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Study Group 1 Question 4

Economic policies and methods of determining the costs of services related to national telecommunication/ICT networks

Output Report on ITU-D Question 4/1

Economic policies and methods of determining the costs of services related to national telecommunication/ICT networks

Study period 2018-2021

Economic policies and methods of determining the costs of services related to national telecommunication/ICT networks: Output Report on ITU-D Question 4/1 for the study period 2018-2021

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The study groups of the ITU Telecommunication Development Sector (ITU-D) provide a neutral platform where experts from governments, industry, telecommunication organizations and academia from around the world gather to produce practical tools and resources to address development issues. To that end, the two ITU-D study groups are responsible for developing reports, guidelines and recommendations based on input received from the membership. Questions for study are decided every four years at the World Telecommunication Development Conference (WTDC). The ITU membership, assembled at WTDC-17 in Buenos Aires in October 2017, agreed that for the period 2018-2021, Study Group 1 would deal with seven Questions within the overall scope of "enabling environment for the development of telecommunications/information and communication technologies."

This report was prepared in response to Question 4/1: Economic policies and methods of determining the costs of services related to national telecommunication/ICT networks under the overall guidance and coordination of the management team of ITU-D Study Group 1 led by Ms Regina Fleur Assoumou-Bessou (Côte d'Ivoire), as Chairman, supported by the following Vice-Chairmen: Ms Sameera Belal Momen Mohammad (Kuwait); Mr Amah Vinyo Capo (Togo); Mr Ahmed Abdel Aziz Gad (Egypt); Mr Roberto Hirayama (Brazil); Mr Vadim Kaptur (Ukraine); Mr Yasuhiko Kawasumi (Japan); Mr Sangwon Ko (Republic of Korea); Ms Anastasia Sergeyevna Konukhova (Russian Federation); Mr Víctor Martínez (Paraguay); Mr Peter Ngwan Mbengie (Cameroon); Ms Amela Odobašic (Bosnia and Herzegovina); Mr Kristián Stefanics (Hungary) (resigned in 2018); and Mr Almaz Tilenbaev (Kyrgyzstan).

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i. Introduction

The transition to new generations of mobile- and fixed-broadband communications is a never-ending process. Mass penetration of digital services in the digital-economy era exerts a huge economic impact on telecommunication/ICT service providers and consumers.

Chapter IV of the ITU Constitution[1] sets out the mandate of the ITU Telecommunication Development Sector (ITU-D), which determines the specific functions of ITU-D, including:

a) *promote, especially by means of partnership, the development, expansion and operation of telecommunication networks and services, particularly in developing countries, taking into account the activities of other relevant bodies, by reinforcing capabilities for human resources development, planning, management, resource mobilization, and research and development;*
b) *promote and coordinate programmes to accelerate the transfer of appropriate technologies to the developing countries in the light of changes and developments in the networks of the developed countries;*
c) *offer advice, carry out or sponsor studies, as necessary, on technical, economic, financial, managerial, regulatory and policy issues, including studies of specific projects in the field of telecommunications;*
d) *collaborate with the other Sectors, the General Secretariat and other concerned bodies in developing a general plan for international and regional telecommunication networks so as to facilitate the coordination of their development with a view to the provision of telecommunication services;*
e) *in carrying out the above functions, give special attention to the requirements of the least developed countries.*

Accordingly, ITU-D is playing a leading role in helping Member States evaluate the technical and economic issues involved in the transition to emerging telecommunication/ICT services for the Member States, with particular attention to developing and least developed countries. In this area, ITU-D has been collaborating closely with both the ITU Radiocommunication Sector (ITU-R) and the ITU Telecommunication Standardization Sector (ITU-T), thus avoiding duplication of work.

The Final Report on Question 4/1 for the previous ITU-D study period (2014-2017)[2] contains initial studies on new methods of charging for certain services and pricing methodologies, as well as information on different models for sharing of telecommunication/ICT infrastructure.

The present Report on Question 4/1 (Economic policies and methods of determining the costs of services related to national telecommunication/ICT networks) for the ITU-D study period 2018-2021 expands upon those studies, sharing the different country and business experiences in the field of national telecommunication/ICT economic policies and regulations, taking into account the studies being conducted in ITU-R Study Group 1 (Spectrum management) and ITU-T Study Group 3 (Tariff and accounting principles and international telecommunication/ICT economic and policy issues).

