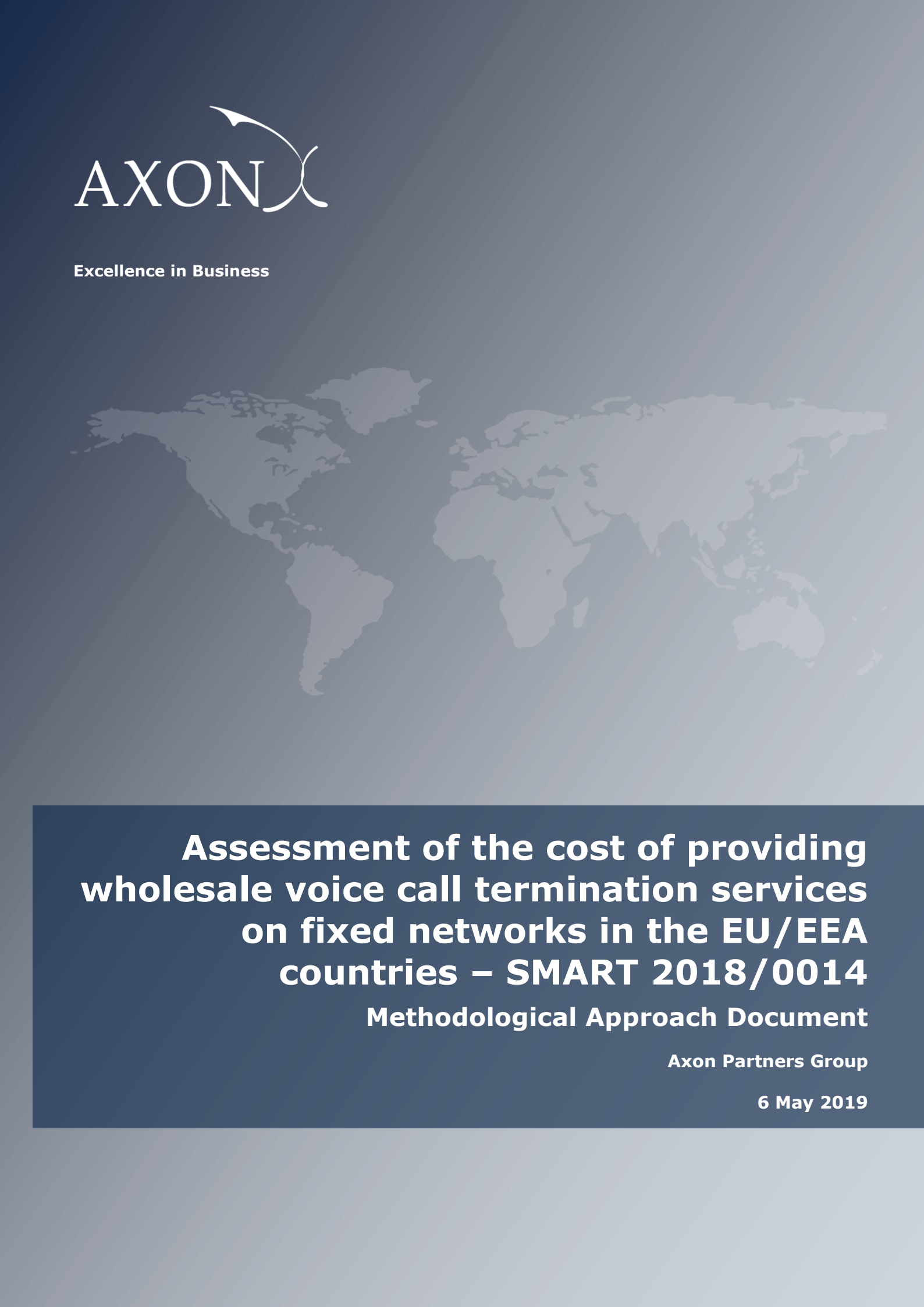


Assessment of the cost of providing wholesale voice call termination services on fixed networks in the EU/EEA countries – SMART 2018/0014

Methodological Approach Document

Axon Partners Group

6 May 2019

Contents

1. Introduction

The European Commission (hereinafter "EC") has commissioned Axon Partners Group Consulting S.L.U. (hereinafter "Axon Consulting" or "Axon") to carry out the "Assessment of the cost of providing wholesale voice call termination services on fixed networks in the EU/EEA countries[1]" ('the Project').

As described during the Workshop 1, held on 23 October 2018 at the EC's headquarters[2], the EC has deemed relevant to develop a new cost study to understand the costs of providing fixed termination voice services in EU/EEA countries. As part of this cost study, the Axon/EC team has developed a Bottom-Up cost model that calculates the costs of providing wholesale voice call termination services on fixed networks in the EU/EEA countries.

This document includes:

- An overview of the main methodological approaches adopted in the development of the cost model, in line with the indications already provided in Workshop 1 (section 2).
- A description of the key inputs considered in the implementation of the model, describing how they have been produced based on the data reported by NRAs (section 3).
- An introduction to the main outputs produced by the model (section 4).

Each of these sections includes a set of questions for which we expect to receive stakeholders' feedback. In order to reply to these questions please use the Template for providing comments that the EC/Axon team have shared with NRAs. Additionally, a summary of the questions raised throughout the document is provided in section 5.

[1] SMART 2018/0014

[2] A video version of the workshop is available at: https://webcast.ec.europa.eu/fixed-termination-rates-workshop-23-10-2018

2. Methodological approach

The Commission Recommendation of 7 May 2009 on the "*Regulatory Treatment of Fixed and Mobile Termination Rates in the EU*"[3] defined the key methodological guidelines to be observed by European NRAs in the determination of fixed and mobile termination rates.

The methodological choices presented in the 2009 Recommendation have been reinforced in the European Electronic Communications Code (EECC)[4], that was adopted on 17 December 2018 and shall be transposed into the national law of EU countries no later than 21 December 2020.

The approach used in our cost study is consistent with the methodological guidelines of the 2009 Recommendation and the provisions of the EECC.

The table below provides a summary of the key methodological approaches adopted in the development of the cost model:

Methodological aspect	Approach Adopted
Cost standard	▶ Pure LRIC[5]
Cost categories considered	▶ Network CapEx ▶ Network OpEx ▶ Wholesale specific costs
Modelled operator	▶ Hypothetical Efficient operator
Assets valuation method	▶ Current Cost Accounting (CCA)
Depreciation methodology	▶ Economic depreciation
Modelled period	▶ 2015-2025

Table 2.1: Summary of the main methodological approaches adopted in the development of the cost model [Source: Axon Consulting]

[3] Source: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:124:0067:0074:EN:PDF

[4] Source: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2018:321:FULL&from=EN. Annex III "Criteria for the determination of wholesale voice termination rates" includes the relevant methodological indications about the calculation of fixed voice termination costs.

[5] Pure Long-Run Incremental Costs

Regarding the use of the Pure LRIC cost standard, the Annex III of the EECC establishes the following:

> *(b) the relevant incremental costs of the wholesale voice termination service shall be determined by the difference between the total long-run costs of an operator providing its full range of services and the total long-run costs of that operator not providing a wholesale voice termination service to third parties;*
>
> *(c) only those traffic related costs which would be avoided in the absence of a wholesale voice termination service being provided shall be allocated to the relevant termination increment;*
>
> *(d) costs related to additional network capacity shall be included only to the extent that they are driven by the need to increase capacity for the purpose of carrying additional wholesale voice termination traffic;*

In light of this, and as described during the presentation of the model's methodology in Workshop 1, network elements with no impact for the fixed voice termination service have not been modelled. This includes:

- **Access network elements** (cable, civil infrastructure, access ports and most of access equipment). These elements are driven by the number of users served - not traffic -. Therefore, costs associated with these assets are not incremental to voice termination traffic.
- **Fibre transmission links (cable) and civil infrastructure elements.** The deployment of fibre wires for transmission is mainly required to comply with the coverage needs along the national territory. Given that their deployments are not driven by voice termination traffic, the associated costs are neither avoidable nor incremental to the voice termination traffic.

The exclusion of these elements from the model was agreed by 58% of the stakeholders, based on the feedback received on the Workshop 1 proposals.

In relation to **active transmission and switching equipment**, it is known that, currently, these network elements are mostly driven by the demand of non-voice services (broadband, TV, leased lines, etc.). Therefore, the relevance of such assets is typically negligible in the calculation of the pure LRIC cost for the voice termination service. Based on the feedback provided by stakeholders in their comments to the methodology presented in Workshop 1, 77% of them agreed that costs associated with active transmission and switching equipment represent a relatively small part of the voice termination cost under the pure LRIC standard. Based on this, most of the stakeholders preferred to model these

costs by means of a mark-up applied over core network costs, rather than the more complex approach of trying to estimate the portion of costs of active equipment that were incremental to voice termination using bottom-up modelling. Hence, active transmission and switching equipment have not been modelled and, instead, their costs are considered in the model by means of a mark-up. This mark-up is calculated taking into account the portion of incremental costs that can be attributed to active transmission and switching equipment costs in several NRAs' fixed termination cost models (as further explained below).

Considerations set out in the previous paragraphs lead us to a scenario where **core network elements** are of the greatest relevance to the calculation of the incremental costs of the fixed voice termination service. In this respect, the model has been focused on the calculation of costs associated with the elements of an IMS[6] network, whose architecture was defined based on the feedback received after the Workshop 1. The employment of this architecture is also in line with the EECC, which also states in Annex III that *"the technology choice of the modelled networks shall be forward looking, based on an IP core network".*

The Annex III of the EECC also establishes that "*only those wholesale commercial costs shall be included which are directly related to the provision of the wholesale voice termination service to third parties*". Thus, in addition to the incremental costs of the core network elements and active transmission and switching equipment described above, **wholesale specific costs** incurred for the provision of wholesale voice termination services to third-party operators have also been considered in the model.

Finally, further indications were already provided in Workshop 1 with regards to the methodological treatment to be applied to other relevant elements of the cost model.

The table below provides an overview of the main methodological aspects and approaches adopted in the cost model, following the indications provided in Workshop 1 and feedback received from stakeholders:

[6] IP Multimedia Subsystem

Methodological aspect	Approach Adopted	Section
Core network architecture	▶ An IMS network architecture for the provision of fixed voice services composed of the following core elements has been modelled: • AS (Voice Application Server) • CDF (Charging Data Function) • I-CSCF (Interrogating CSCF) • S-CSCF (Serving CSCF) • Access SBC (Session Border Controller) - P-CSCF (Proxy CSCF) - IMS-AGW (IMS Access Gateway) • IX SBC (Session Border Controller) - IBCF (Interconnect Border Control Function) - TrGW (Transition Gateway) • ENUM (Electronic Number Mapping System) • MRF (Media Resource Function)	N/A
Core network equipment unitary costs	▶ Based on feedback provided by stakeholders in their comments to the methodology presented in Workshop 1, Unit CapEx prices have been defined in the model by means of price catalogues of modular equipment.	3.1.5
Active transmission and switching	▶ Based on feedback provided by stakeholders in their comments to the methodology presented in Workshop 1, a mark-up percentage applied over core network costs has been considered in the model to reflect the cost associated with active transmission and switching elements.	3.1.6
Economic depreciation	▶ The implementation of economic depreciation is performed at asset level. ▶ Production factors have been determined following a volume-based approach.	Please refer to the Annex 3 – Descriptive manual
Wholesale specific costs	▶ Regression analysis has been used to identify correlation between traffic and costs for each cost category.	3.1.7
Reference operator	▶ The cost model has been developed with a modifiable parameter for the market share of the reference operator.	3.1.1

Table 2.2: Main methodological aspects and approaches adopted in the cost model [Source: Axon Consulting]

Question 1: Do you agree with the methodological approaches adopted to develop the cost model, as presented in Table 2.1 and Table 2.2? Otherwise, please describe what you would have done differently and justify your proposal in detail. Please also describe how your proposal is consistent with the provisions in the 2009 Recommendation and the EECC, as well as provide supporting information and references.

3. Model's inputs

The cost model developed is data-intensive and has been populated with the information requested to NRAs (through the data-gathering process that ran from 4 December 2018 until 1 February 2019) as well as additional publicly available information. All the inputs considered in the cost model are thoroughly described in this section and have been split according to their source, as follows:

- Inputs gathered from stakeholders (Section 3.1)
- Standard industry inputs from publicly available sources (Section 3.2)

3.1. Inputs gathered from stakeholders

Typically, the main inputs included in Bottom-Up cost models relate to the specific characteristics of the market they represent. For this reason, the most important source of information to derive the inputs included in the cost model has been the information reported by stakeholders (NRAs and operators) through the data gathering process.

A brief description of the key milestones of the data gathering process is presented below:

- A draft Data Request Form and Manual were initially submitted to NRAs for comments on 1 November 2018.
- NRAs provided comments by 15 November 2018, which were thoroughly assessed by the EC/Axon team.
- Following the treatment of the feedback received, the final Data Request Forms[7] and the Manual were shared with NRAs on 4 December 2018 (1st Data Request) and 10 December 2018 (2nd Data Request and Manual).
- NRAs responded to the Data Request before 1 February 2019.
- The EC/Axon team assessed the completeness and validity[8] of the information received and issued requests for clarifications and missing information on 22 February 2019.
- NRAs responded to the request for clarifications and missing information by 1 March 2019.

[7] The Data Request Form was split into two parts.

[8] See following subsections regarding the validation process.

Based on the outcomes of this process, the table below recaps the data available and its level of consistency[9]:

Section	Input	Availability of information	Consistency of information
3.1.1	Market Share	High	High
3.1.2	Demand	High	High
3.1.3	Network Statistics	Medium	High
3.1.4	Percentage of traffic in the busy hour and in weekdays	High	High
3.1.5	Core Network Equipment Unitary Costs	Low	Medium
3.1.6	Mark-up for active transmission and switching costs	High	Medium
3.1.7	Wholesale specific costs	Medium	Medium
3.1.8	Core Nodes	Medium	High
3.1.9	Useful Lives	High	High
3.1.10	WACC	High	High

Table 3.1: Availability and consistency of the inputs collected from stakeholders [Source: Axon Consulting]

A thorough assessment of the information received from EU/EEA countries for each of the above inputs is presented in the upcoming subsections 3.1.1 to 3.1.10.

Each of the subsections is structured in the following blocks:

- Sources of information
- Input validation and treatment
- Input definition

Sources of information

The 'sources of information' subsection provides a high-level overview of the information provided to the EC/Axon team. In this section, we also show the level of confidentiality

[9] Assessed through cross-country comparisons with other NRAs' data and/or publicly available reports.

that the NRAs and operators indicated should be associated to each piece of information, based on the three levels of confidentiality defined in the Data Request Manual, namely:

- *Confidentiality Level 0 – Public Level:* This confidentiality level is associated with information which is available in the public domain and could be directly shared with or used in other NRAs' models to fill any potential gaps.
- *Confidentiality Level 1 – National Level:* This confidentiality level is associated with information that cannot be disclosed to NRAs of other countries (unless it is anonymised or averaged with data from other NRAs). This information can, however, be disclosed to national stakeholders in the version of the model to be shared with the NRA.
- *Confidentiality Level 2 – Operator Level:* This confidentiality level is associated with information that cannot be disclosed to any party involved in the process (unless it is anonymised or averaged with data from other operators/countries). When the model is shared for public consultation, the inputs classified under this confidentiality level are not shared with NRAs from other countries nor with the NRA from the subject country (e.g. to avoid national operators having access to information from other national operators). Therefore, this information has been anonymised or averaged before sharing the model.

Input validation and treatment

The 'Input validation and treatment' section describes the analysis performed to verify the reasonability and validity of the information received, as well as to ensure its completeness and representativeness. These analyses have been performed under three different perspectives[10]:

- *Intra-country validation*: The information provided by NRAs was analysed on a stand-alone basis to verify that it was reasonable and consistent.
- *Inter-country validation*: The information provided by NRAs was also cross-checked against the data reported by other EU/EEA NRAs. The objective of this assessment is to identify potential discrepancies between information provided by different NRAs beyond those that can be explained by country specificities.
- *Validation against public sources*: Public sources such as BEREC were consulted to cross-check the reasonability of the information received. Similarly, some relevant KPIs

[10] Not all perspectives may have been used in all the cases. Please see sections below for the detail on the perspective used in each case.

(e.g. operators' market share and number of fixed telephony lines) were also cross-checked against other international sources of that country's data to identify any potential issues with the data provided by NRAs.

We have also ensured to involve NRAs in the validation process. For example, when issues have been identified with the information provided by an NRA during the validation process, clarifications have been sought from that NRA.

Input definition

Finally, the 'input definition' section outlines the methodology used to define the inputs employed to populate the model. This section describes the entire analysis relied on by the EC/Axon team to reach the input value(s) that should be adopted in the cost model and, in particular, on whether it was more appropriate to either use an input value (i) defined at country-level or (ii) defined commonly across EU/EEA countries. The table below describes the inputs that were defined at (i) national level and (ii) using EEA averages:

Worksheet	Input level
1A INP MARKET SHARE	National level / Theoretical values (25% and 50%) (see section 3.1.1)
1B INP DEMAND	National level
1C INP NW STATISTICS	National level
1D INP CORE PLATF UNITARY COSTS	EEA average for all countries
1E INP ACTIVE TRANSMISSION COST	EEA average for all countries
2A INP NW	Standard and constant values
2B INP CORE NODES	National level
2C INP BUSY HOUR	National level
2D INP RESOURCES LIFE	EEA average for all countries
2E INP WACC	National level
2F INP SERVICE SPEC COSTS	EEA-based regressions for all countries. The conversion of minutes to calls is defined at national level.

Table 3.2: Definition of the inputs of the model at national/EEA level [Source: Axon Consulting]

3.1.1. Market Share

The market share is used in the model to define the size of the reference operator in each EU/EEA country.

Based on conclusions reached after the review of stakeholders' comments to the methodology presented in Workshop 1 and the lack of a clear preference, the cost model has been developed allowing the change of the market share of the reference operator.

More specifically, the EC/Axon has identified three potential scenarios to define the market share of the reference operator to be used in the cost model:

- *Market share of the incumbent operator (scenario 1):* Under this scenario, the market share of the incumbent operator in each country is used and shown in worksheet 1A INP MARKET SHARE[11]. Please refer to section 3.1.1.3 for further details on how this input has been defined.
- *Market share of a hypothetical operator:* In this case, the market share is set as a theoretical figure. Based on the percentages used by some NRAs in EU/EEA countries, the following options have been defined:
  - 25% (scenario 2)
  - 50% (scenario 3)

Stakeholders can assess the results obtained under each scenario by selecting the desired option in the control panel of the model (see Annex 2 - User manual for further indications on how to run the model):

[11] Note that no confidential information has been disclosed in the non-confidential version model shared with NRAs for consultation. Please refer to the main consultation document for further indications on the treatment given to confidential information in the cost model circulated to NRAs.

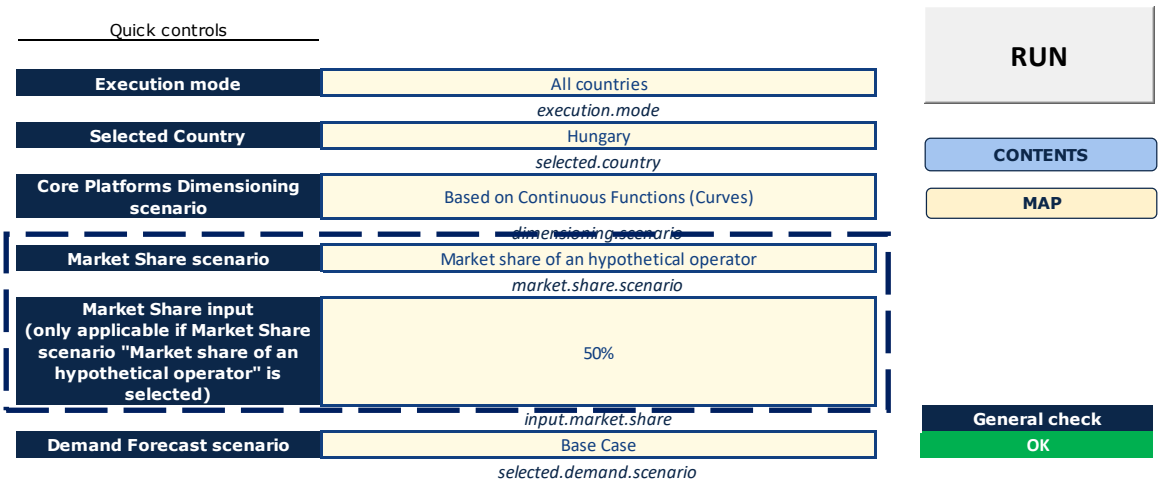


Exhibit 3.1: Selection of the market share scenario in the model [Source: Axon Consulting]

Question 2: In your opinion, what scenario should be adopted to consider the market share of the reference operator in EU/EEA countries? Please describe your preferred approach in detail and explain the regulatory rationale behind your choice. In case you consider that a market share different from the options provided should be used, please provide supporting information justifying your choice.

Question 3: In your opinion, should the same scenario for the market share of the reference operator be applied to all EU/EEA countries? Please describe the rationale behind your answer, providing supporting references and any regulatory principles or regulations that support your position.

3.1.1.1. Sources of information

Market share information was provided by NRAs through the Data Request Form. They indicated the number of fixed operators in the market as well as their market shares. The tables below indicate the availability and confidentiality of the data reported by NRAs.

Data availability

Status	Countries
Complete information	AT, BE, BG, CY, CZ, DE, DK, EE, EL, ES, FR, HR, HU, IE, IT, LT, LU, LV, MT, NL, NO, PL, PT, RO, SE, SI, SK, UK
High-priority information provided	-
Not all high-priority information provided	-
No information provided	FI, IS, LI[12]

Table 3.3: Market Share – Data availability [Source: Axon Consulting]

Data confidentiality

Confidentiality level	Countries
Confidentiality level 0	AT, BG, CY, CZ, ES, HR, IT, LU, MT, NO, SE, UK
Confidentiality level 1	-
Confidentiality level 2	BE, DE, DK, EE, EL, FR, HU, IE, LT, LV, NL, PL, PT, RO, SI, SK

Table 3.4: Market Share – Data confidentiality [Source: Axon Consulting]

No confidential information has been disclosed in the non-confidential version of the model shared with NRAs for consultation. Please refer to the main consultation document for further indications on the treatment given to confidential information in the non-confidential version of the cost model circulated to NRAs.