1 ITU. Constitution and Convention.
2 ITU-D. Final Report on ITU-D Study Group 1 Question 4/1 for the study period 2014-2017. Economic policies and methods of determining the costs of services related to national telecommunication/ICT networks, including next-generation networks. Geneva, 2017.

ii. Studies related to Question 4/1 (Economic policies and methods of determining the costs of services related to national telecommunication/ICT networks)

To avoid duplication of effort and in order to consider the results of studies carried out in ITU-R and ITU-T, it is necessary to refer to past ITU deliverables related to economic policies:[3]

ITU-R

- ITU-R Handbook on National Spectrum Management. Geneva, 2015.
- Report ITU-R SM.2012. Economic aspects of spectrum management. Geneva, 2018.
- Report ITU-R SM.2404. Regulatory tools to support enhanced shared use of the spectrum. Geneva, 2017.

ITU-T

- Recommendation ITU-T D.000. Terms and definitions for the D-series Recommendations. Geneva, 2010.
- Recommendation ITU-T D.261. Regulatory principles for market definition and identification of operators with significant market power – SMP. Geneva, 2016.
- Recommendation ITU-T D.264. Shared uses of telecommunication infrastructure as possible methods for enhancing the efficiency of telecommunications. Geneva, 2020.
- Recommendation ITU-T D.271. Charging and accounting principles for NGN. Geneva, 2016.
- Recommendation ITU-T D Suppl. 1. Cost and tariff study method. Geneva, 1988.
- Recommendation ITU-T D Suppl. 3. Handbook on the methodology for determining costs and establishing national tariffs. Geneva, 1993.

iii. Methodology and sources of information for the Report on Question 4/1 (Economic policies and methods of determining the costs of services related to national telecommunication/ICT networks)

The main source of information for ITU-D study group reports is contributions from Member States, ITU-D Sector Members and Academia. Such contributions were received by the Telecommunication Development Bureau (BDT) for the meetings of ITU-D Study Group 1 and its rapporteur groups.[4] In addition, the ITU Regional Economic Dialogues (REDs) organized by BDT provided the opportunity to hold dedicated discussion sessions in ITU-D Study Group 1 Question 4/1 Experts' Knowledge Exchange meetings, with the purpose of collecting regional experiences on the topics related to the terms of reference of the Question.

Furthermore, in the context of the COVID-19 global pandemic, which started at the end of 2019, ITU-D organized a series of web dialogues aiming to share an analysis of the response

[3] ITU-D SG1 Document SG1RGQ/89 from the Rapporteur for Question 4/1

[4] As the rapporteur and vice-rapporteurs participated in related ITU/BDT events, such as the regional economic dialogues (REDs), where specific panel sessions on the topics within the mandate of Question 4/1 were organized, this report also contains information taken from presentations and materials from these events. This information is considered by ITU-D Study Group 1 meetings on the basis of consensus. The results from these events are available at: ITU-D Events on Regulatory, Economic and Financial Issues.

to the pandemic from the perspective of specific ITU-D study group Questions. In respect of Question 4/1, two webinars were held:

- Webinar on the economic implications of COVID-19 for national telecommunication/ICT infrastructure, held on 29 June 2020
- Webinar on the impact of unequal access to ICT infrastructure on the geography of COVID-19 diffusion, held on 29 July 2020.

The conclusions from these webinars have been taken into account in the development of this report. **Annex 7** to this report provides a summary of the main conclusions of both webinars.

Abbreviations and acronyms

ABC	activity-based costing
ACE	African Coast to Europe
ADSL	asymmetric digital subscriber line
AfDB	African Development Bank
AFIX	African IXP Association
AI	artificial intelligence
ANATEL	*Agência Nacional de Telecomunicações* (National Telecommunications Agency) of Brazil
APIX	Asia-Pacific Internet Exchange Association
ARCEP	*Autorité de Régulation des Communications Électroniques et des Postes* (Regulatory Authority for Electronic Communications and Posts) of Burkina Faso
ARPU	average revenue per user
ARTP	*Autorité de Régulation des Télécommunications et des Postes* (Posts and Telecommunications Regulatory Authority) of Senegal
BDT	Telecommunication Development Bureau
BEREC	Body of European Regulators for Electronic Communications
BSS	business support systems
BU	bottom-up
CAP	content and application providers
CAPEX	capital expenditure
CCA	current cost accounting
CNMC	*Comisión de los Mercados y la Competencia* (National Commission of Markets and Competition) of Spain
CONATEL	*Comisión Nacional de Telecomunicaciones* (National Telecommunication Commission) of Paraguay
CPCA	Cambridge and Peterborough Combined Authority
DTV	digital television
DWDM	dense wavelength division multiplexing
EC	European Commission
ECOWAS	Economic Community of West African States
EEA	European Economic Area

(continued)

EECC	European Electronic Communications Code
EPMU	equi-proportional mark-up
EU	European Union
Euro-IX	European Internet Exchange Association
FAC	fully allocated costs
FBB	fixed broadband
FDC	fully distributed costs
5G	fifth-generation
FTR	fixed termination rates
FTTH	fibre-to-the-home
FV	fixed voice
G&A	general and administrative costs
GNI p.c.	gross national income per capita
GSC	Gambia Submarine Cable Co. Ltd
GSM	Global System for Mobile communications
GVA	gross value added
HCA	historical cost accounting
HF	high-frequency
IADB	Inter-American Development Bank
ICT	information and communication technology
ICTA	Information and Communication Technologies Authority of Turkey
IIC	international Internet connectivity
IM	immediate messaging
IMF	International Monetary Fund
IMS	IP multimedia subsystem
IoT	Internet of Things
IP	Internet protocol
IRR	internal rate of return
ISP	Internet service provider
ITU	International Telecommunication Union
ITU-D	ITU Telecommunication Development Sector

(continued)

ITU-R	ITU Radiocommunication Sector
ITU-T	ITU Telecommunication Standardization Sector
IXP	Internet exchange points
LAC-IX	Latin American and Caribbean Association of IXP operators
LAN	local area network
LDC	least developed country
LLU	local loop unbundling
LRAIC	long-run average incremental costs
LRIC	long-run incremental costs
LRIC+	long-run incremental costs plus common costs
LTE	Long-Term Evolution
MANRS	Mutually Agreed Norms for Routing Security
MBB	mobile broadband
MNO	mobile network operator
MTR	mobile termination rates
MVNA	mobile virtual network aggregator
MVNE	mobile virtual network enabler
MVNO	mobile virtual network operator
NEBA	*Nuevo servicio Ethernet de banda ancha* (new broadband Ethernet service)
NGA	next-generation access
NGN	next-generation network
NIIR	Radio Research & Development Institute, Russian Federation
NPV	net present value
NRA	national regulatory authority
NREN	national research and education network
NTRA	National Telecommunication Regulatory Authority of Egypt
OECD	Organisation for Economic Co-operation and Development
OPEX	operational expenditures
OSS	operation support systems
OTT	over-the-top
PCS	personal communications service

(continued)

PGMC	*Plano Geral de Metas de Competição* (General Plan of Competition Goals)
PJSC	public joint-stock company
PMS	personal mobile service
PPP	purchasing power parity
PSTN	public switched telephone network
QoS	quality of service
RAN	radio access network
RINEX	Rwandan IXP
RLAH	roam like at home
SAC	standalone costs
SDG	United Nations Sustainable Development Goals
SMP	significant market power
SMS	short message service
SPV	special purpose vehicle
STMC	*servicio de telefonía móvil celular* (cellular-mobile telephony service)
TD	top-down
TdE	*Telefónica de España* S.A.U.
TD-FH	top-down FAC-HCA cost model
TDM	time-division multiplexing
TELKODER	Turkish Competitive Telco Operators' Association
UMTS	Universal Mobile Telecommunications System
VAS	value-added service
VDSL	very high-speed digital subscriber line
VoIP	voice over Internet Protocol
VULA	virtual unbundling local access
WACC	weighted average cost of capital
WB	World Bank
WLR	wholesale line rental
WSIS	World Summit on the Information Society

Chapter 1 – New charging methods (or models, if applicable) for services provided over NGN networks

As a reminder, a next-generation network (NGN) is a packet-based network able to provide telecommunication/ICT services and able to make use of multiple broadband, quality-of-service (QoS)-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. An NGN enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users.[1]

An NGN is characterized by the following basic features:

- packet-based transfer;
- separation of control functions among bearer capabilities, call/session and application/service;
- decoupling of service provision from transport, and provision of open interfaces;
- support for a wide range of services, applications and mechanisms based on service building blocks (including real time/streaming/non-real time and multimedia services);
- broadband capabilities with end-to-end QoS and transparency;
- interworking with legacy networks via open interfaces;
- generalized mobility;
- unfettered user access to different service providers;
- a variety of identification schemes that can be resolved to IP addresses for routing in IP networks;
- unified service characteristics for the same service as perceived by the user;
- converged services between fixed and mobile networks;
- independence of service-related functions from underlying transport technologies;
- support of multiple last-mile technologies;
- compliance with all regulatory requirements, for example concerning emergency communications, security/privacy, etc.