3.1.1.2. Input validation and treatment

The information provided by the NRAs was validated by checking that the sum of the market share of all the operators reported was representative of the total market at country level. Specifically, the sum of market shares was verified to fall within a ±5% range from 100%.

Issues were initially identified in LT, LV and SE, where the sum of individual market shares were below 95%. The NRAs of these countries were contacted to identify the reasons.

[12] As it will be observed throughout this document, FI, IS and LI did not participate in the data collection process. Therefore, no information about these three countries is presented anywhere in this document.

They clarified that the remaining percentages belonged to small operators that had not participated in the process.

3.1.1.3. Input definition

Under the scenario 1 defined in previous paragraphs, the market share of the reference operator is defined at country level and equal to the market share of the incumbent operator in each EU/EEA country.

Therefore, the market share of the reference operator was determined equal to the market share of the incumbent operator[13].

Question 4: Do you agree with the validation, treatment and definition of the market share inputs? Otherwise please describe your rationale in detail and provide supporting information and references.

3.1.2. Demand

Traffic demand was defined at country level, per year and per service and refers to the traffic registered[14] in a country in one full year (sum of all months). In the case of fixed telephony lines, these are defined as the annual average number of active lines in the country.

The table below lists all the services considered in the model, for which demand had to be included in the model, as well as the name associated to each service in the model:

[13] Note however that, in the non-confidential version of the model shared with NRAs for consultation, this figure may not be equal to the market share of the incumbent operator for confidentiality reasons. Please refer to the main consultation document for further indications on the treatment given to confidential information in the non-confidential version of the cost model circulated to NRAs.

[14] Including free and invoiced traffic.

Service	Name in the model
Fixed Telephony Lines	
Fixed Telephony Lines	Lines.Lines.Retail.Fixed Voice Lines[15]
Voice services	
Voice On-net	Voice.On Net.Retail.On-net
Voice Off-net to fixed national	Voice.Outgoing.Retail.Off-net to fixed national
Voice Off-net to mobile national	Voice.Outgoing.Retail.Off-net to mobile national
Voice Off-net to international	Voice.Outgoing.Retail.Off-net international
Voice Incoming from fixed national	Voice.Incoming.Wholesale.Incoming from fixed national
Voice Incoming from mobile national	Voice.Incoming.Wholesale.Incoming from mobile national
Voice Incoming from international	Voice.Incoming.Wholesale.Incoming from international
Voice transit	Voice.Transit.Wholesale.Transit
Other voice traffic	Voice.Other.Retail/Wholesale.Other voice traffic

Table 3.5: Demand - List of services included in the Model [Source: Axon Consulting]

The demand input involves information corresponding to past years (from 2015 to 2018) – referenced as historical demand -, as well as forecasts corresponding to future years (from 2019 to 2025) - referenced as forecast demand -.

The demand information is used to define the traffic requirements that the reference operator will need to face on a yearly basis.

The demand inputs are included in worksheet '1B INP DEMAND' of the model.

3.1.2.1. Sources of information

Both historical and forecast demand information were gathered from the NRAs through the Data Request Form. As requested, the NRAs provided the information for each of the services at country level and this was used as the primary source of information to fill in the demand-related inputs of the model.

In order to validate the information received and/or to perform additional analyses, other sources of information were also utilized, namely:

- *Termination rates at European level BEREC Report[16]:* Information on number of telephony lines and market shares of fixed operators reported by BEREC. This data

[15] Please note that while this service does not affect the results of voice termination services in the model, its inclusion is necessary to perform the reconciliation assessment described in section 4.1.

[16] Termination rates at European level BEREC Reports

was used to validate the figures of telephony lines and market shares reported by NRAs.

- *Annual Reports of NRAs:* Annual reports published by NRAs were a useful source of information to cross-check some relevant KPIs from the data reported.

The tables below indicate the availability and confidentiality of demand data per country.

Data availability

Historic Demand / Demand Forecasts	Available	High-priority information provided	Not all high priority information provided	Not available
Available	BG, LT, LV, NO, RO	-	-	-
High-priority information provided	CY, CZ, DE, DK, EE, EL, ES, FR, HR, HU, IE, LU, MT, NL, PL, SK, UK	-	-	-
Not all high priority information available	IT, SI	-	-	-
Not available	AT, BE, PT	-	SE	-

Table 3.6: Demand - Data availability [Source: Axon Consulting]

July 2018:
https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/8306-termination-rates-at-european-level-july-2018
July 2017:
https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/7524-termination-rates-at-european-level-july-2017
July 2016:
https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/6603-termination-rates-at-european-level-july-2016
July 2015:
https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/5591-termination-rates-at-european-level-july-2015

Data confidentiality

Historic Demand / Demand Forecasts	Confidentiality level 0	Confidentiality level 1	Confidentiality level 2
Confidentiality level 0	AT, CZ, ES, HR, IT, LU, NL, NO	-	-
Confidentiality level 1	-	CY, PL	-
Confidentiality level 2	EL, MT, UK	BG	BE, DE, DK, EE, FR, HU, IE, LT, LV, PT, RO, SE, SI, SK

Table 3.7: Demand - Data confidentiality [Source: Axon Consulting]

No confidential information has been disclosed in the non-confidential version of the model shared with NRAs for consultation. Please refer to the main consultation document for further indications on the treatment given to confidential information in the non-confidential version of the cost model circulated to NRAs.

Thorough validation and treatment exercises were performed to maximise the consistency, reasonability and completeness of the demand information provided by NRAs. The validation exercises were performed on the two sets of demand information - historical demand and demand forecasts. Given the relevant differences between the data validation exercises performed for both, they are presented in different subsections below.

3.1.2.2. Input validation, treatment and definition – Historical demand

Data validation

The historical demand information provided by NRAs was validated by performing the following analyses:

- *Representativeness of the market*: Verification (and adjustment, if required) to ensure that the demand data provided was representative of the whole market.
- *Consistency between national incoming from fixed and national outgoing to fixed traffic*: At a national level, incoming traffic from fixed network and outgoing traffic to

fixed network should be equal. Therefore, in the cases in which this condition did not hold true, the data reported was adjusted to fit this criterion.

- *Cross-country comparison:* The voice traffic per line and per month was compared across EEA references to identify potential outliers.
- *Reasonability of historical trends:* The goal of this validation was to verify that the historical trends provided were consistent across the years and, in some particular cases, consistent across the EU/EEA countries (please refer to the paragraphs below for further indications on the specific consistency checks performed). When a field of information was identified to be inconsistent, even after the clarification process with the NRAs, it was estimated based on EU/EEA averages or other alternative approaches which are described in detail below.

Each of these analyses is described in more detail in the following subsections.

Representativeness of the market

The information provided for each of the services per country and year was analysed to identify if it was representative of the total market (100% of the market share). This analysis was performed primarily using the comments provided by the NRAs and was complemented by our own assessment of the information to understand if any data could be missing (these cases were clarified with NRAs).

The information reported by NRAs showed that, in some cases, the data provided did not represent the whole market, but only a percentage of it. Therefore, the values reported had to be adjusted, by dividing them by the market share of the operators they represented, to extrapolate to the total market share. Countries for which these adjustments had to be applied are listed below:

Service	Countries in which demand has been adjusted per market share
Fixed telephony lines	
Fixed telephony lines	BG, DE, EE, IT, LT, NL, NO, PL, PT, RO, SI, SK
Voice services	
Voice On-net	BG, DE, DK, EE, IE, IT, LT, LV, NL, NO, PL, PT, RO, SI, SK
Voice Off-net to fixed national	BG, DE, DK, EE, IE, IT, LT, LV, NL, NO, PL, PT, RO, SE, SI, SK, UK
Voice Off-net to mobile national	AT, BG, DE, DK, EE, IE, IT, LT, LV, NL, NO, PL, PT, RO, SE, SI, SK, UK
Voice Off-net to international	BG, DE, DK, EE, IE, IT, LT, LV, NL, NO, PL, PT, RO, SE, SI, SK, UK

Service	Countries in which demand has been adjusted per market share
Voice Incoming from fixed national	BG, CY, DE, DK, IE, IT, LT, LV, NL, NO, PL, PT, RO, SE, SI, SK, UK
Voice Incoming from mobile national	AT, BG, CY, DE, DK, EE, IE, IT, LT, LV, NL, NO, PL, PT, RO, SE, SI, SK, UK
Voice Incoming from international	BG, CY, DE, DK, EE, IE, IT, LT, LV, NL, NO, PL, PT, RO, SE, SI, SK, UK
Voice transit	BG, CY, DE, DK, IE, IT, LT, LV, NL, NO, PL, PT, RO, SI, SK, UK
Other voice traffic	BG, CY, DE, DK, HU, IE, IT, LV, NO, PL, RO, SK, UK

Table 3.8: Demand - Data validation – Historical Demand – Demand adjustments per market share [Source: Axon Consulting]

Consistency between national incoming from fixed and national outgoing to fixed traffic

In the model's input demand, all voice incoming traffic originated on fixed national operators should be equal to the voice off-net traffic to fixed national operators. The reason behind this is that all calls generated towards national fixed numbers should be equal to the total number of calls received from fixed national numbers. When this condition was not met, the data provided was adjusted as described below to ensure that both services had exactly the same amount of traffic.

The table below summarises the countries for which this issue was identified and describes the actions taken to ensure consistency.

Country	Input adjusted	Issues identified	Approach adopted
AT, BG, DE, DK, EL, HR, HU, IE, LV, MT, PL, SE, SI, SK	▶ Voice Off-net to fixed national ▶ Voice Incoming from fixed national	The figures provided for off-net to fixed national and incoming from fixed national services did not coincide.	The lowest traffic figure from the two services was adjusted to make it equal to the highest reference.
CY	▶ Voice Off-net to fixed national ▶ Voice Incoming from fixed national	The figures provided for off-net to fixed national and incoming from fixed national services did not coincide. The NRA has stated that *"In the voice incoming from fixed national, the figures include both on and off net."*	The figure provided for incoming from fixed national was adjusted to make it equal to the figure for off-net to fixed national, ensuring no on-net traffic is included as incoming.

Table 3.9: Demand - Data validation – Historical demand - Consistency between national incoming from fixed and national outgoing to fixed traffic [Source: Axon Consulting]

Cross-country comparison

The voice traffic per line and per month was compared across EEA references to identify potential outliers. The following graph exhibits the amount of outgoing[17] monthly traffic per user in descending order of EU/EEA countries in the year 2018. Note that names of the countries are not disclosed due to confidentiality reasons.

[17] Calculated as the sum of the following services: Voice On-net, Voice Off-net to fixed national, Voice Off-net to mobile national and Voice Off-net to international.

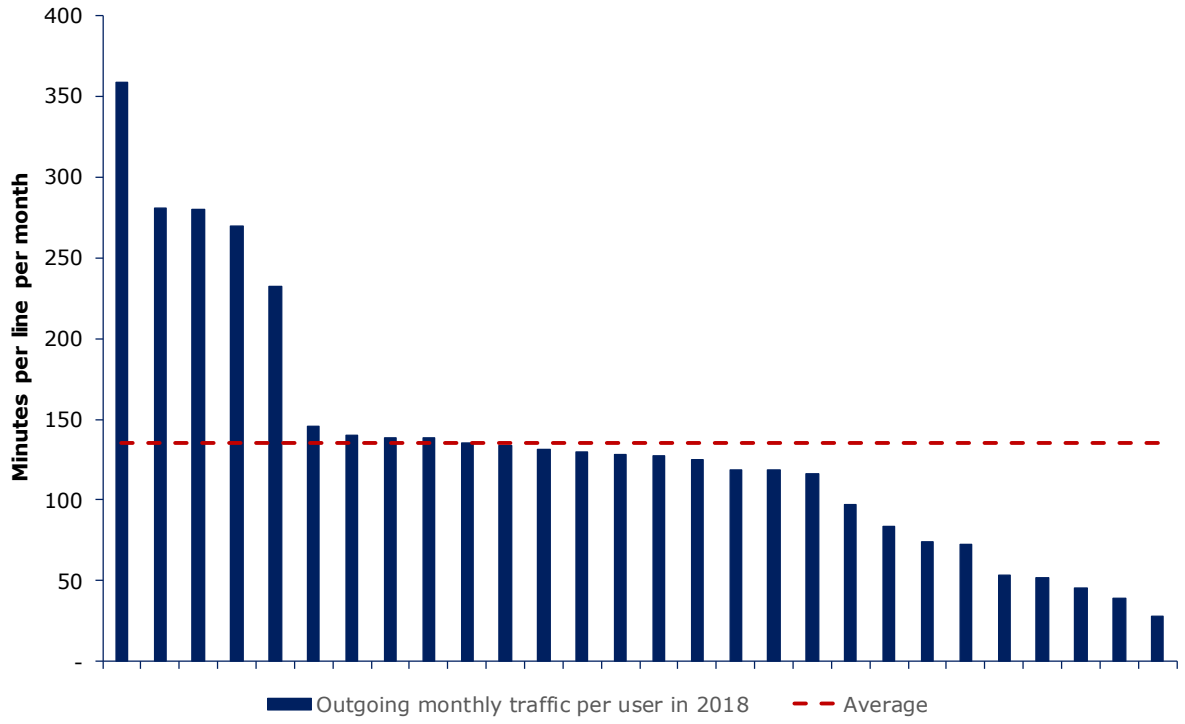


Exhibit 3.2: Demand - Data validation – Historical demand – Outgoing monthly traffic per user [Source: Axon Consulting based on information received from EEA countries]

Based on this information, we observe that significant divergences can be found among countries. However, it is not possible to conclude whether there may be errors in the information provided solely on the basis of an analysis of national monthly consumption per user.

Reasonability of historical trends

This analysis was aimed at identifying potential inconsistencies or unreasonable trends in the demand traffic information per service, country and year. The main analyses performed are described below:

- *Reasonability of annual growth rates:* The annual growth rates per service from 2015 to 2018 were analysed to identify potential unreasonable growth rates in the information provided by NRAs. The following table summarises the adjustments performed on the reported data when unreasonable growth rates have been identified in the information received.

Country	Input adjusted	Issues identified	Approach adopted
Fixed telephony lines			
SI	▶ Fixed telephony lines	Growth between 2016 and 2017 was well above thresholds. NRA stated that the values for 2015 and 2016 were not considering the number of voice channels since they were not available.	2015 and 2016 values were estimated by applying the 2017-2018 growth rate to the 2017 value.

Table 3.10: Demand - Data validation – Historical demand – Summary of reasonability of trends [Source: Axon Consulting]

- *Assessment of the comments provided by NRAs:* In some cases, NRAs highlighted specific and relevant comments in the spaces provided for this purpose in the information requests. These comments were assessed and the following issues were identified:

Country	Input adjusted	Issues identified	Approach adopted
LT	▶ Voice Off-net to fixed national ▶ Voice Incoming from fixed national ▶ Voice transit	The figures provided for off-net to fixed national and incoming from fixed national services did not coincide. Regarding the incoming from fixed national traffic, the NRA stated in the space reserved for comments the following: *"Traffic from national Operators (including international traffic)".* On the basis of NRA's comments, the difference between off-net to fixed national traffic and incoming from fixed national traffic would be due to minutes related to international transit traffic. Additionally, regarding the transit traffic, the NRA stated in the space reserved for comments the following: *"National transit".*	The difference between the figures provided for incoming from fixed national and for off-net to fixed national was added to the voice transit service, since it related to international transit traffic. The figure provided for incoming from fixed national was adjusted to make it equal to the figure for off-net to fixed national.

Country	Input adjusted	Issues identified	Approach adopted
PL	▶ All voice services except the "Other voice traffic" service	The values for 2018 were only representative of ranges between 7% and 20% of market, depending on the service. However, values over the period 2015-2017 were representative of ranges between 74% and 86% of the market, also depending on the service. For 2018, the adjustment by market share was not used as the range 7%-20% was not considered enough to extrapolate the data for the whole market.	2018 traffic of each voice service was estimated by applying the 2015-2017 growth rate registered in PL to the 2017 traffic.
PT	▶ All voice services	The NRA has indicated that the values for 2018 correspond to the traffic until September 2018	Traffics in the year 2018 has been multiplied by the ratio 12/9 to consider the traffic in the whole year.
RO	▶ All voice services	The NRA has indicated that the values for 2018 correspond only to the traffic of the first semester of the year	Traffics in the year 2018 has been multiplied by 2 to consider the traffic in the whole year.
SE	▶ Voice Off-net to fixed national ▶ Voice Off-net to mobile national ▶ Voice Off-net to international	The NRA has indicated that the values for 2018 correspond only to the traffic of the two first quarters of the year	In order to calculate the traffic for the whole year 2018, the traffic reported was multiplied by 2.

Table 3.11: Demand - Data validation – Historical demand – Assessment of the comments provided by NRAs [Source: Axon Consulting]

The historical traffic demand for all the services per year and per country was therefore validated through the multiple analyses described through this section. Once the historical demand information was validated, this information was treated to further increase its robustness, as explained in the following subsection.

Data treatment

Once the historical demand information was validated, it still required further treatment before it was suitable to be used in the model. This section deals with the modifications performed on the data provided by NRAs and the estimations made in the absence of information. The two modifications performed were as follows:

- *Disaggregation of consolidated data:* Some NRAs provided service level information in an aggregated manner (e.g. only one figure was provided for two different services). This section describes the steps adopted to disaggregate the data into the different services.
- *Estimation of missing information:* This section indicates how the information that was not provided by NRAs was estimated.

A more detailed description of each of these approaches is presented in the next two sections.

Disaggregation of consolidated data

NRAs/operators stated that in some cases they were not able to disaggregate the data provided for the services requested and they provided information in a consolidated manner. In these cases, we had to disaggregate the information provided into the applicable services.

The table below shows the countries for which we had to perform such disaggregation and describes the approach adopted.

Country	Input adjusted	Issues identified	Approach adopted
BE	▶ Voice On-net ▶ Voice Off-net to fixed national	The two inputs were provided in a consolidated manner (as on-net traffic)	The voice off-net to fixed national traffic was considered equal to the voice incoming from fixed national traffic. The on-net traffic was obtained as the difference between the total traffic provided and the voice off-net to fixed national traffic calculated above.

Country	Input adjusted	Issues identified	Approach adopted
EE	▶ Voice Incoming from fixed national ▶ Voice Incoming from mobile national	The two inputs were provided in a consolidated manner (as incoming from mobile national traffic)	The voice incoming from fixed national traffic was considered equal to the voice off-net to fixed national traffic. The voice incoming from mobile national traffic was obtained as the difference between the total traffic provided and the voice incoming from fixed national traffic calculated above.
ES	▶ Voice On-net ▶ Voice Off-net to fixed national	The two inputs were provided in a consolidated manner (as voice off-net to fixed national traffic)	The traffic provided was multiplied by the average EEA percentage of on-net over all originated traffic to fixed national to obtain the on-net traffic. The off-net to fixed national traffic was obtained as the difference between the total traffic provided and the on-net traffic calculated above.
	▶ Voice Incoming from fixed national ▶ Voice Incoming from mobile national	The two inputs were provided in a consolidated manner (as incoming from fixed national traffic)	The voice incoming from fixed national traffic was considered equal to the voice off-net to fixed national traffic (see row above). The voice incoming from mobile national traffic was obtained as the difference between the total traffic provided and the voice incoming from fixed national traffic calculated above.
FR	▶ Voice Incoming from fixed national	The figures provided for incoming from fixed national was equal to the sum of figures for on-net and for off-net to fixed national	The voice incoming from fixed national traffic was considered equal to the voice off-net to fixed national traffic.

Country	Input adjusted	Issues identified	Approach adopted
LU	▶ Voice off-net to fixed national ▶ Voice off-net to mobile national ▶ Voice off-net to international	The three inputs were provided in a consolidated manner (voice off-net to fixed national)	The voice off-net to fixed national traffic was considered equal to the voice incoming from fixed national traffic. The off-net to mobile + off-net to international traffic was obtained as the difference between the total traffic provided and the off-net to fixed national traffic calculated above. The traffic obtained above was multiplied by the average EEA percentage of off-net to mobile over off-net to mobile + off-net to international to obtain the off-net to mobile traffic. And finally, the off-net to international traffic was obtained as the difference between the total and the calculated off-net to mobile traffic.
NO	▶ Voice On-net ▶ Voice Off-net to fixed national	The two inputs were provided in a consolidated manner over the period 2016-2018 (as voice on-net traffic)	The total traffic provided in years 2016-2018 was multiplied by split between on-net and off-net to fixed national traffic observed in the year 2015.
	▶ Voice Incoming from fixed national ▶ Voice Incoming from mobile national	The two inputs were provided in a consolidated manner (as incoming from fixed national traffic)	The voice incoming from fixed national traffic was considered equal to the voice off-net to fixed national traffic. The voice incoming from mobile national traffic was obtained as the difference between the total traffic provided and the voice incoming from fixed national traffic calculated above.

Country	Input adjusted	Issues identified	Approach adopted
RO	▶ Voice Incoming from fixed national ▶ Voice Incoming from mobile national	The two inputs were provided in a consolidated manner (as incoming from fixed national traffic)	The voice incoming from fixed national traffic was considered equal to the voice off-net to fixed national traffic. The voice incoming from mobile national traffic was obtained as the difference between the total traffic provided and the voice incoming from fixed national traffic calculated above.

Country	Input adjusted	Issues identified	Approach adopted
UK	▶ Voice On-net ▶ Voice Off-net to fixed national ▶ Voice Incoming from fixed national	On the one hand, the on-net and off-net to fixed national traffic was provided in a consolidated manner (as voice off-net to fixed national traffic) On the other hand, it was noticed that the traffic provided for incoming from fixed national was higher than the consolidated on-net + off-net to fixed national traffic. The NRA explained that one of the reasons could be that, in some cases, the fixed national operator sees the call as an incoming call received from another fixed national operator, while this call could have been originated from abroad or from mobile operators (for instance, being handled through a transit service).	The on-net + off-net to fixed national traffic provided was multiplied by the average EEA percentage of on-net over on-net + off-net to fixed national to obtain the on-net traffic. The off-net to fixed national traffic was obtained as the difference between the total traffic provided and the on-net traffic calculated above. Finally, the voice incoming from fixed national traffic was considered equal to the voice off-net to fixed national traffic.