1.1 Methods for determining the costs of wholesale/advanced services

One of the objectives of national regulatory authorities (NRAs) is to create favourable conditions for promoting and encouraging fair competition and innovation in the ICT sector. In pursuit of that goal, NRAs may use cost models to determine the cost of providing a given service. The sections below provide guidance to NRAs on how to implement cost models, structured as follows:

- Methodological choices and common options
- Methodological approaches followed internationally
- New trends in wholesale costing/pricing schemes in the light of NGN.

1 ITU-T. Recommendation ITU-T Y.2001 (12/2004). General overview of NGN.

1.1.1 Methodological choices and common options

The development of cost models is generally characterized by the range of options available in their implementation. The objective of this section is to introduce the main methodological issues and outline the different possible options, in order to provide guidance to NRAs in implementing cost models.

When determining the methodology for the development of cost models, the following aspects should be addressed:

- costing approach;
- cost standard;
- cost elements to be considered;
- treatment of capital-related costs;
- treatment of revenues;
- definition of the reference operator;
- services and increments;
- geographical modelling.

Costing approach

From a high-level perspective, there are two main cost-modelling approaches that can be used:

- **Top-down cost models**: These models are built up starting from an operator's general ledger and balance sheet. Based on a number of steps (generally two or three, although more complex models can be also adopted) and allocation criteria, costs are distributed across the end services. Top-down models ensure full reconciliation with the operator's costs, except for cost-of-capital allowances and potential revaluations of assets. As such, they do not allow NRAs to identify potential inefficiencies in the operator's activity and are not fit for calculating the costs of hypothetical (efficient) operators. Although they can be used for forecasting, top-down models are less flexible than bottom-up cost models and thus less suitable for that purpose. In practical terms, top-down models (in any of their various forms, such as accounting separation or regulatory accounting) are typically implemented and updated by operators, and not by NRAs, as they require a significant amount of information that is difficult for an NRA to gather. On the other hand, it is quite common, where the model is requested by the NRA (e.g., as a remedy imposed as a result of a market analysis), for the NRA to audit/review the results produced by such models so as to ensure they are accurate and comply with existing regulations (or commission a third party to do so).
- **Bottom-up cost models**: These models are built up starting from a set of basic inputs (e.g., demand, coverage, geographical and technical information). Based on these inputs, bottom-up models dimension the required network using technical engineering algorithms to fulfil the coverage and capacity requirements. The total network costs are then calculated as the product of the number of network elements and their unit cost. Capital expenses (CAPEX) are depreciated according to the selected depreciation methodology. Total costs are then allocated to the relevant services, based on a predefined set of criteria. This approach does not reconcile exactly with an operator's financial accounts, but it can (and should) be properly designed to accurately represent their operations in the relevant area and/or country. Bottom-up models allow the calculation of forecasts, what-if analyses, different scenarios, planning, and so forth. Additionally, they can be used to calculate the costs of a reference operator that does not exist in the market (hypothetical operator), an essential step for assessing the contestability of a market. However, non-network costs, such as those associated more with human resources than with capital investment, can be difficult to model through a bottom-up approach (especially retail costs). Contrary to top-down models, bottom-up models can be developed by both NRAs and operators,

as they require less data. When the model is used for regulatory purposes, it is typically developed by the NRAs, affording them more control over the methodologies applied.

Cost standard

A model's cost standard refers to how costs are allocated to services, and is a key factor in service costing. The methodological approaches that are most commonly followed are:

- **Fully allocated costs (FAC)/fully distributed costs (FDC)**: This method attributes costs (including common and joint costs) to services based on the utilization each service makes of the different cost elements (i.e. a table of routing factors).
- **Pure long-run incremental costs (pure LRIC)**: This method calculates the costs that would be saved if certain services, groups of services or activities (defined as an increment) were not provided. These incremental costs are a proxy of the variable costs in the long run. Using this approach, neither common costs nor joint costs are allocated to the services, as they would remain even if the increment was not provided.
- **Long-run incremental costs plus common costs (typically known as LRIC+)**: This method allows for the recovery of common and joint costs that are not incremental to any given service, on top of pure LRIC.