Table 3.12: Demand - Data treatment – Historical demand – Disaggregation of consolidated information [Source: Axon Consulting]

Estimation of missing information

It is important to ensure that the demand information corresponding to all services in the model is complete. Missing information for a particular country was estimated based on the information available from that same country and/or making use of EEA averages. The missing data that we had to estimate, and the approach adopted to estimate it, are described below:

Country	Input adjusted	Issues identified	Approach adopted
Fixed telephony lines			
BE	▶ Fixed telephony lines	No data reported for 2018	2018 lines were estimated by applying the 2015-2017 growth rate registered in BE to the 2017 lines.
Voice services			
BE	▶ All voice services	No data reported for 2018	2018 traffic was estimated by applying the 2015-2017 growth rate registered in BE to the 2017 traffic.
	▶ Voice Incoming from international	No data reported	Voice incoming from international was estimated as the product of voice incoming from fixed national and the average ratio between voice incoming from international and voice incoming from fixed national from reporting EEA countries. This ratio was calculated separately for each year (2015, 2016 and 2017).
FR	▶ Voice Incoming from international	No data reported	Voice incoming from international was estimated as the product of voice incoming from fixed national and the average ratio between voice incoming from international and voice incoming from fixed national from reporting EEA countries. This ratio was calculated separately for each year (2015, 2016 and 2017).
PT	▶ Voice Incoming from international	No data reported for 2015	2015 traffic was estimated by applying the 2016-2017 growth rate registered in PT to the 2016 traffic.

Country	Input adjusted	Issues identified	Approach adopted
SE	▶ Voice On-net	No data reported	Voice on-net was estimated as the product of voice off-net to fixed national and the average ratio between voice on-net and voice off-net to fixed national from reporting EEA countries. This ratio was calculated separately for each year (2015, 2016 and 2017).
	▶ Incoming from fixed national	No data reported for 2017 and 2018	The voice incoming from fixed national traffic was considered equal to the voice off-net to fixed national traffic.
	▶ Incoming from mobile national	No data reported for 2017 and 2018	2017 and 2018 traffics were estimated by applying the 2015-2016 growth rate registered in SE to the 2016 traffic.
	▶ Incoming from international	No data reported for 2018	2018 traffic was estimated by applying the 2015-2017 growth rate registered in SE to the 2017 traffic.

Table 3.13: Demand - Data treatment – Historical Demand – Estimation of missing information [Source: Axon Consulting]

Input definition

Once validated and treated as described in the paragraphs above, the historical demand data provided by the NRAs has been fed into the model.

3.1.2.3. Input validation, treatment and definition – Forecast demand

For historical demand, the main objective was to ensure that the data provided by NRAs was fully representative of the market situation. On the other hand, for demand forecasts, the validation, treatment and definition were performed to assess the likelihood of the projections reported by NRAs.

This section has been split as follows:

- Validation and definition of fixed telephony lines forecasts
- Validation and definition of voice forecasts

Validation and definition of fixed telephony lines forecasts

This section describes how the fixed telephony lines trends provided by NRAs have been validated as well as how this input has been ultimately defined in the model.

Validation of fixed telephony lines forecasts

The validation of fixed telephony lines trends was performed to ensure the representativeness and consistency of the future telephony lines reported by NRAs compared to the historical trends. Particularly, when lines submitted represented growth rates outside the range +/- 15%[18], these were discarded from our exercise[19].

The validation process indicated that the references provided by SK had to be dismissed as they exhibited growth rates higher than 100% for a particular year.

Additionally, we have observed that forecasts reported by some NRAs for certain years were not sufficiently representative of the entire fixed market, since they corresponded to a reduced portion of the operators in terms of market share. In these cases, values reported have also been discarded from our exercise. The following table summarises these cases:

[18] This range was defined based on expected evolutions reported by all EEA countries.

[19] In the case of NO, while growth rates were outside the indicated range, reasonable explanations were provided by the stakeholders to justify this situation, so the submitted lines have been accepted.

Country	Forecast demand - Years discarded due to the reduced representativeness of the information in terms of market share
BG	2022-2025
DE	2019-2025
PL	2021-2025
RO	2023-2025

Table 3.14: Demand - Data validation – Forecast demand – Years of trends discarded due to the reduced representativeness of the information in terms of market share [Source: Axon Consulting]

The references provided by the remaining NRAs were considered reasonable and used as such in the construction of the telephony lines forecasts.

Projection of total fixed telephony lines

The approach adopted to project the number of fixed telephony lines until 2025 depended on the data available. In particular, two different alternatives were designed depending on whether NRAs' forecasts were available and reasonable, or not:

- *NRAs' information available (for more than three years) and validated*: Future lines reported by the NRAs were considered as such to project the number of fixed telephony lines. When information was not provided for one or more years, lines' projections were estimated through the available growth rates (including both historical and future periods).
- *NRAs' information not available (or available for less than three years) or discarded*: The number of fixed telephony lines for the 2019-2025 period was calculated as the product of 2018 lines and the growth rate observed in the historical period (2015-2018).

Validation and definition of voice forecasts

This section describes how voice forecasts provided by NRAs have been validated as well as how these inputs have been ultimately defined in the model.

Validation of voice forecasts

In the case of voice services, we observed that the forecasts reported by NRAs were significantly different across Member States, in spite of presenting, in some cases, similar trends over the historical period. The following exhibit shows an illustrative example of this situation:

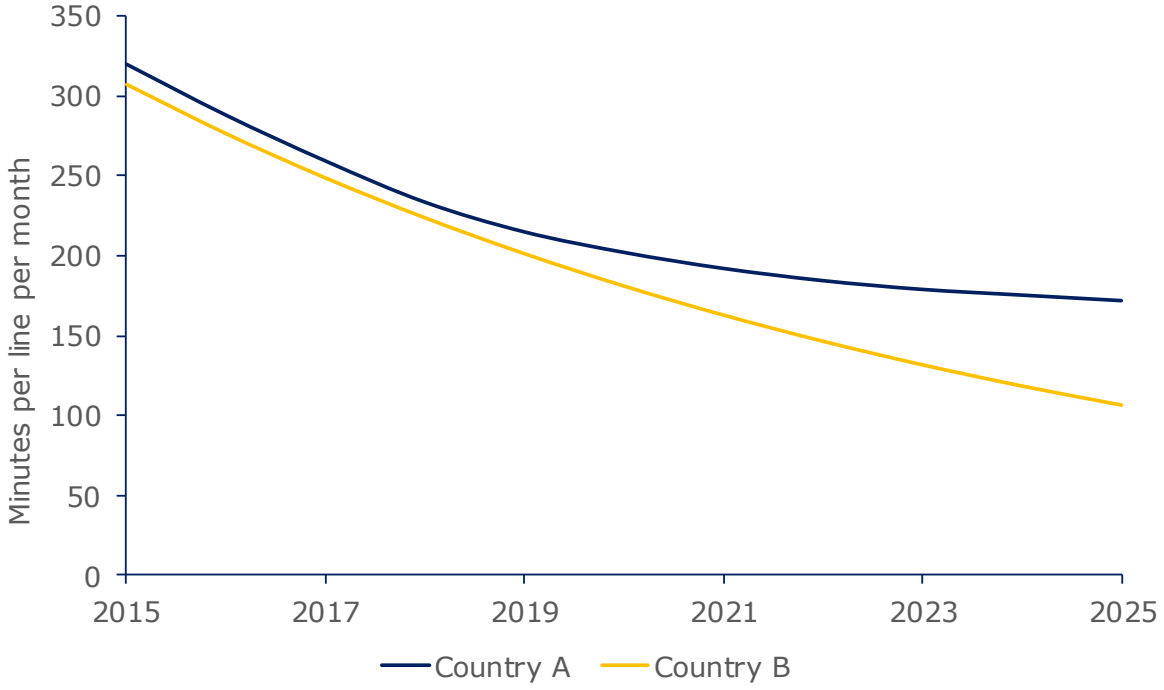


Exhibit 3.3: Demand - Data validation – Forecast demand – Illustrative example of voice forecasts reported by NRAs [Source: Axon Consulting]

As it can be extracted from above, both countries A and B present a similar trend in the past period. However, while country B shows a continuation of the decrease rate observed in the past, country A, by contrast, shows a more optimistic view. In these cases, it seems evident that the observed differentials arise more from the differences in future expectations (e.g. degree of optimism) shown by the various stakeholders that provided information to us, than from historical evolutions and/or events that might support such deviations between the two countries. It seems reasonable that differences stemming from differences in future expectations that are not necessarily founded on past evidence (e.g. founded on distinct degrees of optimism) should be excluded from our analysis.

In some countries, we have also noticed that information about voice trends reported was only representative of a small portion of operators in terms of market share. The employment of such trends for the whole fixed voice market was not suitable since they led in many of these cases to unusual future behaviours when compared with historic and/or expected trends.

Other stakeholders have calculated the future trends by directly extrapolating the historic trends, as indicated in the space reserved for comments in the Data Request Form.

In this context, we consider voice services to be mature throughout the EU/EEA countries. This fact was demonstrated by the evolution of the voice traffic over the historical period, where no sudden changes were observed in the vast majority of countries.

Given the predictability and the maturity of voice services, we considered it more appropriate to follow a common forecasting methodology for all EU/EEA countries.

In light of the above, the forecasts reported by NRAs have been discarded in favour of using a common forecasting methodology based on the historical trends registered in each country. This approach has also permitted to solve the issues described in the above paragraphs.

Projection of voice traffic

Demand projections were performed at traffic per subscriber level for each service modelled. Additionally, as outlined in the section about the validation of voice forecasts, NRAs' forecasts were not considered for the projection of voice services' traffic. Instead, the same forecasting methodology based on historical growth rates was applied for all EU/EEA countries.

As also indicated in previous sections, the evolution observed in EU/EEA countries for voice services in the past, together with the maturity of this market, suggests that no abrupt changes are expected in the coming years. Despite this, the EC/Axon also recognises the intrinsic uncertainty of future demand trends, reason why the following three scenarios have been considered with regards to the voice demand forecasts, to assess how changes in the expected demand trends could affect the results obtained:

- *Base Case*. This is the base-case scenario, where growth rates observed in the historical period (2015-2018) has been directly[20] used to estimate the future demands of voice services, as follows:

[20] Certain exceptions have been considered in a few cases in which services with a reduced relevance in the historic period, but presenting a high historic growth rate, were leading to unreasonable forecasts over the future period. In these cases, the CAGR of the historic period has been smoothed, multiplying it by a set of modulation factors for the different future years. These modulation factors have been defined as follows: 80% - 2019, 60% - 2020, 50% - 2021, 40% - 2022, 30% - 2023, 20% - 2024, 10% - 2025.

The list of services corresponding to these exceptions are:

- Voice transit in the case of HR, HU, LV, LT, MT, NO, PL and RO.
- Voice off-net to mobile national in the case of CZ.
- Voice incoming from mobile national in the case of SE.
- Voice incoming from international in the case of SK.

$$Traffic\ per\ user\ (year\ i) = Traffic\ per\ user\ (year\ i-1) \cdot (1 + CAGR\ (2015-2018))$$

- *Conservative*. This scenario assumes a more pessimistic than the originally expected growth of the voice services. Particularly, while the same high-level approach as in the base-case scenario has been adopted to calculate the demand forecasts, we have defined this scenario by adjusting the growth rate, deducting 5 percentual points[21] from it, as presented in the formula below:

$$Traffic\ per\ user\ (year\ i) = Traffic\ per\ user\ (year\ i-1) \cdot (1 + CAGR\ (2015-2018)\ - 5\%)$$

- *Aggressive*. This scenario assumes a more optimistic than the originally expected growth of voice services. In a similar manner, we have defined this scenario by adjusting the growth rate, adding 5 percentual points to it, as presented in the formula below:

$$Traffic\ per\ user\ (year\ i) = Traffic\ per\ user\ (year\ i-1) \cdot (1 + CAGR\ (2015-2018)\ + 5\%)$$

The exhibit below provides a graphical illustration of the results obtained under each of these three scenarios:

- Other voice traffic in the case of CY.

[21] This value has been defined by assessing differences between historic growth rates among EEA countries.

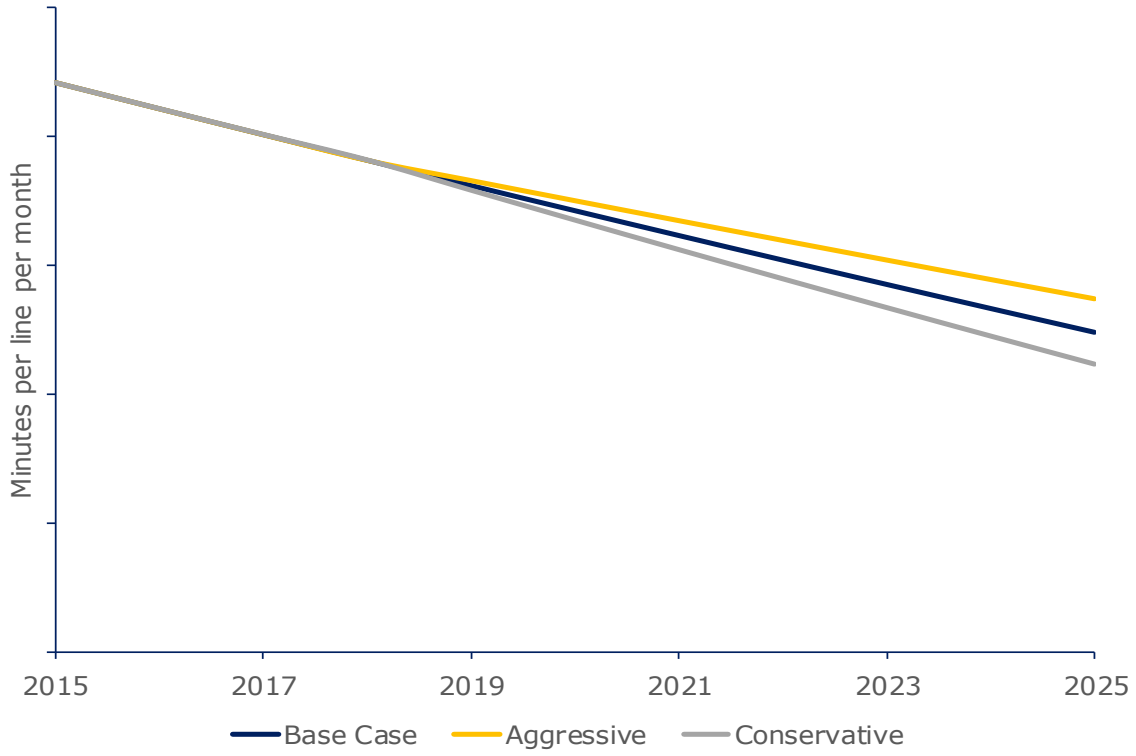


Exhibit 3.4: Demand – Input definition – Voice forecast under different scenarios [Source: Axon Consulting]

Stakeholders can assess the results obtained under each scenario by selecting the desired option in the control panel of the model (see Annex 2 - User manual for further indications on how to run the model):

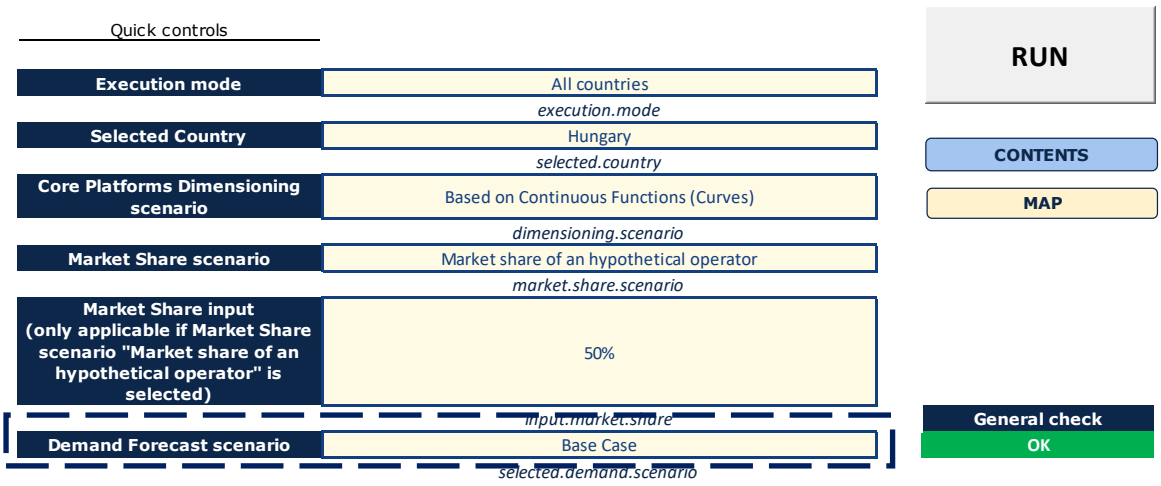


Exhibit 3.5: Selection of the alternative voice demand forecast scenarios in the model [Source: Axon Consulting]

Question 5: Do you agree with the validation, treatment and estimation of the values for demand inputs? Otherwise please describe your preferred approach in detail and provide supporting information and references.

Question 6: In your opinion, what voice demand forecast scenario do you expect to better represent the traffic evolution in your country? Please, describe your preferred approach in detail and provide supporting information and references.

3.1.3. Network Statistics

Network statistics are needed for the dimensioning algorithms of the model as they provide valuable information on consumers' usage patterns that are relevant to measure network requirements.

The network statistics are defined at country level.

The network statistics inputs are included in worksheets '1C INP NW STATISTICS' of the model.

3.1.3.1. Sources of information

Network statistics were provided by NRAs through the Data Request Form in the requested manner and at the country level.

The tables below indicate the availability and confidentiality of the network statistics reported by NRAs per country.

Data availability

Status	Countries
Complete information	AT, BE, BG, CY, CZ, DE, EL, ES, HR, IT, LV, MT, NL, PL, RO, SI
Partial information	EE, HU, IE, LT, PT, SE, SK, UK
No information	DK, FR, LU, NO

Table 3.15: Network Statistics - Data availability [Source: Axon Consulting]

Data confidentiality

Confidentiality level	Countries
Confidentiality level 0	AT, CZ, DE, HR, IE, IT, SE, SK
Confidentiality level 1	CY, LV, PL
Confidentiality level 2	BE, BG, EE, EL, ES, HU, LT, MT, NL, PT, RO, SI, UK

Table 3.16: Network Statistics - Data confidentiality [Source: Axon Consulting]

No confidential information has been disclosed in the non-confidential version of the model shared with NRAs for consultation. Please refer to the main consultation document for further indications on the treatment given to confidential information in the non-confidential version of the cost model circulated to NRAs.

3.1.3.2. Input validation, treatment and definition

This section indicates the validation and treatment performed on the voice traffic statistics reported by the NRAs, as well as how these inputs have been ultimately defined.

Input validation and treatment

The relevant voice statistics requested to NRAs comprised:

- Uncompleted Calls Over Total Calls Percentage – Busy
- Uncompleted Calls Over Total Calls Percentage - Not Taken
- Average Call Duration
- Average Ringing Time

Each of these indicators was validated and defined per country for the following services:

- Voice On-net
- Voice Off-net to fixed national
- Voice Off-net to mobile national
- Voice Off-net to international
- Voice Incoming from fixed national
- Voice Incoming from mobile national
- Voice Incoming from international

The main validation exercise performed based on this information consisted in removing inconsistent information. In particular, we ensured that the information considered for each country was reasonable and that figures were not significantly different to general trends observed in other countries (which could be a sign of inaccurate information).

The main conclusions of the exercise are highlighted in the table below:

Country	Voice statistics	Issues identified	Adopted approach
BG	▶ *Uncompleted Calls Over Total Calls Percentage – Busy* for all Voice Off-net services and the Incoming from international	Identified to be significantly lower than the EEA average	Values discarded.

Country	Voice statistics	Issues identified	Adopted approach
DE	▶ *Average Ringing Time* for Voice On-net and all Off-net services	Identified to be significantly lower than the EEA average	Values discarded.
LT	▶ Uncompleted Calls Over Total Calls Percentage – Busy and Uncompleted Calls Over Total Calls Percentage – Not Taken for Voice On-net and all Off-net services ▶ *Average Ringing Time* for Voice On-net, Voice Off-net to fixed national and Voice Off-net to mobile national	Identified to be significantly lower than the EEA average	Values discarded.
	▶ *Average Call Duration* for Voice On-net and Voice Off-net to mobile national	Identified to be significantly higher than the EEA average	Values discarded.
NL	▶ Uncompleted Calls Over Total Calls Percentage – Busy and Uncompleted calls over total calls percentage - not taken for the Voice On-net	Identified to be significantly lower than the EEA average	Values discarded.

Table 3.17: Network Statistics - Input validation– Voice statistics [Source: Axon Consulting]

Input definition

Voice statistics were defined as per the following approach:

- If the statistics reported by an NRA successfully passed our validation exercise, these were directly considered in the model.
- If i) the statistics reported by an NRA were discarded during the validation process or ii) no information was provided by an NRA, EEA average figures were considered[22].

[22] In some cases, NRAs have been able to provide network statistics only for certain services. In these situations, EEA average figures have been employed exclusively for the missing services.

The following table summarises the voice statistics that had to be estimated based on EEA averages.

Network statistic	Service	Country figures estimated based on EEA averages[23]
Uncompleted calls over total calls percentage – busy	On-net	AT, DK, EE, ES, FR, HU, IE, LT, LU, NL, NO, SE, SK, UK
	Off-net to fixed national	BG, DK, EE, FR, HU, IE, LT, LU, NO, SE, SK
	Off-net to mobile national	BG, DK, EE, FR, HU, IE, LT, LU, NO, SE, SK
	Off-net to international	BG, DK, EE, FR, HU, IE, LT, LU, NO, SE, SK
	Incoming from fixed national	DK, EE, FR, HU, IE, LT, LU, NO, PT, SE, SK
	Incoming from mobile national	DK, EE, FR, HU, IE, LT, LU, NO, PT, SE, SK
	Incoming from international	BG, DK, EE, FR, HU, IE, LT, LU, NO, PT, SE, SK
Uncompleted calls over total calls percentage - not taken	On-net	AT, DK, EE, FR, HU, IE, LT, LU, NL, NO, SE, SK, UK
	Off-net to fixed national	DK, EE, FR, HU, IE, LT, LU, NO, SE, SK
	Off-net to mobile national	DK, EE, FR, HU, IE, LT, LU, NO, SE, SK
	Off-net to international	DK, EE, FR, HU, IE, LT, LU, NO, SE, SK
	Incoming from fixed national	DK, EE, FR, HU, IE, LT, LU, NO, PT, SE, SK
	Incoming from mobile national	DK, EE, FR, HU, IE, LT, LU, NO, PT, SE, SK
	Incoming from international	DK, EE, FR, HU, IE, LT, LU, NO, PT, SE, SK
Average call duration	On-net	AT, DK, FR, LT, LU, NO, SE

[23] Includes countries that did not provide information or that the information they provided was classified as an outlier.

Network statistic	Service	Country figures estimated based on EEA averages[23]
	Off-net to fixed national	DK, FR, LU, NO
	Off-net to mobile national	DK, FR, LT, LU, NO
	Off-net to international	DK, FR, LU, NO
	Incoming from fixed national	DK, EE, FR, LT, LU, NO, SE
	Incoming from mobile national	DK, FR, LT, LU, NO, SE
	Incoming from international	BE, DK, FR, LT, LU, NO, SE
Average ringing time	On-net	AT, DE, DK, EE, ES, FR, IE, LT, LU, LV, NO, PT, SE, SK, UK
	Off-net to fixed national	DE, DK, EE, FR, IE, LT, LU, NO, PT, SE, SK, UK
	Off-net to mobile national	DE, DK, EE, FR, IE, LT, LU, NO, PT, SE, SK, UK
	Off-net to international	DE, DK, EE, FR, IE, LU, NO, PT, SE, SK, UK
	Incoming from fixed national	DE, DK, EE, FR, IE, LT, LU, NO, PT, SE, SK, UK
	Incoming from mobile national	DE, DK, EE, FR, IE, LT, LU, NO, PT, SE, SK, UK
	Incoming from international	DE, DK, EE, FR, IE, LT, LU, NO, PT, SE, SK, UK

Table 3.18: Network Statistics - Input Definition – Voice statistics [Source: Axon Consulting]

Question 7: Do you agree with the validation, treatment and estimation of the value for the network statistics inputs? Otherwise please describe your rationale in detail and provide supporting information and references.

3.1.4. Percentage of traffic in the busy hour and in weekdays

The percentage of traffic that is generated in the busy hour of the day is a critical input of a Bottom-Up model, as it characterises the amount of traffic for which the network needs to be dimensioned. The busy hour input in the model is defined per country.

The definition of the percentage of traffic in the busy hour is complemented by the characterisation of the percentage of traffic in weekdays. This element provides a more accurate characterisation of the distribution of traffic through the week and ensures that the network is modelled according to the day (weekday or weekend) in which more traffic is generated.

The inputs concerning the percentage of traffic in the busy hour and in weekdays are included in worksheet '2C INP BUSY HOUR' of the model.

3.1.4.1. Sources of information

The information provided by NRAs through the Data Request Form was used to calculate the percentage of traffic in the busy hour and in weekdays. The tables below indicate the availability and confidentiality of the information reported by NRAs.

Data availability

Status	Countries
Complete information	AT, BE, BG, CY, CZ, DE, DK, EE, EL, ES, FR, HR, HU, IE, IT, LV, MT, NL, PL, PT, RO, SE, SI, SK, UK
High-priority information provided	-
Not all High-priority information provided	-
No information	LT, LU, NO

Table 3.19: Busy hour and traffic in weekdays - Data availability [Source: Axon Consulting]

Data confidentiality

Confidentiality levels	Countries
Confidentiality level 0	AT, CY, CZ, DE, ES, HR, IE, IT
Confidentiality level 1	BG, LV, PL
Confidentiality level 2	BE, DK, EE, EL, FR, HU, MT, NL, PT, RO, SE, SI, SK, UK

Table 3.20: Busy hour and traffic in weekdays - Data confidentiality [Source: Axon Consulting]

No confidential information has been disclosed in the non-confidential version of the model shared with NRAs for consultation. Please refer to the main consultation document for further indications on the treatment given to confidential information in the non-confidential version of the cost model circulated to NRAs.

3.1.4.2. Input validation and treatment

Both hourly traffic and traffic during weekdays were reviewed to ensure their robustness and maximise the representativeness of the information collected. In particular, the following analyses were performed:

- *Traffic in weekdays – inter-country comparison*: The percentages of traffic provided by NRAs were cross-checked against each other to identify any clear outliers. References were classified as outliers when they deviated by more than 10 percentage points from the EEA average, as these would constitute relevant discrepancies with respect to the expected range. No values were identified outside this range and, therefore, no issues were detected.
- *Hourly traffic per service – 100% sum:* The values reported by NRAs were reviewed to ensure that the sum of the hourly traffic distribution added up to 100%. As a result of this review, we observed that this was not the case for the following countries:

Country	Issues identified	Approach adopted
EL	The NRA had introduced a formulation mistake when weighting the information received from the operators. In particular, it was noticed that the NRA had not divided by the sum of the operators' market shares considered in the calculation.	The formulation mistake was corrected.
SE	It was observed that the sum of hourly traffic distribution percentages added up to 102% due to rounding.	The hourly traffic distribution was adjusted multiplying by the ratio 100/102.

Table 3.21: Busy hour and traffic in weekdays – Input validation – Busy hour traffic percentage [Source: Axon Consulting]

- *Hourly traffic per service – Inter-country assessment*: The resulting percentage of traffic in the busy hour in each country was cross-checked against that in other EEA countries, to verify that they were not more than 5 percentage points from the EEA average, as these would constitute relevant discrepancies with respect to the expected range. No issues were identified.

3.1.4.3. Input definition

The paragraphs below describe the steps performed to calculate the percentage of traffic generated in weekdays as well as the percentage of traffic generated in the busy hour of a day.

Percentage of traffic generated in weekdays

The percentage of traffic generated in weekdays was set at country level, and therefore, the value provided by the NRA was directly considered in the model when it successfully passed the validation exercise performed (as described in the previous section).

When information was missing or discarded, the percentage of traffic generated in weekdays was calculated by means of an EEA average. The table below indicates the cases in which EEA average was used:

Services	Countries with estimated information based on an EEA average
Voice traffic	LT, LU, NO

Table 3.22: Busy hour and traffic in weekdays - Input definition – Weekdays traffic percentage [Source: Axon Consulting]

Percentage of traffic generated in the busy hour of a day

When NRAs provided the hourly distribution of traffic for an average day and it successfully passed the validation exercise performed (as described in the previous section), the busy hour traffic percentage was determined as the highest hourly traffic percentage from the information reported by the NRA.

When information was missing or discarded, the busy hour traffic percentage was calculated by means of an EEA average. The table below indicates the cases in which EEA average was used:

Services	Countries with estimated information based on an EEA average
Voice traffic	LT, LU, NO

Table 3.23: Busy hour and traffic in weekdays - Input definition – Busy hour traffic percentage [Source: Axon Consulting]

Question 8: Do you agree with the validation, treatment and estimation of the percentage of traffic in the busy hour and in weekdays? Otherwise please describe your rationale in detail and provide supporting information and references.

3.1.5. Core Network Equipment[24] Unitary Costs

The unitary costs for the network assets are defined in the model for the reference year 2018. This input refers to the CapEx and OpEx costs of the core network elements, as well as the applicable trends. All cost items are considered in the model in Euros.

Given the relevance of the unitary cost information, a detailed methodology aiming at maximising the quality and robustness of this information was set up, which placed special emphasis on the data reported by the stakeholders. The methodology adopted is described in detail throughout this section.

Unitary costs are introduced in the cost model for each of the network resources modelled. These costs are separated between CapEx and OpEx:

- *Unitary CapEx:* Includes the costs associated with the purchase and installation of the network element.
- *Unitary OpEx:* Includes the annual cost of maintenance and operation of the network element.

In addition to this, a cost trend for CapEx is defined in the cost model in order to represent the evolution of costs over the years.

The unitary cost values used in the cost models are based on EEA average figures, obtained as described in section 3.1.5.3 below. They are included in worksheet '1D INP CORE PLATF UNITARY COSTS' of the model.

3.1.5.1. Sources of information

Core network equipment unitary costs are mostly based on data reported by the stakeholders. Even though several stakeholders did not provide information for all the cost

[24] Please note that the detail of the IMS architecture employed in the model for the dimensioning of the core network equipment is provided in the `Annex 3 – Descriptive manual´ of the consultation materials.

items requested, we were able to obtain, collectively, enough information for each network element.

Further, in order to process and validate the information reported by the NRAs, the following additional source of information was considered:

- Euro/European Currency Unit (ECU) exchange rates[25]. These exchange rates reported by Eurostat were used to convert unit prices reported in local currencies to Euros.

The tables below indicate the availability and confidentiality of the unitary costs data per country reported by NRAs.

Data availability

Status	Countries
Complete information	ES
High-priority information provided	BG, CZ, DE, EL, FR, HR, IT, PL, SK, UK
Not all High-priority information provided	BE, CY, DK, HU, IE, LU, LV, MT, NL, PT, RO
No information	AT, EE, LT, NO, SI, SE

Table 3.24: Unitary Costs - Core network elements - Data availability [Source: Axon Consulting]

Data confidentiality

Confidentiality level	Input
Confidentiality level 0	-
Confidentiality level 1	LU, LV
Confidentiality level 2	BE, BG, CY, CZ, DE, DK, EL, ES, FR, HR, HU, IE, IT, MT, NL, PL, PT, RO, SK, UK

Table 3.25: Unitary Costs - Core network elements - Data confidentiality [Source: Axon Consulting]

[25] Euro/ECU exchange rates - annual data (Ref. date 18/01/2019): http://ec.europa.eu/eurostat/web/products-datasets/-/ert_bil_eur_a

Please note that unit costs inputs have been defined based on EEA averages and anonymised afterwards[26] in some cases. Therefore, both the confidential and non-confidential versions of the cost models contain non-confidential unit cost information.

3.1.5.2. Input validation and treatment

A thorough exercise has been performed to ensure the consistency, reasonability and completeness of the data provided by NRAs. This exercise led to the adjustment of a number of figures in order to generate a robust set of inputs.

Specifically, the activities performed are classified below under the following categories:

- Local-Currency adjustments
- Data validation
- Treatment of the information received for the SBC components

Local-Currency adjustments

In order to ensure that the references received are comparable to each other, the information reported in local currency by some NRAs was converted to Euros with the exchange rates reported by Eurostat.

Data validation

Given the particularities of the approach adopted to define the unitary costs, the validation performed is described in the 'inputs definition' section below.

Treatment of the information received for the SBC components

The information submitted by stakeholders regarding the Access SBC and the IX SBC showed that they were not generally able to separate the costs associated to the following sub-functions contained in them:

- Access SBC
  - P-CSCF (Proxy CSCF) which handles signalling of Access SBC
  - IMS-AGW (IMS Access Gateway) which handles traffic of Access SBC

[26] Please refer to the main consultation document for further indications on the treatment given to confidential information in the cost model circulated to NRAs.

- IX SBC
  - IBCF (Interconnect Border Control Function) which handles signalling of IX SBC
  - TrGW (Transition Gateway) which handles traffic of IX SBC

In light of this, both Access SBC and IX SBC core elements have been modelled without separating the signalling and traffic related parts.

3.1.5.3. Input definition

The next step consisted in the definition of the unitary costs (OpEx and CapEx categories) and the associated CapEx trends in the cost model. The sections below provide further indications on the approach used to define the unit costs and associated trends:

- Unit CapEx prices
- Unit OpEx prices
- CapEx trends

Unit CapEx prices

This section describes the steps required to define the unitary CapEx information used in the model.

As described during the presentation of the model's methodology in Workshop 1, and based on the feedback received by the industry, Unit CapEx prices are defined in the model by means of price catalogues of modular equipment[27]. This means that only a set of discrete configurations/capacities are available for each core network element. The following table illustrates this approach:

[27] Based on the feedback received, 57% of stakeholders supported the utilization of price catalogues.

Equipment	Capacity (Gbps)	Unit CapEx Cost ('000 EUR)
Core equipment Cat. 0	1	100
Core equipment Cat. 1	2	150
Core equipment Cat. 2	4	200
Core equipment Cat. 3	8	250
Core equipment Cat. 4	16	300
Core equipment Cat. 5	32	350

Exhibit 3.6: Illustrative example of a price catalogue of modular equipment [Source: Axon Consulting]

The use of price catalogues at EEA level was adopted due to the reasons indicated below:

- **Capability to fill any gaps in the information provided**: Several countries were not capable of reporting unit cost information for all the core network elements. Therefore, adopting EEA averages would have been needed in any case for multiple countries.
- **Representativeness of the information received**: We observed that in many cases the values reported were reasonably similar across countries, implying that there were no significant price differences among Member States for the same elements in terms of capacity.
- **Existence of a limited number of equipment manufacturers**: Telecommunication operators purchase their network equipment from a limited number of international providers, resulting in similar prices for equivalent equipment elements.
- **Consistency with the efficient operator assumption**: The model is not aimed at reflecting the characteristics of any specific operator in any country, but a hypothetical efficient operator. Therefore, operator-driven unit cost differentials should be excluded from any cross-country analysis.

A price catalogue was defined for each core network element. The approach used to build up these price-catalogues consisted in calculating averages of the data points collected from all EEA countries, excluding outliers as described later in this section. More specifically, the following steps were adopted:

- Step 1: Conversion of capacity units of the dominant technical constraint associated to each modelled core network element into equivalent capacity units
- Step 2: Selection of the dominant capacity unit
- Step 3: Consolidation of OpEx and CapEx in the case of the Software components

- Step 4: Rejection of outlier values
- Step 5: Cost analysis and definition of price catalogues

Step 1: Conversion of capacity units of the dominant technical constraint associated to each modelled core network element into equivalent capacity units

The capacity unit of the dominant technical constraint is the unit in which the maximum capacity of the equipment is measured (e.g. Mbps, Erlangs, BHCA, Subscribers, Transactions/sec etc.).

The capacity unit of the dominant technical constraint was provided by stakeholders for each modelled core network element.

During the review of the capacity units submitted, it was observed that even if stakeholders often make use of different nomenclatures, many of these capacities were equivalent or directly comparable. In light of this, the first step consisted of converting these equivalent and comparable units into common units (e.g. voice channels, Erlangs, concurrent/simultaneous sessions, concurrent/simultaneous calls and CAPS - Call Attempt per Second - were all considered as the same unit).

Step 2: Selection of the dominant capacity unit

Once capacity units were homogenised to facilitate their comparison, the dominant capacity unit was selected based on the most widespread configuration reported by stakeholders, as shown in the table below:

Core network element	Dominant capacity unit (selected)		Alternative capacity unit		Other capacity units	Total No. ref.
	Capacity Unit	No. ref.	Capacity Unit	No. ref.	No. ref.	
AS	Subscribers	54	Call per second	6	1	61
CDF	CDR/hour	11	Subscribers	10	2	23
I-CSCF	Subscribers	20	CAPS	5	7	32
S-CSCF	Subscribers	19	BHCA	5	1	25
Access SBC	Concurrents Sessions	38	Subscribers	27	1	66
IX SBC	Concurrent Sessions	25	Subscribers	1	6	32
ENUM	Subscribers	14	ENUM resource record number	5	8	27
MRF	Concurrent Voice Channels	17	Subscribers	4	3	24

Table 3.26: Capacity units and number of samples of the dominant technical constraints of core network elements [Source: Axon Consulting based on data reported by stakeholders]

As can be observed above, we have identified a number of network elements for which the dominant constraint is the number of subscribers. It is important to note that, based on the methodology described in Annex III[28] of the EECC, the cost associated to these network elements is not incremental to the wholesale voice termination service and, thus, shall not be allocated to this service. For this reason, the following core network elements, whose dominant capacity unit is the number of subscribers, have not been considered part of the incremental cost of fixed voice termination:

[28] Principle (c): *"only those traffic related costs which would be avoided in the absence of a wholesale voice termination service being provided shall be allocated to the relevant termination increment"*

- Application Server (AS),
- I-CSCF (Interrogating CSCF)
- S-CSCF (Serving CSCF)
- ENUM (Electronic Number Mapping System)

It is worth noting that, despite not having any impact in the results of the voice termination service, these core network elements have been included in the model to be able to perform the reconciliation exercise described in section 4.

Step 3: Consolidation of OpEx and CapEx for Software components

Regarding the treatment of the software component, in the Data Request Form addressed to stakeholders, data about the following three options of payment schemes was requested:

- **Initial investment**: if the full payment is incurred in the moment of acquiring the software (i.e. CapEx oriented).
- **Annual fee**: if an annual payment is incurred for the software license and associated support services (i.e. OpEx oriented).
- **Both**: if the two previous cases are applicable simultaneously for the equipment reported (CapEx + OpEx).

The information submitted by stakeholders showed that the vast majority of unit prices reported (around 80%) fell under the first option (Initial investment). In light of this, a single CapEx component was considered when defining these inputs.

However, with the objective of considering all data points received from stakeholders in the definition of the cost inputs, the OpEx component of data points reported by means of the second and third options was converted into a CapEx component, by means of the NPV (Net Present Value) formula and applying: i) the WACC corresponding to the operator's country as rate of return (see further detail in section 3.1.10 about WACC) and ii) the useful life of the corresponding asset in each case (see further detail in section 3.1.9 about how useful lives have been determined).

Additionally, in the case of the third option (Both), the OpEx figure converted into CapEx using the approach described above was added to the CapEx reported.

Step 4: Rejection of outlier values

Pairs of costs-capacities were discarded when, once pictured in a graph, these were found to be outside the reasonable range/trend exhibited by other peers. The table below illustrates the number of references collected for each core network element, indicating the number of values that were accepted/rejected in each case.

It is important to note that only data points corresponding to the capacity unit selected in Step 2 were considered in this exercise, given that the rest of data points presented capacities that were not comparable. It is also worth noting that the figures in the following table may differ from figures in Table 3.26. In this case, only data points reported with complete data (cost, capacity and capacity unit) are considered[29].

[29] In particular, differences mainly arise from operators' difficulties to provide all the information required to define the cost-capacity relationships. For instance, in some cases, while operators have been able to provide the dominant capacity unit (therefore, considered in Table 3.26) for a certain network asset, they have not been able to report the value of the corresponding capacity or the cost associated with it (therefore, excluded from this analysis).

Core network element	Values reported	Rejected values	Accepted values
AS – Hardware	21	11	**10**
AS – Software	18	7	**11**
CDF - Hardware	3	1	**2**
CDF – Software	3	1	**2**
I-CSCF – Hardware	6	-	**6**
I-CSCF - Software	5	1	**4**
S-CSCF – Hardware	7	2	**5**
S-CSCF – Software	8	4	**4**
Access SBC – Hardware	15	5	**10**
Access SBC – Software	7	3	**4**
IX SBC – Hardware	12	1	**11**
IX SBC – Software	11	1	**10**
ENUM – Hardware	4	1	**3**
ENUM – Software	6	2	**4**
MRF – Hardware	7	3	**4**
MRF – Software	5	4	**1**

Table 3.27: Values reported and outliers for each core network element [Source: Axon Consulting based on data reported by stakeholders]

Step 5: Cost analysis and definition of price catalogues

As stated throughout this section, unitary CapEx costs to be included in the model in the form of price catalogues were extracted from the set of data points (pairs of costs-capacities) received from EEA countries for each core network element.

The following steps were carried out to define the price catalogues:

1. The references collected for each core network element were grouped into four clusters (or less, when not enough data was available) according to their capacity (Cluster 1, Cluster 2, Cluster 3 and Cluster 4).
2. The average capacity of the references within each cluster was calculated as a simple average. A capacity representative of each cluster was defined by rounding this simple average.

3. The average price of the references within each cluster was calculated as the arithmetic average of the price/capacity ratio of all valid points within that cluster, multiplied by the capacity calculated in step 2.
4. The average cost-price pair for each cluster was used in the definition of the price catalogue for each core network element.

The following tables provide a detailed overview of the results obtained for each core network element.

It is important to note that, in the version of this document shared with NRAs, some information has been redacted due to confidentiality reasons. As explained in the main consultation document, information about unit costs of core equipment is considered to be highly sensitive since it could disclose vendors' actual level prices. Because of this, unit costs of each core equipment have also been anonymised (i.e. values presented in the following tables are not the true values). Please refer to the main consultation document for further indications on the treatment given to confidential information of core equipment unitary costs.