More detailed information on cost modelling can be found in the separate *Guidelines on cost modelling*.[2]

1.1.2 Methodological approaches followed internationally

This section presents the methodological approaches[3] adopted by NRAs for advanced wholesale services.[4] The main findings, based on the information collected by the ITU Tariff Policy Survey 2019-2020, are as follows:[5]

- Modelling approach:
  - Fixed services: The predominant model used in Africa, Europe and the Americas is the bottom-up approach, whereas the Arab States have a preference for top-down or hybrid models, and Asia and the Pacific for the top-down approach. No major changes were observed in 2020, except in the case of the Arab States where the usage of hybrid models has declined and both top-down and bottom-up models have gained ground.
  - Mobile services: There is a clear preference for using the bottom-up approach in Europe and the Americas (the latter with a relevant increase in 2020). In Africa, Member States tend to use either bottom-up or hybrid models, although bottom-up models gained ground in 2020. The Asia and the Pacific region uses top-down and bottom-up approaches in equal measure. The Arab States use a hybrid approach, closely followed by the top-down approach. The CIS countries showed a preference for hybrid models.
- Cost standard:
  - Fixed services: A form of LRIC is preferred in Africa, the Arab States, Europe and the Americas (pure LRIC mostly used only in the Americas and Europe, although there

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2 Guidelines on cost modelling for telecommunications/ICTs are presented in ITU-D SG1 Document 1/422 from the Rapporteur for Question 4/1.

3 More detailed information on the methodological approaches can be found in the separate Guidelines on cost modelling for telecommunications/ICTs.

4 Advanced wholesale services mean services based on NGN/IP networks.

5 Note that detailed statistics on methodologies used by NRAs are presented in **Annex 3** to this report.

is a decrease in its usage). The Asia and the Pacific region and the CIS region show a preference for fully distributed costs (FDC). The Arab States have changed from a preference for use of LRIC+ to a more mixed adoption of FDC and other forms of LRIC. Some countries in the Arab States and Americas regions have reported usage of SAC for the first time.

  - Mobile services: A form of LRIC is preferred in Africa, the Arab States, Europe and the Americas. Pure LRIC is by far the most used option in Europe and the second most common in the Americas (third in 2020). The Arab States and the Americas tend to prefer to use the LRIC+ approach. The Asia and the Pacific region and the CIS region tend more frequently to use fully distributed costs.

- Costs included:

  - Fixed services: Most respondents in all regions include network capital expenses (CAPEX), network operational expenses (OPEX), weighted average cost of capital (WACC) and general and administrative costs (G&A) in the cost items. In all regions, except Europe, the inclusion of licences and spectrum fees is also very common. Retail costs are as frequently included as the other categories.
  - Mobile services: Most respondents in all regions include CAPEX and OPEX. All regions tend also to include WACC, with a lower frequency in the Asia and the Pacific region. G&A costs and licences and spectrum fees are commonly included, with lower frequency in those regions showing a higher preference for the pure LRIC cost standard (Europe and the Americas). Retail costs is the category least frequently included by Member States.

- Asset valuation:

  - Fixed services: In Europe and the Americas, there is a clear trend in favour of using current cost accounting (CCA); the other regions show a slight preference for that methodology, too, but with a similar number of responses indicating the use of either historical cost accounting (HCA) or hybrid approaches.
  - Mobile services: Africa, the Americas and Europe display a clear trend in favour of CCA. The Arab States opt for CCA and HCA in similar measure, with an increased use of HCA in 2020. The Asia and the Pacific countries tend to use equally CCA, HCA or hybrid approaches. The Americas region tends to use CCA more, followed by HCA and then by hybrid approaches.

- Annualization method:

  - Fixed services: There is a general preference for using economic depreciation, except in Europe, where the tilted annuities method is more prevalent, and the CIS region, where linear annualization is used.
  - Mobile services: Africa, Asia and the Pacific, Europe and the Americas show a clear preference for using the economic depreciation approach. The Arab States display a slight preference for linear annualization. A few Member States report using standard annuities in Africa and Europe.

- Network topology design:

  - Fixed services: A general preference is observed for the scorched-node approach or modified scorched-node approach, except in the Americas, where scorched earth enjoys higher preference, although in 2020 it is equivalent to the usage of modified scorched node.

  - Mobile services: There is a clear preference for the scorched-node approach in Africa and the Arab States. In the case of Europe, there is a slight preference for scorched node, closely followed by the modified scorched-node approach. Asia and the Pacific region countries report using only the modified scorched-node approach. The Americas region shows a slight preference for the scorched-earth approach, although modified scorched node surpassed it in 2020. The CIS countries report only use of scorched earth.

- Reference operator:
  - Fixed services: Significant changes were observed in 2020, without any clear trend.
  - Mobile services: Africa and the Arab States do not register a clear preference for any particular option. Asia and the Pacific reports a clear preference for modelling a dominant service provider. The CIS countries, Europe and the Americas display a preference for modelling a hypothetical average operator, although in the case of the CIS region, we see an equivalent frequency in 2020 for modelling the dominant provider.

- Allocation of common and network costs:
  - Fixed services: Most regions show a preference for use of the equi-proportional mark-up (EPMU) approach, followed (except for the Arab States and Asia and the Pacific) by relevant use of required capacity. The Asia and the Pacific region, Arab States and Africa also report some use of the Ramsey pricing approach. A few countries in Europe report using Shapley Shubik, but use of this methodology is decreasing in 2020.
  - Mobile services: Most regions prefer EPMU, followed (except for the Arab States) by relevant use of required capacity. A few countries in Africa and in the Arab States reported some usage of Ramsey Pricing, and a few in Europe use of Shapley Shubik.

1.1.3 New trends in wholesale costing/pricing schemes in the light of NGN

Case study: New reference offer for broadband wholesale access[6]

The Spanish incumbent fixed-telecommunication operator *Telefónica de España S.A.U.* (TdE) has been regulated for several years. Under one of the regulatory remedies imposed by the national regulatory authority – the *Comisión de los mercados y la competencia* (CNMC) (Commission for Markets and Competition) – TdE was required to offer a number of wholesale services to allow alternative operators to use TdE's fixed access network.

With the evolution of TdE's network towards a next-generation access (NGA) network, a set of new wholesale services has been created.[7] The new reference offer has been called NEBA, standing for *Nuevo servicio Ethernet de banda ancha* (new broadband Ethernet service). This

6 ITU-D SG1 Document 1/158 from Axon Partners Group Consulting (Spain)

7 *Comisión de los mercados y la competencia* (CNMC). Specification and development of obligations. Current wholesale offers.

new service is a Level 2 bitstream offer, which allows alternative operators access to both copper and fibre-to-the-home (FTTH) subscribers. There are two options:

- the NEBA[8] offering includes a bitstream service accessed from regional interconnection points;
- the NEBA Local[9] offering allows indirect access to FTTH loops in the local exchanges (i.e., it is a virtual unbundling local access (VULA) type of service).

The main difference in terms of pricing lies in the evolution from a profile-based pricing model to a capacity-based pricing model.

Previous bitstream offerings included a price per subscriber that depends on throughput, QoS and aggregation level (bitstreams collected at national level were more expensive than those collected at regional level to account for the additional transmission required). This model limits alternative operators' offerings (in terms of bit rate, QoS, etc.) to those provided by the incumbent.

NEBA defines two payment concepts (apart from ancillary services):

- *Access*: A fixed recurrent cost per line, independent of the throughput. It only varies between technologies (copper or FTTH).
- *Capacity*: A recurrent cost depending on the peak throughput conveyed (measured in Mbit/s) and QoS. It should be noted that this concept does not apply for local access, since transmission from the local exchange is handled by the alternative operator.

Under this model, alternative operators are free to decide the level of service delivered to customers. For instance, the operator can purchase more/less capacity to offer higher/lower quality to its customers at a higher/lower cost.

Furthermore, CNMC has altered the regulatory approach in terms of how prices are determined. Traditionally, prices of wholesale access services have been set by the NRA based on information obtained from CNMC's own bottom-up cost models and TdE's regulatory accounting system.

In the case of NEBA services, CNMC has adopted the following approaches:

- *For copper access*: CNMC maintains a similar approach to that applied for traditional services (LLU, Layer 3 bitstream) and determines the price on the basis of cost models.
- *For fibre access*: The price is proposed directly by TdE. CNMC assesses the replicability of the price proposed by TdE and accepts/rejects it according to whether the price passes/ fails a margin squeeze test.
- *For capacity*: CNMC determines the price based on its own bottom-up cost model.

1.2 Significant market power (SMP) – national aspects

1.2.1 Market analysis process / Significant market power in Turkey[10]

Turkey's regulatory framework has been founded on the same pillars as that of the European Union (EU), with regulatory mechanisms designed to enhance liberalization and competition.

8 CNMC. New Broadband Ethernet Service (NEBA). *Oferta de referencia del nuevo servicio ethernet de banda ancha*. [in Spanish]
9 CNMC. Disaggregated virtual access to the fibre-optic loop (NEBA Local). *Servicio NEBA Local*. [in Spanish]
10 ITU-D SG1 Document SG1RGQ/238 from Türk Telekom A.S. (Turkey)

These regulatory mechanisms are based on a number of EU directives, regulations and recommendations, which constitute the EU regulatory framework.