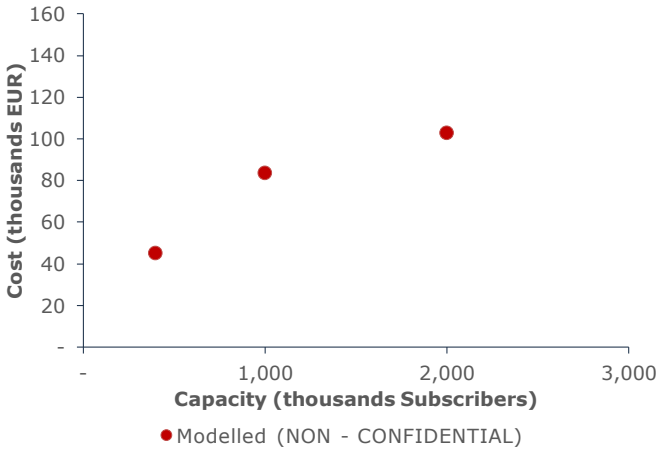
Core element	AS (Voice Application Server) - Hardware

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph



Table

Capacity (Subscribers)	Cost (EUR)
400,000	45,130
1,000,000	83,594
2,000,000	102,737

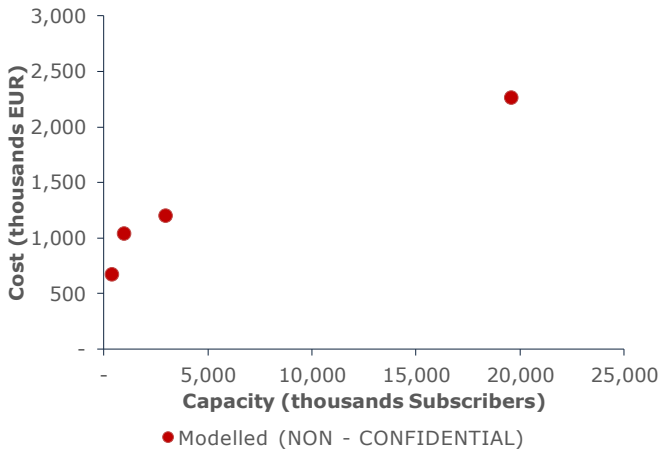
Core element	AS (Voice Application Server) - Software

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph



Table

Capacity (Subscribers)	Cost (EUR)
400,000	670,481
1,000,000	1,036,376
3,000,000	1,198,820
19,600,000	2,263,916

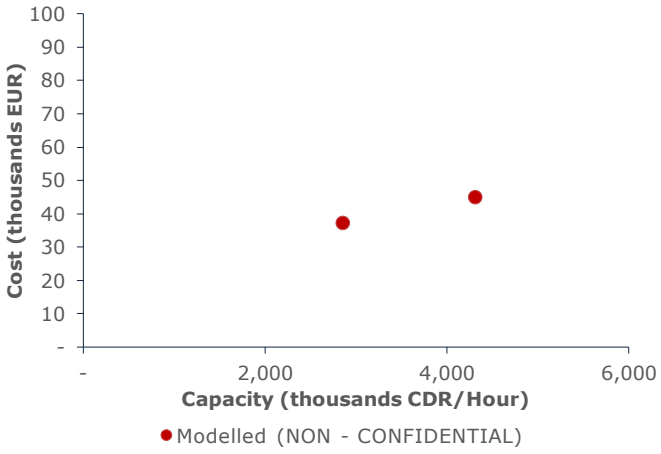
Core element	CDF (Charging Data Function) - Hardware

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph



Table

Capacity (CDR/hour)	Cost (EUR)
2,860,000	37,052
4,320,000	44,908

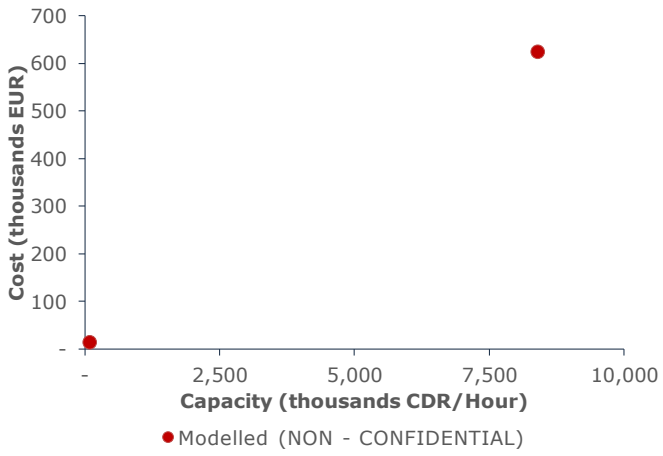
Core element	CDF (Charging Data Function) - Software

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph



Table

Capacity (CDR/hour)	Cost (EUR)
97,000	12,932
8,400,000	624,400

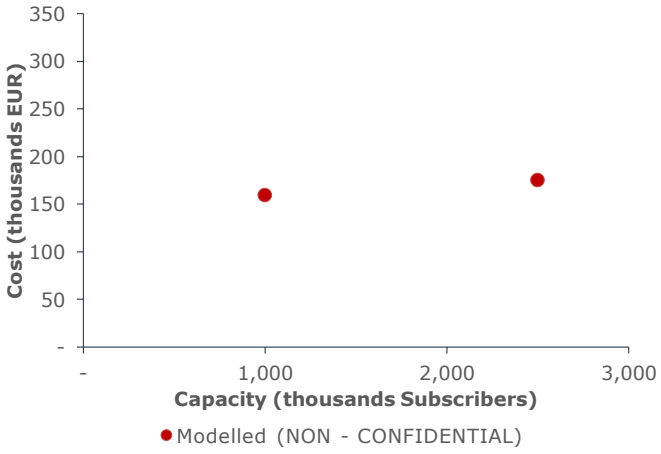
Core element	I-CSCF (Interrogating CSCF) - Hardware

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph	Table



Capacity (Subscribers)	Cost (EUR)
1,000,000	159,611
2,500,000	174,784

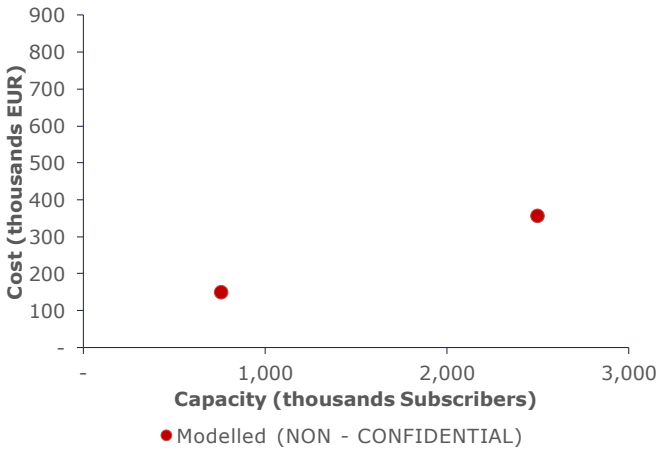
Core element	I-CSCF (Interrogating CSCF) - Software

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph	Table



Capacity (Subscribers)	Cost (EUR)
760,000	149,349
2,500,000	355,350

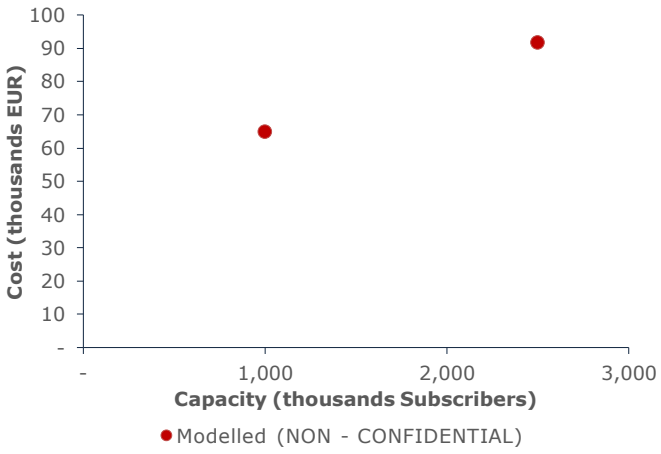
Core element	S-CSCF (Interrogating CSCF) - Hardware

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph	Table



Capacity (Subscribers)	Cost (EUR)
1,000,000	64,805
2,500,000	91,723

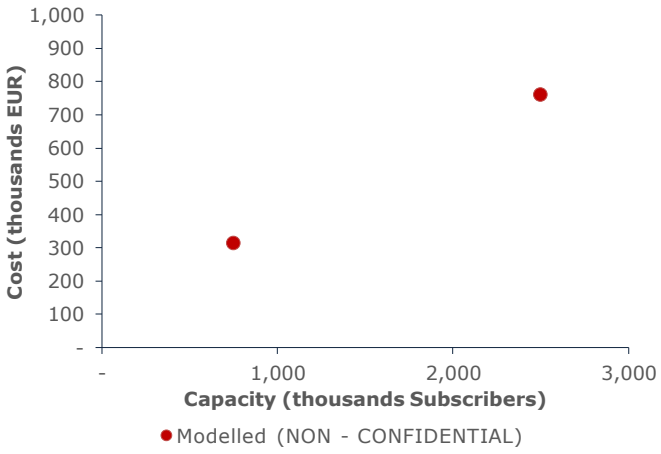
Core element	S-CSCF (Interrogating CSCF) - Software

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph



Table

Capacity (Subscribers)	Cost (EUR)
750,000	313,345
2,500,000	759,619

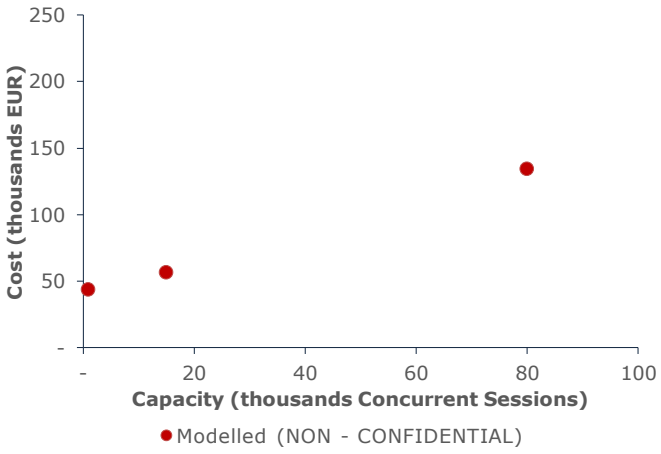
Core element	Access SBC (Session Border Controller) - Hardware

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph



Table

Capacity (Concurrent Sessions)	Cost (EUR)
1,000	43,613
15,000	56,277
80,000	134,047

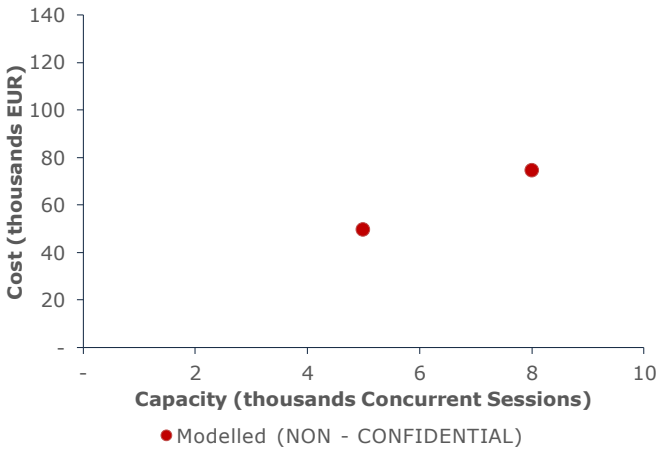
Core element	Access SBC (Session Border Controller) - Software

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph



Table

Capacity (Concurrent Sessions)	Cost (EUR)
5,000	49,729
8,000	74,664

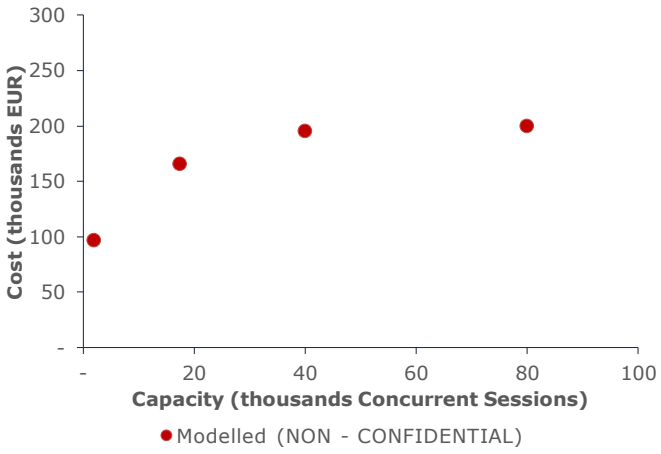
Core element	IX SBC (Session Border Controller) - Hardware

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph



Table

Capacity (Concurrent Sessions)	Cost (EUR)
2,000	96,576
17,500	165,654
40,000	195,103
80,000	199,649

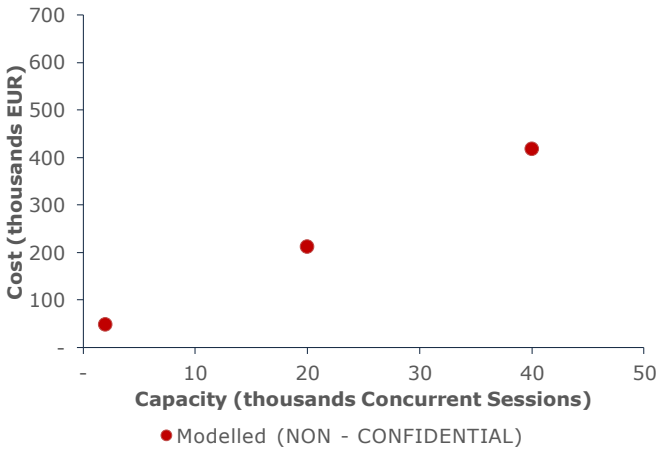
Core element	IX SBC (Session Border Controller) - Software

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph



Table

Capacity (Concurrent Sessions)	Cost (EUR)
2,000	48,435
20,000	211,666
40,000	417,330

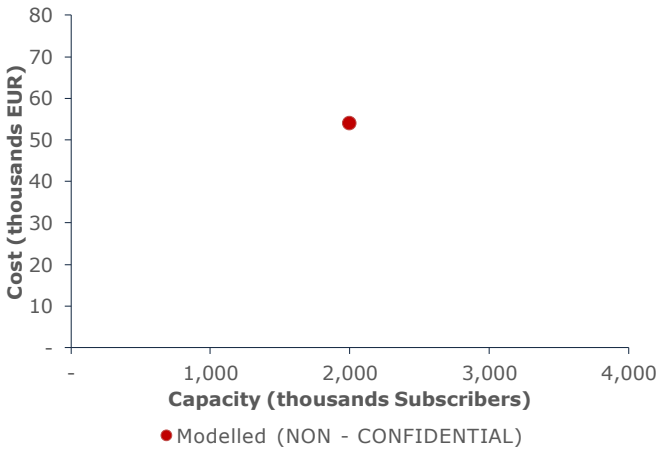
Core element	ENUM (Electronic Number Mapping System) - Hardware

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph	Table



Capacity (Subscribers)	Cost (EUR)
2,000,000	53,958

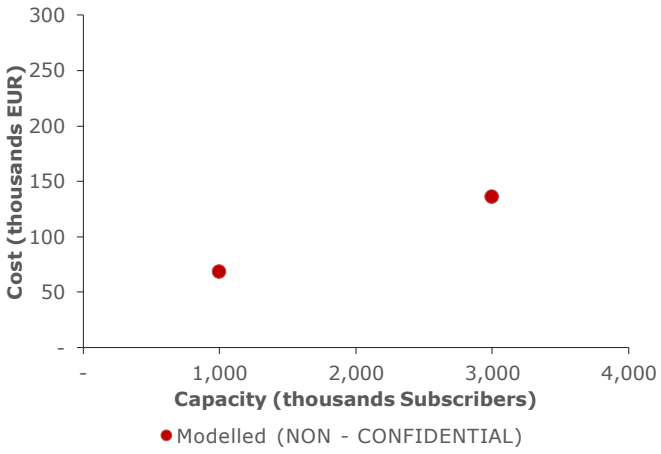
Core element	ENUM (Electronic Number Mapping System) - Software

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph



Table

Capacity (Subscribers)	Cost (EUR)
1,000,000	68,287
3,000,000	136,001

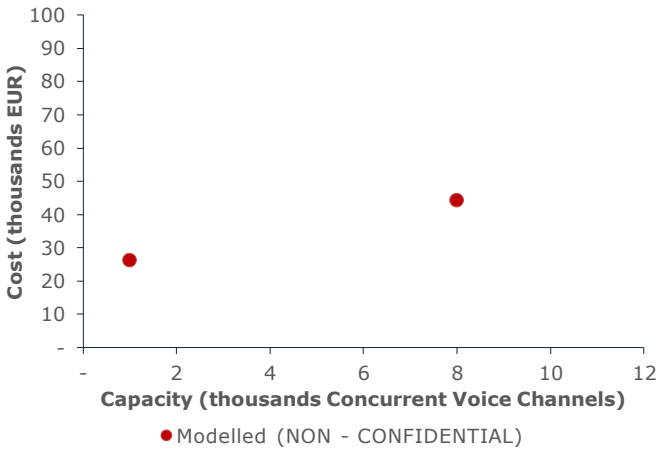
Core element	MRF (Media Resource Function) - Hardware

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph



Table

Capacity (Concurrent Voice Channels)	Cost (EUR)
1,000	26,159
8,000	44,150

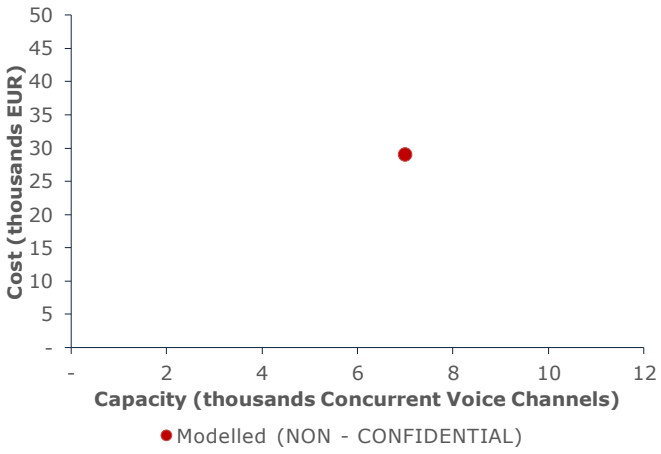
Core element	MRF (Media Resource Function) - Software

Overview of the references observed

All references	Zoom into the most populated range
This information has been redacted due to confidentiality reasons	This information has been redacted due to confidentiality reasons

Price catalogue defined

Graph



Table

Capacity (Concurrent Voice Channels)	Cost (EUR)
7,000	29,036

Unit OpEx prices

This section describes the steps adopted to define the unitary OpEx information used in the model. OpEx includes the annual cost of energy, maintenance and operation of the network element.

The unitary OpEx information is defined in the model by means of a percentage over the equipment acquisition price (% of OpEx over CapEx) and is based on percentages requested to stakeholders through the Data Request Form.

These OpEx percentages were calculated by considering the average of the information received from stakeholders, after removing outliers, to ensure the representativeness of the figures considered.

The identification of outliers was performed using two different approaches, both based on the number of references received for a percentage:

- When the number of references collected was less than 4, a manual comparative exercise was performed to review the reasonability of each of the sources. When discrepancies were detected, these were considered as outliers.
- When the number of references collected was 4 or more, the values that fell within the top or bottom 20% of the references collected were discarded as outliers. This threshold was set with the objective of maximising the consistency and reasonability of the references considered. On average, the adoption of this approach reduced the average standard deviation of the references considered by more than half.

Core network element	% OpEx over CapEx
AS – Hardware	9.43%
AS – Software	6.07%
CDF – Hardware	8.08%
CDF – Software	6.95%
I-CSCF – Hardware	10.50%
I-CSCF – Software	7.27%
S-CSCF – Hardware	9.36%
S-CSCF – Software	6.38%
Access SBC – Hardware	11.76%
Access SBC – Software	15.08%
IX SBC – Hardware	10.11%

Core network element	% OpEx over CapEx
IX SBC – Software	10.02%
ENUM – Hardware	8.85%
ENUM – Software	4.38%
MRF - Hardware	9.90%
MRF – Software	5.05%

Table 3.28: Unit OpEx prices – Input definition [Source: Axon Consulting]

It is also worth noting that OpEx percentages have been defined at EEA level, without differentiating among countries, given that no clear correlation was identified between the percentages received and the PPP of countries were operators providing the information were located.

CapEx trends

CapEx trends were based on the average of the information received from stakeholders, after removing outliers, following the same methodology as in the case of the Unit OpEx prices (see section above). The standard deviation was also calculated to verify that it decreased significantly after the removal of outliers.

The outcomes of our assessment are presented below:

Core network element	CapEx trends
AS - Hardware	-2.2%
AS – Software	2.7%
CDF – Hardware	-2.2%*
CDF – Software	2.7%
I-CSCF – Hardware	-2.3%
I-CSCF – Software	2.1%*
S-CSCF – Hardware	-2.5%*
S-CSCF – Software	2.7%*
Access SBC – Hardware	-2.0%
Access SBC – Software	-4.6%*
IX SBC – Hardware	-2.0%
IX SBC – Software	-5.1%*
ENUM – Hardware	-2.2%

Core network element	CapEx trends
ENUM – Software	2.7%*
MRF – Hardware	-2.5%
MRF – Software	2.6%*

Table 3.29: CapEx trends – Input definition. [Source: Axon Consulting based on data reported by stakeholders] Note (*): As explained in the main consultation document, these values have been anonymised due to confidentiality reasons

Question 9: Do you agree with the validation, treatment and estimation of the values for core network equipment unit cost inputs? Otherwise please describe your rationale in detail and provide supporting information and references.

Additionally, it is worth noting that the model considers two different scenarios regarding the treatment given to the core network equipment unitary costs:

- *Prices catalogues*. Only a set of configurations/capacities is available (discrete points), based on pairs of costs-capacities defined in Step 5 of this same section. If the capacity required falls between two configurations, the higher one must be purchased. Although it is more aligned with information provided by operators, it results in higher variability of costs under LRIC.
- *Continuous functions (Curves)*. The set of configurations/capacities of the `Prices catalogues´ option is connected to produce a continuous function for each core equipment. This option diverts from configurations provided by stakeholders but is aligned with a forward-looking LRIC approach and produce more stable results.