In this context, the Information and Communication Technologies Authority of Turkey (ICTA) carries out market analyses, for *ex ante* regulation, in order to determine relevant markets and identify operators having significant market power (SMP) in those markets, if any. Its "Guidance document on market analyses in the electronic telecommunications industry" sets out the procedures and principles to be followed. As reflected in that document, the major steps in this process are as follows:

- Determination of relevant market
- Determination of relevant service market
- Determination of relevant geographic market
- Regulation requirement analysis
- Assessment of SMP / competition analysis:
    - Removal of remedies (if any) in competitive markets
    - Assessment of SMP and imposition of remedies in non-competitive markets.

Determination of relevant market

In a market analysis process, determination of a relevant market is the first step, which builds the frame for analyses of the level of competition. It has two basic dimensions – service and geographic. Determination of a relevant market begins in practice with the service dimension (determination of relevant service market), followed by the geographical perspective (determination of relevant geographic market).

Determination of relevant service market

A relevant service market consists of services provided by operators and substitutes for those services. In determining the services, substitutability analyses are based on both demand and supply.

Determination of relevant geographic market

Once services in a relevant market are determined, the geographic boundaries of the market have to be defined as well. The same methods as in determining the relevant service market can also be used here. Relevant markets can be defined as international, national or in certain parts of the country. For all regulated markets in Turkey, the markets are defined nationally.

Regulation requirement analysis

Any market can be defined as relevant for regulation if the so-called "three criteria test" is cumulatively met.

- The first criterion is the presence of high and non-transitory barriers to entry. These may be structural, legal or of a regulatory nature.
- The second criterion admits only those markets whose structure does not tend towards effective competition within the relevant time horizon.
- The third criterion is that application of competition law alone would not adequately address the market failure(s) identified.

Assessment of SMP / competition analysis

Significant market power can be defined as the ability of an operator to act independently of competitors and subscribers. In order to determine operators having SMP, notions such as market share, control of easily replicable infrastructure, technological advantages, stabilizing purchasing power, privileged access to financial resources and capital markets, service variety, economies of scale and scope, vertical integration, and advanced distribution and sales channels should be taken into consideration.

Once a relevant market is defined as competitive on the basis of the three criteria test, remedies, if any, are to be removed. In a non-competitive market, on the other hand, if there are any operators having SMP, a variety of remedies could be introduced. In terms of pricing, ICTA may impose tariff control, cost-based tariff approval and price-cap remedies. Once all these processes are finalized, the analysis document is published on ICTA's webpage for public consultation for a period of at least one month.

Türk Telekom Group, as an undertaking designated as having SMP and subject to a cost-based tariff obligation in all six regulated fixed markets, and accounting separation and cost accounting obligations in five of them, and subject to all these obligations in one regulated mobile market (two other mobile operators are also regulated in the "Wholesale mobile call termination" market), is of the opinion that, when imposing obligations in terms of tariff regulations, country-specific macroeconomic conditions and sustainability of investments should be taken into consideration. To date, since the first round of market analyses, in currently regulated markets price-control mechanism remedies still remain as before. The "Wholesale call transit on fixed network", "Call service on fixed network" and "Wholesale access to and call origination on mobile network" markets are no longer regulated.

1.3 Different models for planning NGN networks

ITU's ICT infrastructure business planning toolkit[11]

Deployment of broadband Internet in big towns and cities happens almost naturally, from an economic point of view. But deploying these networks to rural and remote areas is markedly more challenging – economic, geographic and/or demographic barriers mean that many people remain unconnected to the digital world.

Regulators and policy-makers have a major role to play in changing this. When designing an optimal broadband network business – one that can respond and adapt to a wide range of infrastructure deployment projects – these public agents need to consider a great deal of information.

This includes: technology options; deployment, operation, migration and further development of national and cross-border infrastructure; and, most importantly, the relative associated costs and the optimal strategies for financing the necessary investments.

To tackle these issues and support network expansion, ITU has published the "ICT infrastructure business planning toolkit".[12] Inspired by practical implementation, this new toolkit offers

[11] ITU-D SG1 Document 1/394 from the BDT focal points for Questions 1/1 and 4/1
[12] ITU. ICT infrastructure business planning toolkit. Geneva, 2019.

regulators and policy-makers a clear and practical methodology for delivering an accurate economic evaluation of proposed broadband infrastructure installation and deployment plans.

The toolkit intends to:

- serve as a practical manual for regulators and policy-makers working towards extending broadband network deployment and access;
- address key elements for successful business planning for ICT infrastructure development;
- present and explain best practices in infrastructure installation and deployment planning as well as assessment of economic feasibility to support decision-making;
- provide quantitative examples of the most topical projects, such as the construction of optical fibre backbones, wireless broadband networks (including 4G) and FTTH access network projects.