The following charts illustrate both cases:

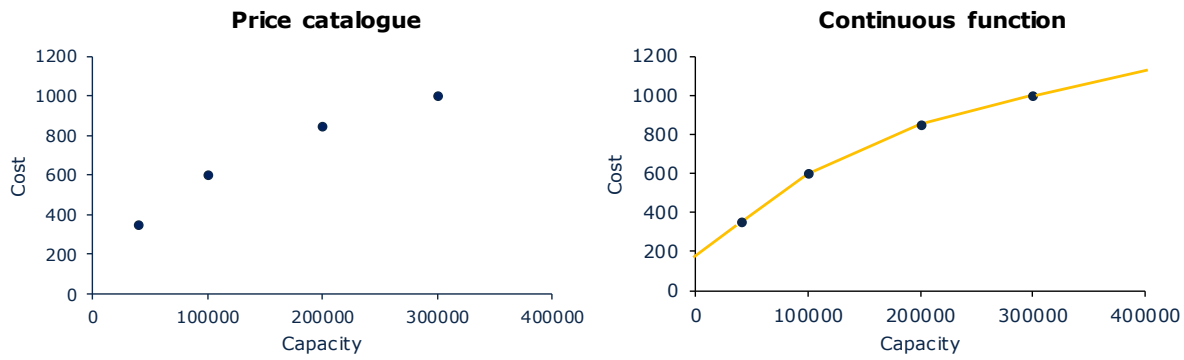


Exhibit 3.30: Scenarios included in the model regarding the treatment given to the core network equipment unitary costs [Source: Axon Consulting]

Stakeholders can assess the results obtained under each scenario by selecting the desired option in the control panel of the model (see Annex 2 - User manual for further indications on how to run the model):

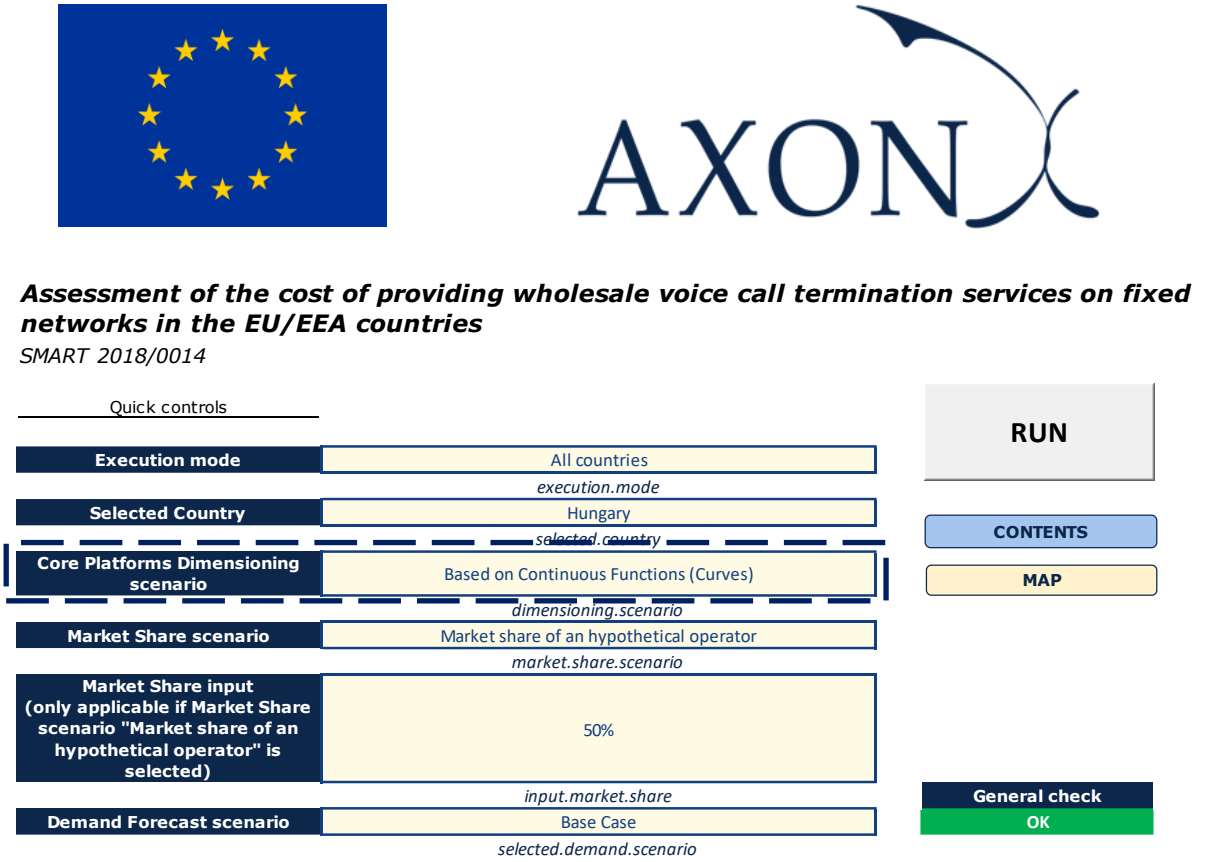


Exhibit 3.7: Selection of the core platform dimensioning scenario in the model [Source: Axon Consulting]

Question 10: In your opinion, which scenario for the core network equipment unit costs should be adopted to estimate the incremental cost of fixed voice call termination? Please, describe your preferred approach in detail and provide supporting information and references.

3.1.6. Mark-up for active transmission and switching costs

Based on the feedback provided by stakeholders in their comments to the methodology presented in Workshop 1, 77% of them agreed that costs associated with active transmission and switching equipment represent a relatively small part of the voice termination cost under the pure LRIC standard. Based on this, most of them preferred to model these costs by means of a mark-up applied over core network costs, rather than the more complex approach of trying to estimate the share of active equipment that was incremental to voice termination using bottom-up modelling.

The mark-up is included in worksheet '1E INP ACTIVE TRANSMISSION COST' of the model.

3.1.6.1. Sources of information

The source of information considered in the definition of the mark-up was the data reported by the NRAs.

The tables below indicate the availability and confidentiality of the data reported by NRAs.

Data availability

Status	Countries
Complete information	BE, BG, CZ, DK, ES, FR, HR, HU, IE, IT, LU, PL, SE, UK
High-priority information provided	CY, MT, PT
Not all High-priority information provided	LV, RO, SK
No information	AT, DE, EE, EL, LT, NL, NO, SI

Table 3.31: Mark-up for active transmission and switching costs - Data Availability [Source: Axon Consulting]

Data confidentiality

Confidentiality level	Countries
Confidentiality level 0	CZ, DK, ES, HR, IT, LU, LV, MT, PT, SE, SK, UK
Confidentiality level 1	-
Confidentiality level 2	BE, BG, CY, FR, HU, IE, PL, RO

Table 3.32: Mark-up for active transmission and switching costs - Data Confidentiality [Source: Axon Consulting]

Note that, since the mark-up has been defined at EEA level, the information contained in both the confidential and non-confidential versions of the model is not confidential.

3.1.6.2. Input validation and treatment

The following validation analyses were performed to ensure the applicability, consistency, and reasonability of the data provided by NRAs:

- *Alignment with the methodological guidelines set in the EECC.* This alignment was evaluated in terms of:
  - *Modelled technologies.* Only the information provided by NRAs that have developed a model which considers a full NGN network, was deemed valid for this exercise. Therefore, information related to models that considered TDM and/or legacy elements were discarded. The reason behind this was to keep consistency with the principles of current cost accounting, efficiency and forward-looking set by the EC in the Annex III of the EECC. This same Annex also establishes clearly that *"the technology choice of the modelled networks shall be forward looking, based on an IP core network, taking into account the various technologies likely to be used over the period of validity of the maximum rate; in the case of fixed networks, calls shall be considered to be exclusively packet switched",* hence supporting the exclusion of models based on TDM and/or legacy technologies from the analysis.
  - *Calculation of the pure incremental costs*. Annex III of the EECC states that *"the relevant incremental costs of the wholesale voice termination service shall be determined by the difference between the total long-run costs of an operator providing its full range of services and the total long-run costs of that operator not providing a wholesale voice termination service to third parties"*. We observed that some NRAs had developed their models following principles for the calculation of the incremental costs that differed from this methodology, making them ineligible for this analysis.

As a result of this process, the following references were discarded:

Country	Issues identified	Adopted approach
BG	The model does not remove the traffic related to termination services for the calculation of the relevant incremental costs.	Values discarded
CZ	The model considers PSTN switching equipment belonging to TDM/legacy technologies.	Values discarded

Country	Issues identified	Adopted approach
DK	The model considers PSTN switching equipment belonging to TDM/legacy technologies.	Values discarded
ES	The model considers elements for IP-TDM conversion.	Values discarded
FR	The model considers PDH/SDH transmission belonging to TDM/legacy technologies.	Values discarded
IT	The model considers PDH/SDH transmission belonging to TDM/legacy technologies.	Values discarded
LV	The model considers PSTN switching equipment belonging to TDM/legacy technologies	Values discarded
PL	The model considers PSTN switching equipment and PDH/SDH transmission belonging to TDM/legacy technologies.	Values discarded
SE	The model considers PSTN switching equipment belonging to TDM/legacy technologies.	Values discarded

Table 3.33: Mark-up for active transmission and switching costs – Input validation [Source: Axon Consulting]

- *Consistency across EEA references*. In order to ensure the consistency and reasonability of the information received, figures provided by NRAs were compared against each other to identify potential discrepancies among them. More specifically, based on the breakdown of costs received from each NRA for the fixed termination service, the mark-up percentage was calculated as the ratio between the cost of active transmission and switching network elements (named as *Ethernet transmission* in the Data Request template) over the cost of core NGN network elements (named as *NGN Core platforms* in the Data Request template). The following outliers were identified:

Country	Issues identified	Adopted approach
HR[30]	Ratio was significantly higher than the EEA average. The NRA explained that main reason could be that the modelled transmission network was ancient, and it had already been switched off.	Values discarded
HU	Ratio was significantly higher than the EEA average.	Values discarded

Table 3.34: Mark-up for active transmission and switching costs – Input validation [Source: Axon Consulting]

3.1.6.3. Input definition

Based on the accepted mark-up percentages produced after the validation and treatment process, all figures calculated were in the range between 0% and 1.2%. The following graph shows the number of references for the ranges of calculated mark-ups. Note that countries' names are not disclosed due to confidentiality reasons.

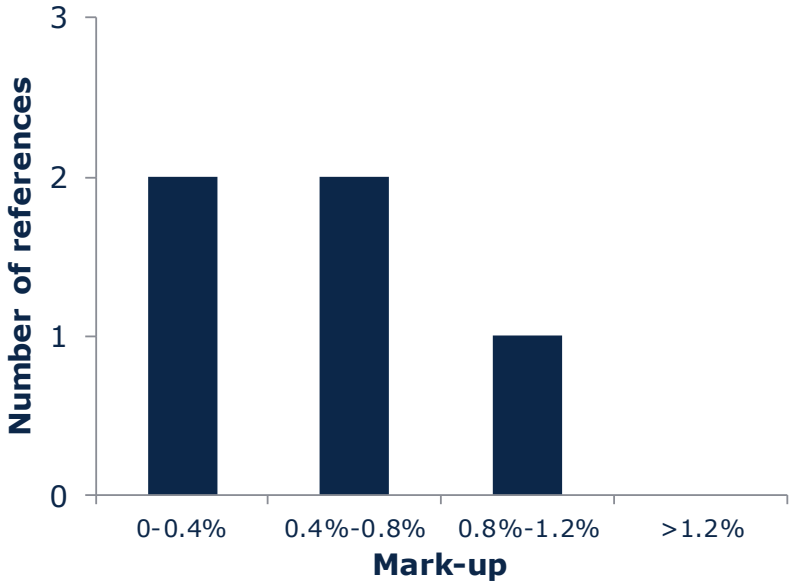


Exhibit 3.8: Mark-up for active transmission and switching costs – Input definition [Source: Axon Consulting based on information received from EEA countries]

[30] Note that in this case transmission costs had been included in the category "Other", indicating "DWDM transmission equipment" in the space reserved for comments.

The mark-up percentage was included in the model as a single figure, obtained as the average (0.38%) of the validated references.

It is important to note that mark-ups of active transmission and switching costs in the case of NGN networks are in general lower than in the case of TDM/legacy networks. This is the reason why mark-ups derived from the models based on TDM/legacy networks that have been discarded in section 3.1.6.2 are likely to present higher percentages than ranges shown in this exhibit. Nevertheless, the provisions in the EECC's Annex III only support relying on NGN networks when modelling the incremental costs of fixed voice call termination and, for this reason, we cannot consider cost models based on TDM/legacy networks.

The main reason why TDM/legacy networks will typically have higher active transmission and switching costs than NGN networks is because the latter have a greater number of active transmission and switching elements that are shared between voice and non-voice services (broadband, TV, leased lines). In other words, the lower (or non-existent) weight of non-voice services in TDM/legacy networks is the reason behind a higher incrementality of active transmission and switching elements for voice services in these circumstances, therefore leading to higher mark-ups.

Question 11: Do you agree with the validation, treatment and estimation of the mark-up percentage to reflect the costs of active transmission and switching equipment? Otherwise please describe your rationale in detail and provide supporting information and references.

3.1.7. Wholesale specific costs

This section outlines the approach used to estimate costs that fixed operators need to incur to provide wholesale voice termination services to third-party operators (so-called wholesale specific costs). These wholesale costs result from the need to provide interconnection between the networks of fixed/mobile operators to ensure end-to-end connectivity in the provisioning of retail voice services.[31]

Equivalent to the approach adopted in the mobile cost study (SMART 2017/0091), these costs have been estimated across EEA countries using regression analysis. The cost categories considered and requested to stakeholders through the Data Request Form are:

- Route testing/monitoring costs
- Operation and maintenance (O&M) costs
- Data clearing costs
- Financial clearing costs
- Negotiation and contract management/regulation costs

The wholesale specific costs inputs are introduced in worksheet '2F INP SERVICE SPEC COSTS' of the model.

3.1.7.1. Sources of information

All information used to assess wholesale specific costs has been reported by the NRAs.

Additionally, in order to perform the regressions, the following information was also employed:

- Traffic demand (obtained as indicated in section 3.1.2).
- Traffic statistics (obtained as indicated in section 3.1.3).

Finally, Euro/European Currency Unit (ECU) exchange rates reported by Eurostat were used to convert unit prices reported in local currencies to Euros.

[31] For instance, voice off-net calls to other national operators.

The tables below indicate the availability and confidentiality of the wholesale specific costs information per country reported by NRAs.

Data availability[32]

Status	Countries
Complete information	CZ, DE, EL, ES, HR, HU, PT, RO
High-priority information provided	AT, CY, FR, IE, MT, NL, PL, SE, SI, SK, UK
Not all High-priority information provided	BG, DK, FR, IT, LU, LV
No information	BE, EE, LT, NO

Table 3.35: Wholesale specific costs – Data availability [Source: Axon Consulting]

Data confidentiality

Confidentiality level	Countries
Confidentiality level 0	AT, CY, SE, UK
Confidentiality level 1	LU, LV
Confidentiality level 2	BG, CZ, DE, DK, EL, ES, FR, HR, HU, IE, IT, MT, NL, PL, PT, RO, SI, SK

Table 3.36: Wholesale specific costs - Data confidentiality [Source: Axon Consulting]

Please note that since this input has been defined at EEA level, the information included in both the confidential and non-confidential versions of the model is not confidential.

3.1.7.2. Input validation and treatment

In order to ensure that the references received were comparable to each other, they were converted to EUR with the exchange rates reported by Eurostat, when applicable.

On the other hand, in terms of data validation, given the particularities of the approach adopted to define the wholesale specific costs (by means of a regression analysis), the validation performed is described in the 'inputs definition' section below.

[32] Availability per country refers to the availability of data from the operator that provided the higher amount of data for each country.

3.1.7.3. Input definition

Wholesale specific costs are defined by means of a regression curve including a fixed and a variable cost component for each of CapEx and OpEx cost category.

The Data Request Form sought to gather cost information for each cost category disaggregated by service type (Fixed national interconnection, Fixed international interconnection EU/EEA, Fixed international interconnection Non-EU/EEA and Other wholesale services). However, many of the references received did not include such split for all service types, impeding a service-based cost analysis. Consequently, the cost assessment has been performed at cost category level, without considering the split per service type reported by some stakeholders.

At the same time, given that only costs associated to interconnection services were relevant for this cost study, stakeholders were required to remove the portion of costs corresponding to `Other wholesale services´ (e.g. Local Loop Unbundling, Bitstream). As explained in Workshop 1, when stakeholders were not able to separate these wholesale specific costs, the Axon/EC team performed this disaggregation based on the revenues/outpayments applicable to each service type. This information had also been requested to stakeholders in the Data Request Form.

Based on the available references, linear regressions were defined separately for each cost category. These regressions define the relationship between the costs of each cost category as reported by fixed operators and a traffic/volume element. Particularly, for each cost category, the regression drivers have been defined consistently with the mobile cost study, namely:

Cost category	Traffic/volume elements
Route testing/monitoring costs	Traffic (measured in minutes)
Operation and maintenance (O&M) costs	TAPs[33] (measured in number of calls)
Data clearing costs	TAPs (measured in number of calls)
Financial clearing costs	TAPs (measured in number of calls)
Negotiation and contract management/regulation costs	Traffic (measured in minutes)

Table 3.37: Traffic/volume elements drivers selected to perform the regressions for each cost category [Source: Axon Consulting in consistency with the drivers defined in the study SMART 2017/0091]

Once these relationships were defined, the following steps were adopted to determine the final input values to be included in the model.

- Step 1: Conversion of voice traffic minutes to TAPs
- Step 2: Consolidation of the costs reported by operators
- Step 3: Rejection of outlier values
- Step 4: Cost analysis and linear regression

Step 1: Conversion of voice traffic minutes to TAPs

In order to use TAPs as regression drivers, services' demand in terms of voice minutes had to be converted into these units.

A TAP record is generated for each voice call. Thus, the number of TAPs generated by a voice minute is obtained as 1 divided by the average call duration. This input has been defined on a country-basis to understand the country-specific voice traffic consumption patterns, as described in Section 3.1.3.

The demand of the following voice services for the year 2018 was considered in the calculation of the equivalent demand in terms of TAPs per operator:

[33] Transferred Account Procedure

- Fixed national interconnection[34]
  - Voice Off-net to fixed national
  - Voice Off-net to mobile national
  - Voice Incoming from fixed national
  - Voice Incoming from mobile national
- Fixed international interconnection[34]
  - Voice Off-net to international
  - Voice Incoming from international

Given that costs were reported at operator level, the market demand reported by NRAs (after adjustments indicated in section 3.1.2) was multiplied by the percentage of traffic corresponding to the relevant operator in each case[35], to calculate its traffic in minutes and TAPs.

Step 2: Consolidation of the costs reported by operators

As previously explained, the cost assessment has been performed at cost category level. Therefore, any split into services reported by stakeholders for the three groups of interconnection services (Fixed national interconnection, Fixed international interconnection EU/EEA and Fixed international interconnection Non-EU/EEA) was added up to assess the total costs per operator and cost category.

Additionally, when stakeholders provided detailed cost data for a specific service category, only the traffic related with such service category was considered in the generation of the regressions.

Step 3: Rejection of outlier values

Once the costs and the traffic drivers used to build up the regressions were defined, outliers were identified and rejected to avoid distorting the trends.

Pairs of costs-drivers were discarded when, once pictured in a graph, these were found to be outside the reasonable range/trend exhibited by other peers. The table below illustrates

[34] Note that according to the descriptions included in the Data Request Form, wholesale specific costs of transit services were not included in this category.

[35] This information was requested to the NRAs as part of the clarification process launched on 22 February 2019.

the number of references collected for each cost category, indicating the number of values that were accepted/rejected in each case:

Cost category	Cost Type	Values reported	Rejected values	Accepted values
Route testing/monitoring costs	OPEX	18	9	**9**
	CAPEX	9	N/A	N/A
Operation and maintenance (O&M) costs	OPEX	22	8	**14**
	CAPEX	8	N/A	N/A
Data clearing costs	OPEX	17	8	**9**
	CAPEX	5	N/A	N/A
Financial clearing costs	OPEX	24	10	**14**
	CAPEX	7	N/A	N/A
Negotiation and contract management/regulation costs	OPEX	22	3	**19**
	CAPEX	4	N/A	N/A

Table 3.38: Values reported and outliers for each cost category [Source: Axon Consulting based on data reported by stakeholders]

We observe that few stakeholders have reported costs associated to the CapEx components of the five cost categories.

This is in line with the situation observed in the cost study SMART 2017/0091, which showed that a limited number of references were collected for CapEx related items, reinforcing the conclusion reached in the mobile cost study that CapEx costs are negligible.

Step 4: Cost analysis and linear regression

The cost-drivers regressions performed for the assessment of wholesale specific costs aimed at providing with a) a fixed cost[36] and b) a variable cost based on traffic for each cost category.

A linear regression model has been developed consistently with the methodology adopted in the mobile cost study. It is important to note that this approach was also selected based

[36] Note that the fixed cost is not considered in the model since this cost would not be avoided by the operator in the absence of the fixed voice termination service.

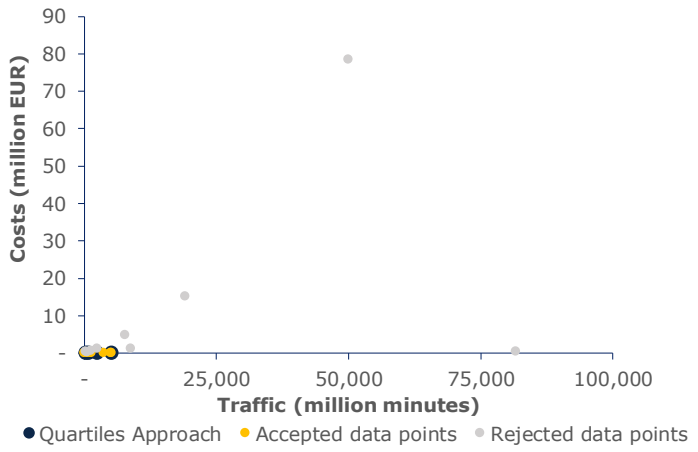
on the general agreement (73%) shown by stakeholders during the public consultation on the model's methodology presented in Workshop 1.

Given the disparity of the references observed for many cost categories, it was complex to identify relevant cost trends where all the references were considered at the same time. Consequently, references were presented in quartiles to better identify the common patterns registered in the different groups of operators. The following tables provide a detailed overview of the results obtained for each cost category.

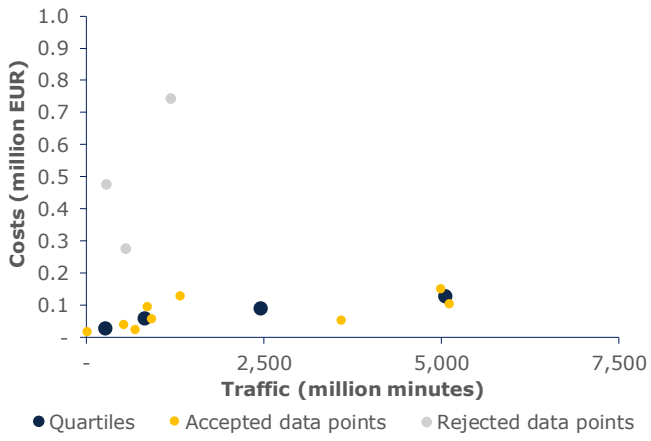
Cost category	ROUTE TESTING/MONITORING COSTS
Cost type	OpEx

Overview of the references observed

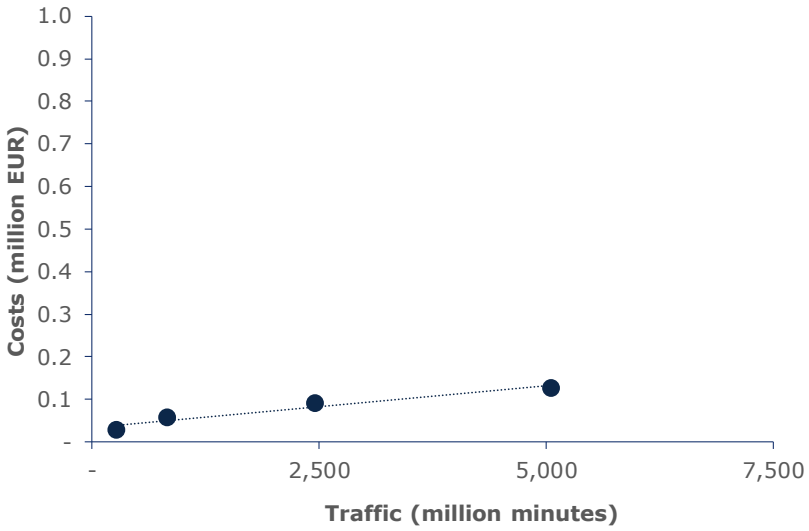
All references



Zoom into the most populated range



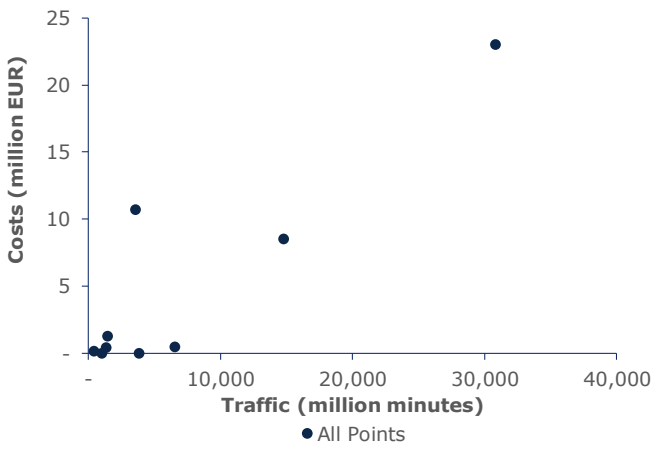
Linear regression based on quartiles



Regression formula	$Y = 1.93 \cdot 10^{-5} x + 34{,}432$

Cost category	ROUTE TESTING/MONITORING COSTS
Cost type	CapEx

Overview of the references observed

All references	Zoom into the most populated range
	N/A

Linear regression based on quartiles

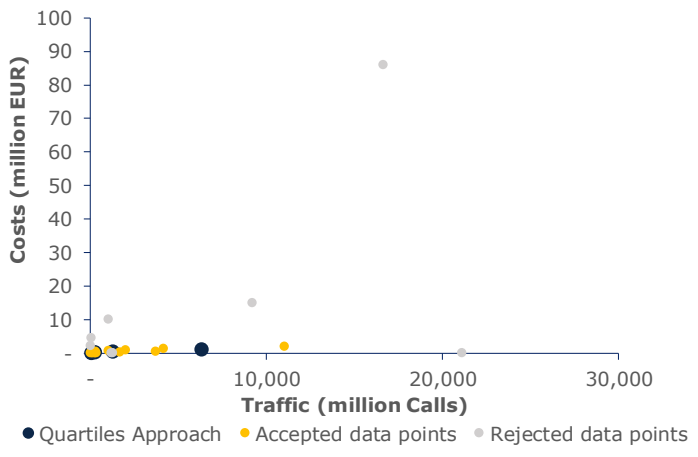
N/A

Regression formula	N/A

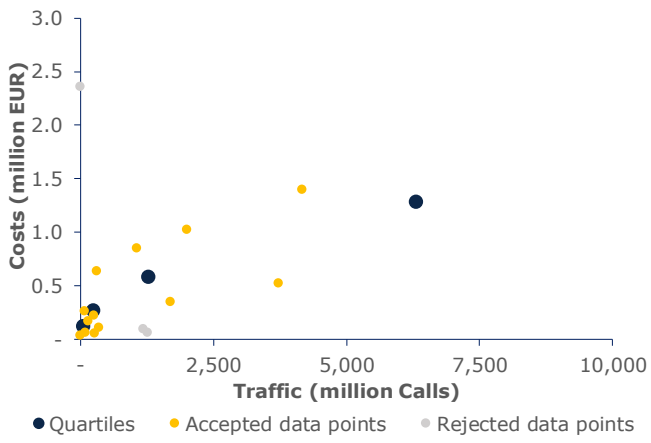
Cost category	OPERATION AND MAINTENANCE (O&M) COSTS
Cost type	OpEx

Overview of the references observed

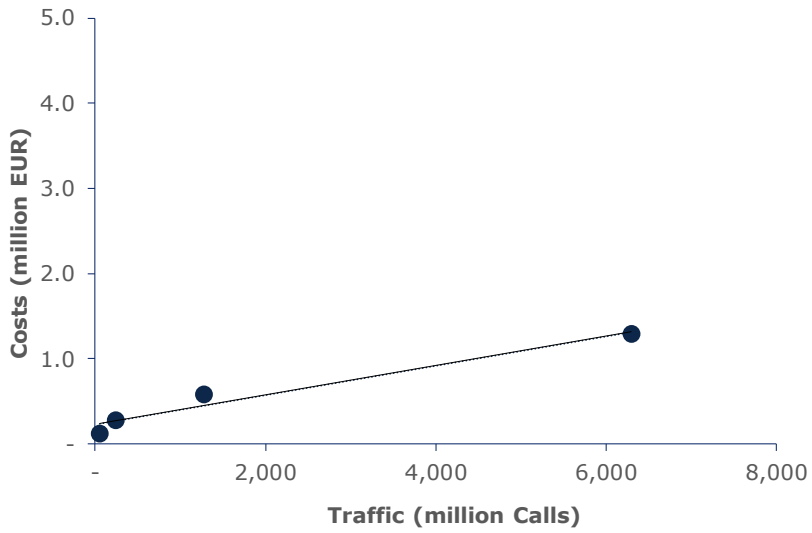
All references



Zoom into the most populated range



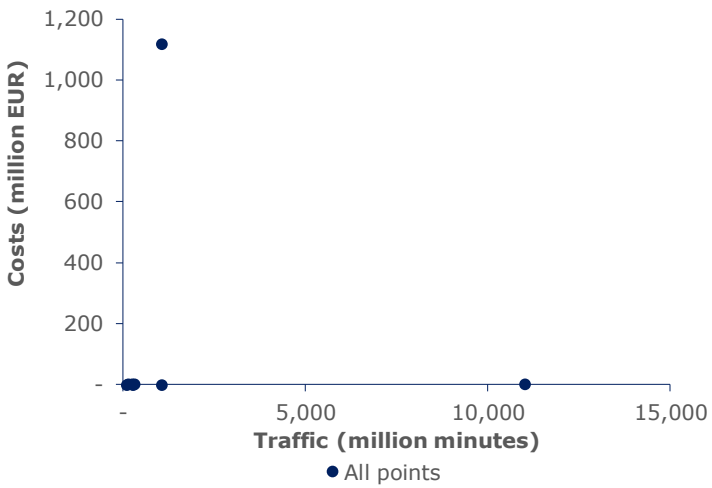
Linear regression based on quartiles



Regression formula	$Y=1.73 \cdot 10^{-4}x + 226{,}288$

Cost category	OPERATION AND MAINTENANCE (O&M) COSTS
Cost type	CapEx

Overview of the references observed

All references	Zoom into the most populated range
	N/A

Linear regression based on quartiles

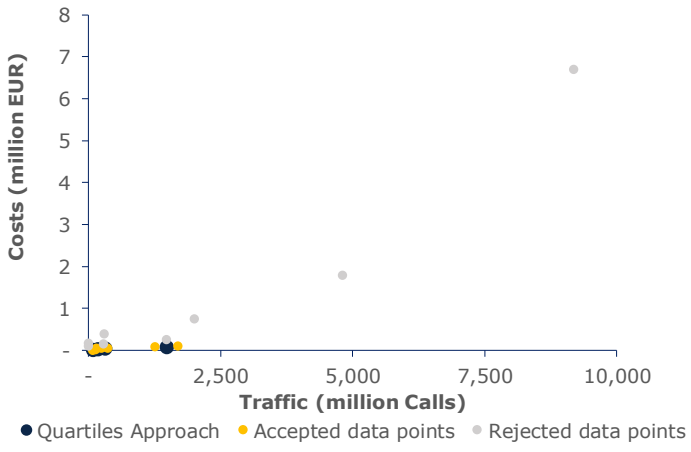
N/A

Regression formula	N/A

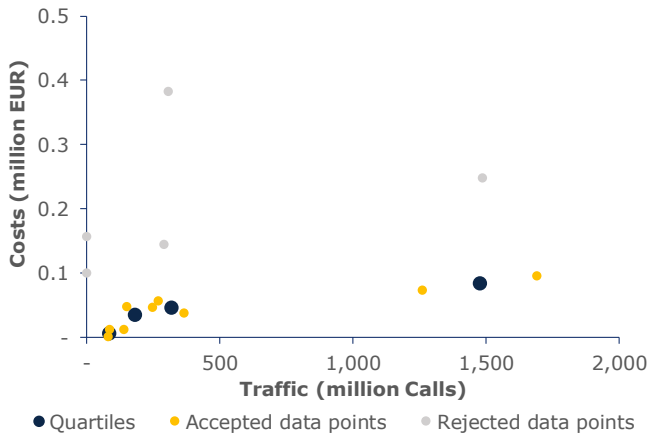
Cost category	DATA CLEARING COSTS
Cost type	OpEx

Overview of the references observed

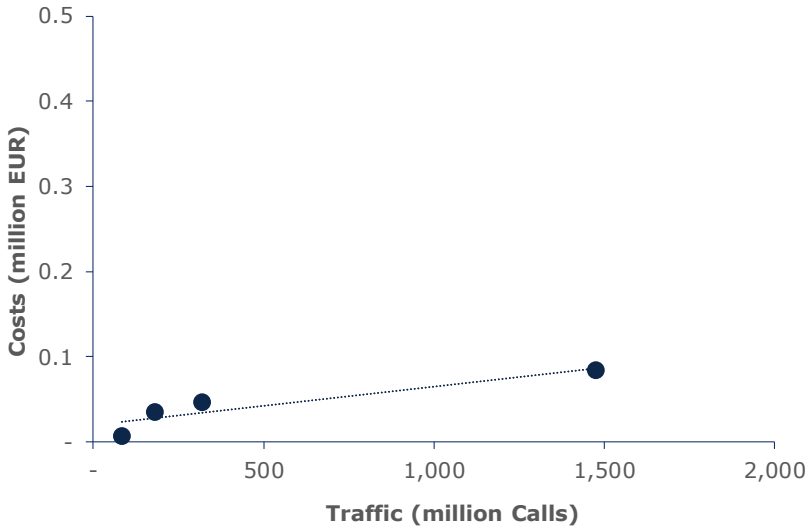
All references



Zoom into the most populated range



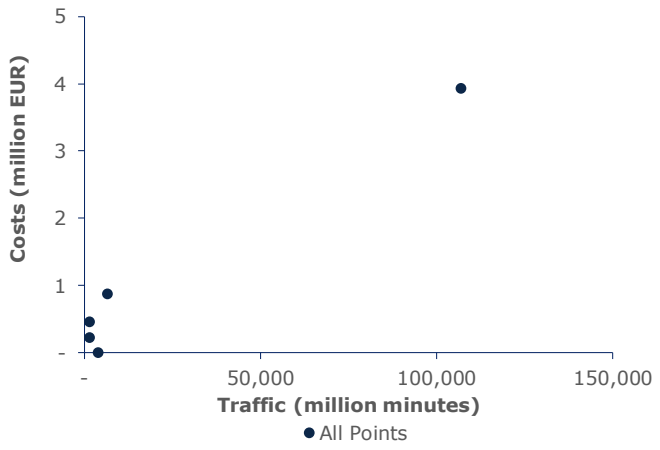
Linear regression based on quartiles



Regression formula	$Y = 4.51 \cdot 10^{-5} x + 19{,}829$

Cost category	DATA CLEARING COSTS
Cost type	CapEx

Overview of the references observed

All references	Zoom into the most populated range
	N/A

Linear regression based on quartiles

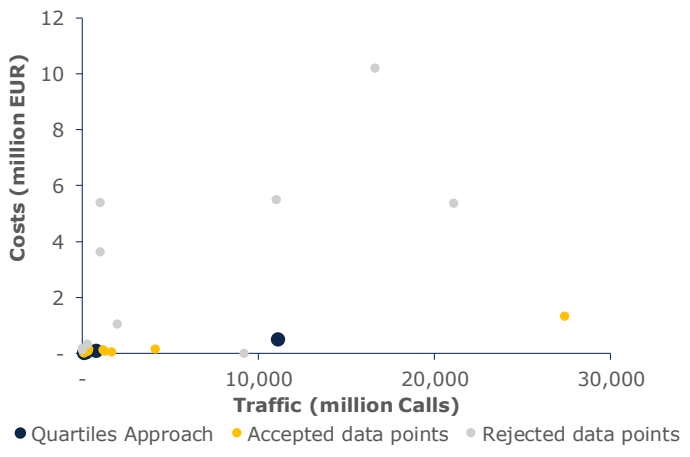
N/A

Regression formula	N/A

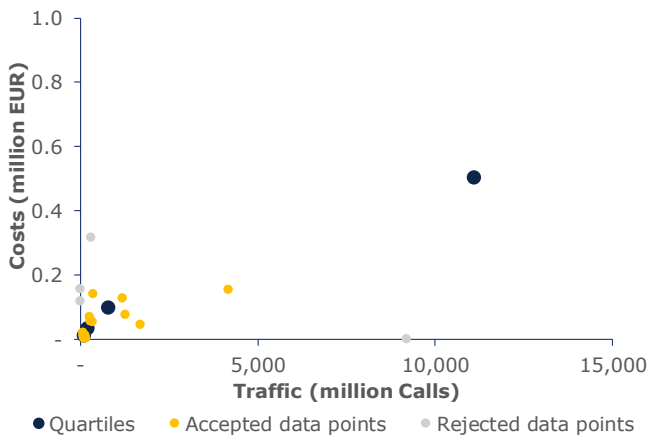
Cost category	FINANCIAL CLEARING COSTS
Cost type	OpEx

Overview of the references observed

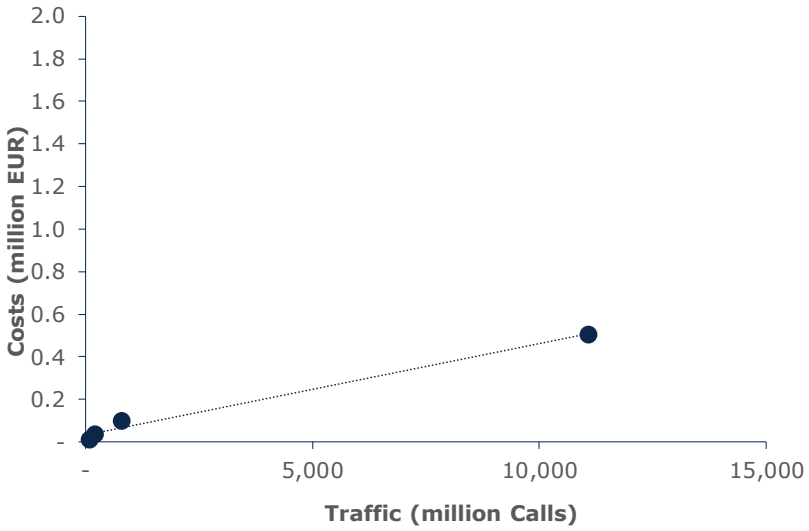
All references



Zoom into the most populated range



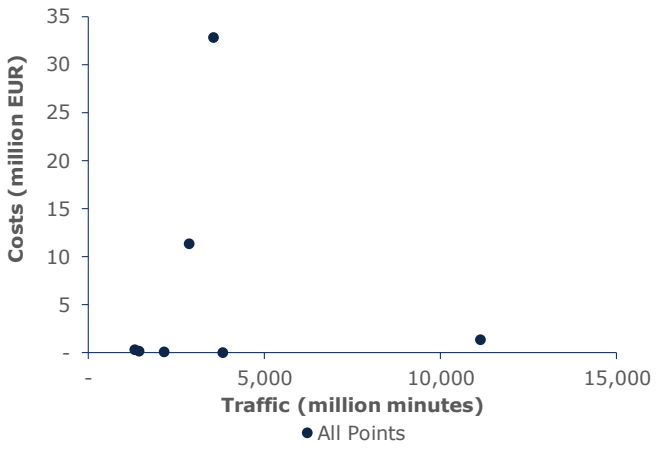
Linear regression based on quartiles



Regression formula	$Y= 4.27 \cdot 10^{-5} x + 32{,}972$

Cost category	FINANCIAL CLEARING COSTS
Cost type	CapEx

Overview of the references observed

All references	Zoom into the most populated range
	N/A

Linear regression based on quartiles

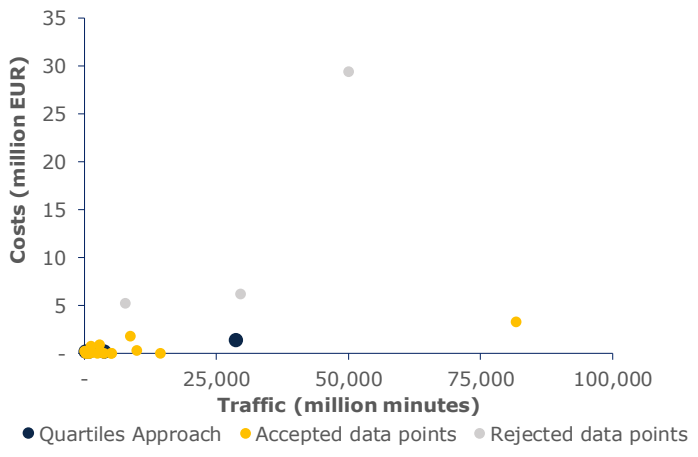
N/A

Regression formula	N/A

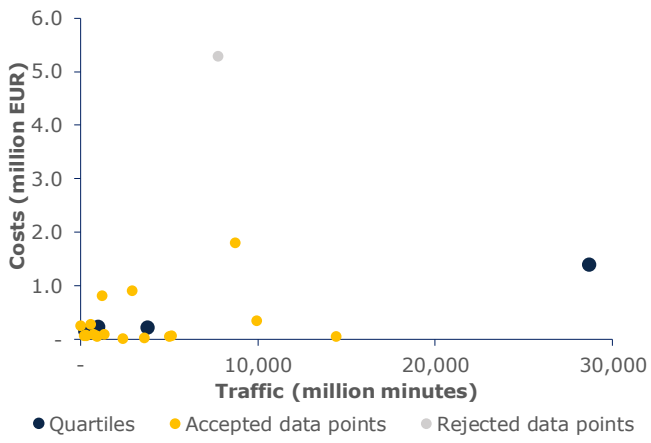
Cost category	NEGOTIATION AND CONTRACT MANAGEMENT/REGULATION COSTS
Cost type	OpEx

Overview of the references observed

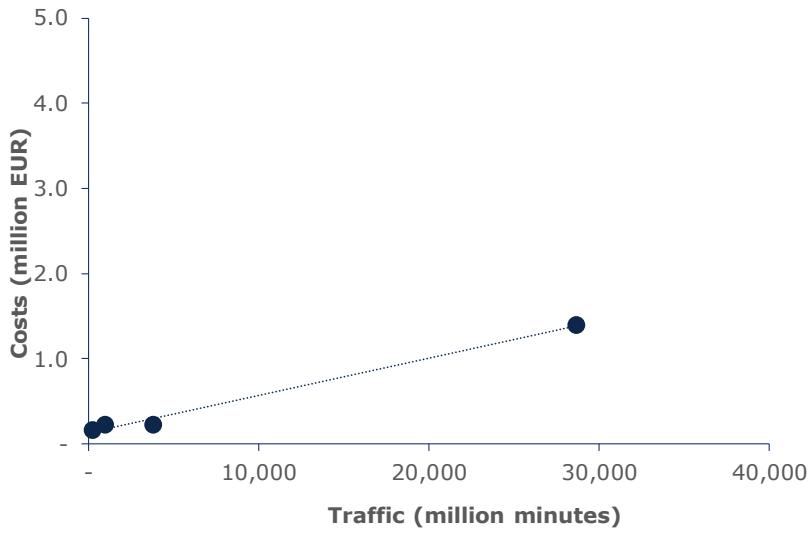
All references



Zoom into the most populated range



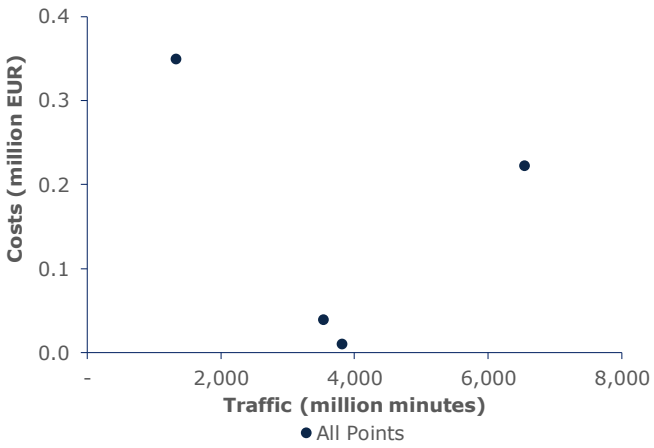
Linear regression based on quartiles



Regression formula	$Y = 4.37 \cdot 10^{-5} x + 131{,}575$

Cost category	NEGOTIATION AND CONTRACT MANAGEMENT/REGULATION COSTS
Cost type	CapEx

Overview of the references observed

All references	Zoom into the most populated range
	N/A

Linear regression based on quartiles

N/A

Regression formula	N/A

Question 12: Do you agree with the validation, treatment and estimation of the wholesale specific costs inputs? Otherwise please describe your rationale in detail and provide supporting information and references.

3.1.8. Core Nodes

Core nodes are used in the model to define the number of locations where the reference operator presents units of core equipment.

Core nodes are defined at country level.

The core nodes inputs are included in worksheet '2B INP CORE NODES' of the model.

3.1.8.1. Sources of information

The source of information was the data reported by NRAs at operator level through the Data Request Form.

The tables below indicate the availability and confidentiality of the core nodes information reported by NRAs per country.

Data availability

Status	Countries
Complete information	BE, BG, CZ, DK, EL, ES, FR, HR, IE, IT, LV, NL, PL, RO, SI, SK, UK
High-priority information provided	CY, DE, PT
Not all High-priority information provided	HU, LU, MT, SE
No information	AT, EE, LT, NO

Table 3.39: Core Nodes - Data availability [Source: Axon Consulting]

Data confidentiality

Confidentiality level	Countries
Confidentiality level 0	-
Confidentiality level 1	LU, SE
Confidentiality level 2	BE, BG, CY, CZ, DE, DK, EL, ES, FR, HR, HU, IE, IT, LV, MT, NL, PL, PT, RO, SI, SK, UK

Table 3.40: Core Nodes - Data confidentiality [Source: Axon Consulting]

No confidential information has been disclosed in the non-confidential version of the model shared with NRAs for consultation. Please refer to the main consultation document for further indications on the treatment given to confidential information in the non-confidential version of the cost model circulated to NRAs.

3.1.8.2. Input validation and treatment

In order to assess the reasonability of the core nodes figures received, the following analyses were performed:

- **Intra-country validation**: The information provided by operators of the same country was analysed on a stand-alone basis to ensure that the number of core nodes were consistent.
- **Inter-country validation**: The values reported for one country were cross-checked against each other to identify potential discrepancies among them.

The main conclusions of the exercise are highlighted in the table below:

Country	Core Equipment Reference[37]	Issues identified	Adopted approach
IT	▶ Highest figure of Access SBC equipment reported (among all references received from the various operators) ▶ Highest and second highest figure of IX SBC equipment reported (among all references received from the various operators)	Identified to be significantly higher than the EEA average	Values updated based on expected future plans indicated by operators with regards to this equipment.
PL	▶ Highest figure of I-CSCF equipment reported (among all references received from the various operators) ▶ Highest figure of S-CSCF equipment reported (among all references received from the various operators)	Identified to be significantly higher than the EEA average and also significantly higher than other operators within the country	Values discarded
SK	▶ Highest figure of ENUM equipment reported (among all references received from the various operators) ▶ Highest figure of MRF equipment reported (among all references received from the various operators)	Identified to be significantly higher than the EEA average and also significantly higher than other operators within the country	Values discarded

Table 3.41: Core Nodes - Input validation [Source: Axon Consulting]

[37] Note that the operators' names are not disclosed due to confidentiality reasons.

3.1.8.3. Input definition

The weighted average, based on market share of fixed telephony lines, of the validated references for each core network element was calculated to determine the number of core nodes to be considered in the model for each EU/EEA country[38].

When information was missing or discarded for a certain country, the number of core nodes was calculated by means of an EEA average[39]. The table below indicates the cases in which EEA average was used:

Core network element	Countries with estimated information based on an EEA average
AS (Voice Application Server)	AT, EE, LT, LU, MT, NO, SE
CDF (Charging Data Function)	AT, DE, EE, HU, LT, LU, MT, NO, PT, SE
I-CSCF (Interrogating CSCF)	AT, EE, HU, LT, LU, MT, NO, PL, SE
S-CSCF (Serving CSCF)	AT, EE, HU, LT, LU, MT, NO, PL, SE
Access SBC (Session Border Controller)	AT, EE, LT, LU, MT, NO, SE
IX SBC (Session Border Controller)	AT, EE, FR, LT, LU, MT, NO, SE
ENUM (Electronic Number Mapping System)	AT, EE, HU, LT, LU, MT, NO, SE, SK
MRF (Media Resource Function)	AT, DE, DK, EE, HU, LT, LU, MT, NO, SE, SK

Table 3.42: Core Nodes - Input definition [Source: Axon Consulting]

Question 13: Do you agree with the validation, treatment and estimation of the values for core nodes inputs? Otherwise please describe your preferred approach in detail and provide supporting information and references.

3.1.9. Useful Lives

Useful lives represent the expected lifespan of network assets and are used to annualise their capital cost over the period considered in the model.

Assets' useful lives were defined using EEA averages based on the information provided by operators in response to our data request. Useful lives are used in the model to implement the economic depreciation profile.

[38] Additionally, for redundancy reasons, a minimum of 2 nodes have been considered in each country.

[39] Based on the ratio of number of telephony lines per each core node observed in EEA countries. Then, the number of core nodes in countries for which information was missing was calculated as the product of this average ratio and the number of telephony lines in that country.

The useful lives inputs are included in worksheet '2D INP RESOURCES LIFE' of the model.

3.1.9.1. Sources of information

NRAs provided all the information required in order to define the assets' useful lives in the model. The tables below indicate the availability and confidentiality of the data reported by NRAs.

Data availability

Status	Countries
Complete information	AT, BE, BG, CY, CZ, DE, EE, EL, ES, FR, HR, HU, IE, IT, LT, LU, LV, NL, NO, PL, PT, RO, SI, SK, UK
High-priority information provided	-
Not all High-priority information provided	DK, MT, SE
No information	-

Table 3.43: Useful lives - Data availability [Source: Axon Consulting]

Data confidentiality

Confidentiality level	Countries
Confidentiality level 0	AT, CY, CZ, DE, ES, HR, IT, LT, LU, LV, NO, RO, SE, SI
Confidentiality level 1	PL
Confidentiality level 2	BE, BG, DK, EE, EL, FR, HU, IE, MT, NL, PT, SK, UK

Table 3.44: Useful lives - Data Confidentiality [Source: Axon Consulting]

Note that, since useful lives have been included in the model as EEA averages, no confidential information has been disclosed in the model shared with NRAs for consultation.

3.1.9.2. Input validation and treatment

A thorough validation exercise was performed to ensure the consistency, reasonability and completeness of the data provided by NRAs. This validation was performed from three different perspectives:

- **Intra-country validation**: The information provided by NRAs was analysed on a stand-alone basis to ensure that useful lives corresponding to similar/related resources were consistent. No issues were identified.

- **Inter-country validation**: The values reported by NRAs were cross-checked against each other to identify potential discrepancies among them. In particular, references that were above 100% or below 50% the EEA average were discarded as outliers. The table below shows the outliers identified through this process:

Asset category	Outliers
AS Hardware	PT
AS Software	SK
CDF Hardware	PT
CDF Software	SK
I-CSCF Hardware	PT
I-CSCF Software	SK
S-CSCF Hardware	PT
S-CSCF Software	SK
Access SBC (Session Border Controller) Hardware	PT
Access SBC (Session Border Controller) Software	SK
IX SBC (Session Border Controller) Hardware	PT
IX SBC (Session Border Controller) Software	SK
ENUM Hardware	PT
ENUM Software	SK
MRF (Media Resource Function) Hardware	
MRF (Media Resource Function) Software	SK

Table 3.45: Useful lives – Data validation [Source: Axon Consulting]

- **Hardware/Software validation**: Useful lives provided by NRAs for each core equipment were analysed to ensure that the useful life reported for the Software was not higher than that for the Hardware (as the Software component is installed over the Hardware component). Only the useful lives reported by CZ for the Application Server and the Media Resource Function presented this issue, which were discarded from the analysis.

3.1.9.3. Input definition

The average of the validated references for each core network element was calculated to determine the useful life input to be considered in the model.

Asset category	Useful life (years)
AS Hardware	6
AS Software	5
CDF Hardware	6
CDF Software	5
I-CSCF Hardware	6
I-CSCF Software	5
S-CSCF Hardware	6
S-CSCF Software	5
Access SBC (Session Border Controller) Hardware	7
Access SBC (Session Border Controller) Software	5
P-CSCF Hardware	7
P-CSCF Software	5
IMS-AGW Hardware	7
IMS-AGW Software	5
IX SBC (Session Border Controller) Hardware	6
IX SBC (Session Border Controller) Software	5
IBCF Hardware	7
IBCF Software	5
TrGW Hardware	6
TrGW Software	5
ENUM Hardware	7
ENUM Software	5
MRF (Media Resource Function) Hardware	6
MRF (Media Resource Function) Software	5

Table 3.46: Useful lives – Input definition [Source: Axon Consulting]

Question 14: Do you agree with the validation, treatment and definition of the useful lives inputs? Otherwise please describe your rationale in detail and provide supporting information and references.

3.1.10. WACC

In regulatory cost modelling, the Weighted Average Cost of Capital ('WACC') is the return allowed on the regulated companies, calculated weighing the return to each of the company's financing sources: equity and debt. WACC is widely used in the telecoms industry by regulators and operators for several different commercial, financial, technical and regulatory processes.

This input is defined at a country level and is a key element of the calculation of the economic depreciation.

The WACC input defined is included in worksheet '2E INP WACC' of the model. It is included in pre-tax nominal terms.

3.1.10.1. Sources of information

The source of information to define the WACC per country was the data provided by the NRAs. The tables below indicate the availability and confidentiality of the data reported by NRAs.

Data availability

Status	Countries
Complete information	AT, BE, BG, CY, CZ, DE, DK, EE, EL, ES, FR, HR, HU, IE, IT, LT, LU, LV, MT, NL, NO, PL, PT, RO, SE, SI, SK, UK
High-priority information provided	-
Not all High-priority information provided	-
No information	-

Table 3.47: WACC - Data availability [Source: Axon Consulting]

Data confidentiality

Confidentiality level	Countries
Confidentiality level 0	AT, BG, CZ, DE, DK, ES, FR, HR, HU, IE, IT, LT, LU, LV, MT, NL, NO, RO, SE, SK, UK
Confidentiality level 1	PL
Confidentiality level 2	BE, CY, EE, EL, PT, SI

Table 3.48: WACC - Data confidentiality [Source: Axon Consulting]

No confidential information has been disclosed in the non-confidential version of the model shared with NRAs for consultation. Please refer to the main consultation document for further indications on the treatment given to confidential information in the non-confidential version of the cost model circulated to NRAs.

3.1.10.2. Input validation and treatment

The following validation analyses were performed to ensure the consistency and reasonability of the data provided by NRAs:

- *Reasonability of WACC figures*: The pre-tax nominal WACC references per country were analysed to identify any potentially unreasonable figures. Based on the WACC rates typically considered by NRAs across Europe, any WACC between 4% and 14% was considered reasonable. No values were identified outside this range and, therefore, no issues were detected.
- *Consistency across EEA references*: The values provided by NRAs were compared against each other to identify potential discrepancies among them. Specifically, references situated outside 5 percentage points from the EEA average were classified as outliers. No values were identified outside this range and, therefore, no issues were detected.

3.1.10.3. Input definition

The pre-tax nominal WACC considered at country level was extracted from the validated inputs, per country, obtained as a result of the exercises described in section 3.1.10.2 above.

Given that all WACC figures were considered reasonable, no adjustments were introduced for any country.

Question 15: Do you agree with the validation, treatment and definition of the WACC input? Otherwise please describe your rationale in detail and provide supporting information and references.

3.2. Standard industry inputs

In addition to all the inputs defined in the previous sections, the model uses a set of inputs that are either standard across the industry or come directly from renowned references.

The table below summarises these cases:

Model input	Sources of information	Comments
Constant parameters (Worksheet: 2A INP NW)	Public sources and standards	Intrinsic constants that need to be considered in the model (e.g. seconds in an hour)

Figure 3.1: Standard industry inputs – Summary [Source: Axon Consulting]

Question 16: Do you agree with the approach adopted to define the standard inputs? Otherwise please describe your rationale in detail and provide supporting information and references.

4. Main outputs of the cost model

This section provides an overview of the main outputs produced by the model. The sections below seek stakeholders' feedback specifically on the following outputs of the model:

- Cost base
- Voice termination costs

4.1. Cost base

Due to their nature, bottom-up cost models are based on a theoretical exercise that takes into account pre-defined criteria (set out in the Annex III of the EECC) and not operators' financial statements (as is the case in top-down cost models). Therefore, it is important to ensure that the cost base estimated by the model is broadly consistent with that of the operators providing the services under analysis (so-called reconciliation exercise).

In this context, it is worth noting that, in relation to fixed voice call termination, the Annex III of the EECC establishes that *"the technology choice of the modelled networks shall be forward looking, based on an IP core network … calls shall be considered to be exclusively packet switched"*. This implies that TDM or legacy network elements should not be considered when assessing the incremental costs of fixed voice call termination. For this reason, such technologies have been excluded from our cost model.

Although it is expected that most fixed network operators will migrate towards a full IP network in the near future, currently, most operators in the EU/EEA region are still using (either fully or partially) TDM/legacy switching networks. This impedes a direct comparison of our model's results (fully based on an NGN core network, consistent with the EECC) with the operators' financials (which to some extent reflect a TDM/legacy network).

In light of the above, in order to perform a reconciliation exercise comparing the cost base produced by the model against that of operators providing fixed voice call termination services, rather than using operators' financial statements, we have compared operators' actual investments for the installation of NGN core network equipment with the results produced by the model.

In order to be able to perform such a reconciliation exercise, relevant information regarding real investments in NGN core networks was requested to all operators

collaborating during the data gathering phase[40]. However, in their replies to our information requests, only few operators provided sufficient information, and most did not provide any information.

In light of this, EC/Axon and the SC agreed to focus the reconciliation exercise on a sub-set of countries. These countries were chosen based on the information provided when replying to our information request – i.e. we selected those that had provided a greater amount of the information that was necessary for the reconciliation exercise. Additionally, the EC/Axon team further interacted with the NRAs and operators within this sub-set of countries to gather additional information required for the reconciliation exercise.

Once the information for the sub-set of countries was gathered, we compared the following references:

- Total investment in NGN core network reported by the operators.
- Total investment produced by the bottom-up model.[41]

The following chart illustrates the outcomes of the reconciliation exercise between the investments reported by the operators[42] and those calculated by the model[43] (before their annualization). The horizontal axis of the chart represents the number of subscribers, to reflect the size of the different operators assessed. Please note that actual values on both chart axis have been redacted, as well as operators' names, to ensure confidentiality.

[40] This information was requested in row "Core network specific for fixed voice services (IP equipment)" of worksheet "FIXED ASSET REGISTER" in the Data Request Form.

[41] As indicated above, most operators are still using legacy networks for part of their traffic/subscribers. Therefore, the model's results for the reconciliation exercise are based on an estimation of the traffic handled by their NGN core networks, based on the information provided by the operators, to ensure comparability.

[42] Extracted from the column "Gross Book Value (GBV)", row "Core network specific for fixed voice services (IP equipment)", of worksheet "FIXED ASSET REGISTER" of the Data Request.

[43] Extracted from the table "Resources Total CapEx Cost" of the worksheet "6B CALC RES CAPEX" of the cost model for the year 2017. The average between the two available scenarios ("Based on Prices Catalogues" and "Based on Continuous Functions (Curves)") for the option "Core Platforms Dimensioning scenario" of the COVER worksheet has been used.

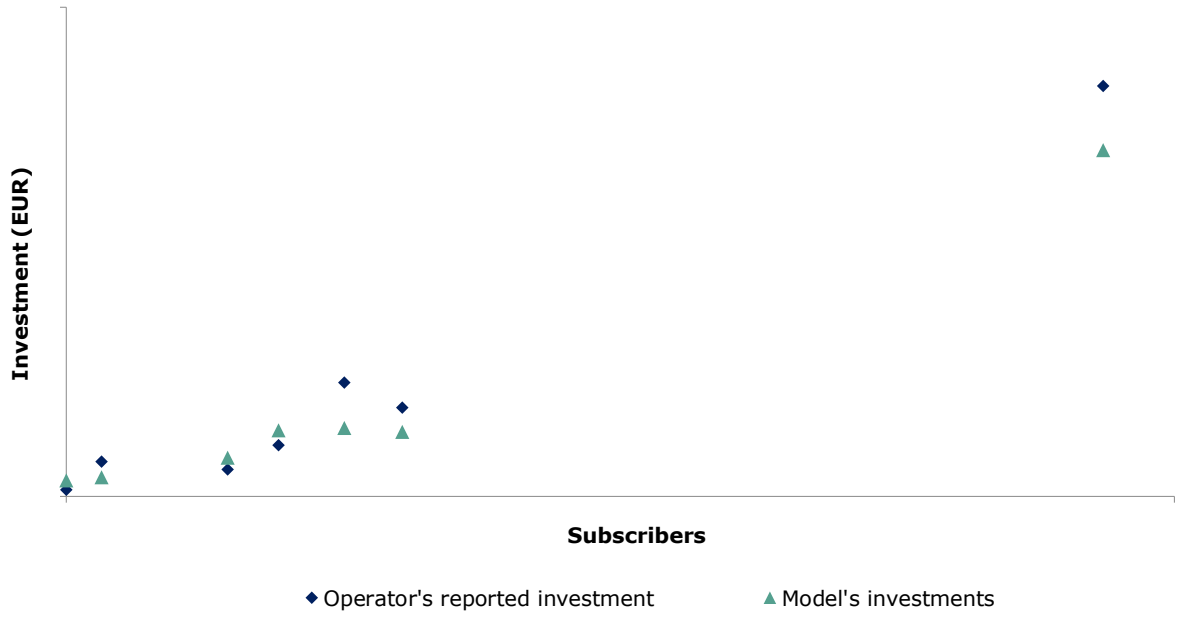


Exhibit 4.1: Outcomes of the reconciliation assessment [Source: Axon Consulting]

As it can be observed, the model's results are in general aligned with the realities faced by fixed operators in the EU/EEA region. While a one-to-one reconciliation is not possible due to the lack of detail of investments provided by the operators, the reconciliation exercise allows to verify the level of investments considered in the model and its reasonability in terms of order of magnitude. This means that results produced by the model are considered to be within a reasonable range of confidence.

Question 17: Do you agree with the approach adopted to assess the reconciliation of the cost base? If you don't, please justify your position and provide supporting information and references.

The table "Overview of the total cost base of the core network (EUR)" in worksheet '7F OUT RESULTS' illustrates the total annualised costs of the core network equipment (OpEx, depreciation and cost of capital) calculated per year for the reference operator in each country.

Question 18: Do you consider that the annual cost base of the core network produced is reasonable for an operator handling all the traffic of the reference operator in your country[44] with an NGN core network? If you don't, please justify your position and provide supporting information[45] and references.

4.2. Voice termination costs

The table "Wholesale voice call termination service on fixed networks results per year and country (EURcents/min)" in worksheet '7F OUT RESULTS' illustrates the voice termination costs in EURcents/min.

Question 19: Do you consider that the unit costs obtained for the voice termination service are reasonable for a theoretical operator in your country with the scale of the reference operator[44], based on the criteria defined in the Annex III of the EECC? If you don't, please justify your position and provide supporting information and references.

[44] Please remember that the reference operator is an operator with the market share defined as explained in section 3.1.1.

[45] Please note that, in order to be able to assess the comment, it is needed that relevant information and evidences are provided including costs based on real operations (e.g. invoices, extracts from the FAR), a detailed description of the elements included and not included in the references provided as well as the amount of traffic handled by the network elements included in the reported information.

5. Summary of questions

This section includes a list of the questions raised throughout this document, as a reference for the reader.

These questions have been included in the template to submit stakeholders' answers, which are to be observed and used by all stakeholders who wish to participate in this process.

#	Question	Section
1	**Question 1:** Do you agree with the methodological approaches adopted to develop the cost model, as presented in Table 2.1 and Table 2.2? Otherwise, please describe what you would have done differently and justify your proposal in detail. Please also describe how your proposal is consistent with the provisions in the 2009 Recommendation and the EECC, as well as provide supporting information and references.	2
2	**Question 2:** In your opinion, what scenario should be adopted to consider the market share of the reference operator in EU/EEA countries? Please describe your preferred approach in detail and explain the regulatory rationale behind your choice. In case you consider that a market share different from the options provided should be used, please provide supporting information justifying your choice.	3.1.1
3	**Question 3:** In your opinion, should the same scenario for the market share of the reference operator be applied to all EU/EEA countries? Please describe the rationale behind your answer, providing supporting references and any regulatory principles or regulations that support your position.	3.1.1
4	**Question 4:** Do you agree with the validation, treatment and definition of the market share inputs? Otherwise please describe your rationale in detail and provide supporting information and references.	3.1.1
5	**Question 5:** Do you agree with the validation, treatment and estimation of the values for demand inputs? Otherwise please describe your preferred approach in detail and provide supporting information and references.	3.1.2
6	**Question 6:** In your opinion, what voice demand forecast scenario do you expect to better represent the traffic evolution in your country? Please, describe your preferred approach in detail and provide supporting information and references.	3.1.2
7	**Question 7:** Do you agree with the validation, treatment and estimation of the value for the network statistics inputs? Otherwise please describe your rationale in detail and provide supporting information and references.	3.1.3

#	Question	Section
8	**Question 8:** Do you agree with the validation, treatment and estimation of the percentage of traffic in the busy hour and in weekdays? Otherwise please describe your rationale in detail and provide supporting information and references.	3.1.4
9	**Question 9:** Do you agree with the validation, treatment and estimation of the values for core network equipment unit cost inputs? Otherwise please describe your rationale in detail and provide supporting information and references.	3.1.5
10	**Question 10:** In your opinion, which scenario for the core network equipment unit costs should be adopted to estimate the incremental cost of fixed voice call termination? Please, describe your preferred approach in detail and provide supporting information and references.	3.1.5
11	**Question 11:** Do you agree with the validation, treatment and estimation of the mark-up percentage to reflect the costs of active transmission and switching equipment? Otherwise please describe your rationale in detail and provide supporting information and references.	3.1.6
12	**Question 12:** Do you agree with the validation, treatment and estimation of the wholesale specific costs inputs? Otherwise please describe your rationale in detail and provide supporting information and references.	3.1.7
13	**Question 13:** Do you agree with the validation, treatment and estimation of the values for core nodes inputs? Otherwise please describe your preferred approach in detail and provide supporting information and references.	3.1.8
14	**Question 14:** Do you agree with the validation, treatment and definition of the useful lives inputs? Otherwise please describe your rationale in detail and provide supporting information and references.	3.1.9
15	**Question 15:** Do you agree with the validation, treatment and definition of the WACC input? Otherwise please describe your rationale in detail and provide supporting information and references.	3.1.10
16	**Question 16:** Do you agree with the approach adopted to define the standard inputs? Otherwise please describe your rationale in detail and provide supporting information and references.	3.2
17	**Question 17:** Do you agree with the approach adopted to assess the reconciliation of the cost base? If you don't, please justify your position and provide supporting information and references.	4.1
18	**Question 18:** Do you consider that the annual cost base of the core network produced is reasonable for an operator handling all the traffic of the reference operator in your country with an NGN core network? If you don't, please justify your position and provide supporting information and references.	4.1

#	Question	Section
19	**Question 19:** Do you consider that the unit costs obtained for the voice termination service are reasonable for a theoretical operator in your country with the scale of the reference operator[44], based on the criteria defined in the Annex III of the EECC? If you don't, please justify your position and provide supporting information and references.	4.2

Table 5.1: Summary of public consultation questions [Source: Axon Consulting]

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