1.4 Country experience and case studies

European experience in the use of different cost models[13],[14],[15]

Looking at practices in European countries, in wholesale markets, especially in Market 1 and Market 2,[16] bottom-up (BU) models based on LRIC are generally used by NRAs. For the other markets, however, it may be said that both FDC and LRIC (long-run average incremental costs) methods are used in similar proportions,[17] and the bottom-up method is more useful in calculating the costs of NGA services. On the other hand, there are also trends towards providing flexibility to the infrastructure owner and, instead of defining regulated prices, just ensuring economic replicability.[18] Since fibre services are new, the bottom-up models, which assume the networks are built in an efficient manner, are appropriate for fibre products so that operators can be fully compensated at today's prices.[19] In other words, for almost all products/markets, LRIC+ is the most frequently used cost-allocation approach; but in termination markets specifically, pure LRIC is the preferred approach. In the access market (Market 3a: Wholesale local access provided at a fixed location), a preference for LRIC+ is discernible.[20] FDC is the preferred approach for duct access, products in Market 4 (Wholesale high-quality access provided at a fixed location) and wholesale line rental (WLR). In Market 3b (Wholesale central access provided at a fixed location for mass-market products) for legacy products, both methods are used.[21]

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13 ITU-D SG1 Document SG1RGQ/237 from Turkey

14 ITU-D SG1 Document 1/276+Annex from the A.S. Popov Odessa National Academy of Telecommunications (ONAT), Ukraine

15 ITU-D SG1 Document 1/284 from Axon Partners Group Consulting (Spain)

16 The markets in which *ex ante* regulation may be needed are defined in European Commission Recommendation 2014/710/EU of 9 October 2014, on relevant product and service markets within the electronic communications sector susceptible to *ex ante* regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council, on a common regulatory framework for electronic communications networks and services. (Market 1: Wholesale call termination on individual public telephone networks provided at a fixed location; Market 2: Wholesale voice call termination on individual mobile networks).

17 According to the Bureau of European Regulators for Electronic Communications (BEREC) Report on regulatory accounting in practice, 2019 (Report BoR (19) 240), in markets other than 1 and 2, FDC and LRIC/LRAIC methodologies are being used equally by NRAs (FDC: 43%, LRIC/LRAIC: 57%).

18 As indicated in European Commission Recommendation 2013/466/EU of 11 September 2013, on consistent non-discrimination obligations and costing methodologies to promote competition and enhance the broadband investment environment

19 ITU-World Bank Digital Regulation Platform. Competition and economics.

20 According to BEREC Report BoR (19) 240 (op. cit.), FDC and LRIC/LRAIC usage ratios by NRAs in Market 3a are 38% and 62%, respectively.

21 BEREC. Report BoR (19) 240 (op. cit.)

An analysis of countries across Europe shows that the vast majority of European NRAs have been using a pure BU LRIC cost model for fixed termination rates (FTRs) and mobile termination rates (MTRs). As shown in **Annex 3** to this report, for setting FTRs, 22 European NRAs out of 36 use pure BU LRIC models; the second most common model is FDC/FAC, used by seven NRAs; six NRAs use benchmarking approaches; and one uses BU LRAIC+. Similarly, for MTRs, BU LRIC models are used; although a significant number of NRAs base their price decision on benchmarking.[22]

On the other hand, with convergence of the services provided, the LRIC method is used for NGA services, as well as, in some cases, the FDC method. If the LRIC approach is used, a certain proportion of common costs may be distributed to the services, and adding in a mark-up for recovery of common costs can be considered.[23]

In addition to differentiation of the cost-allocation methods, additional risk premiums may be applied to include the risks in respect of services provided over NGNs.[24] It is known that an additional risk premium can be used in EU countries over and above the WACC ratio, which is considered as the minimum rate of return expected by investors and a tool to calculate capital costs. In practice, it is seen that additional risk premiums varying from 0.1 to 3.31 points over the WACC for services offered on copper networks are applied in 12 of 18 countries where the services provided over NGN are regulated and WACC data are publicly available.

Finally, it is important to mention that a new European Electronic Communications Code (EECC)[25] was launched in December 2018, overhauling the EU legislative framework established in 2003. The EECC establishes a new harmonized framework for the regulation of electronic communications networks and services in the EU and a template for the wider Europe and CIS region.

Among other aspects, the EECC builds on the earlier EU Recommendation on regulatory treatment of termination rates, going further in that it requires single EU-wide maximum call termination rates (fixed and mobile "Eurorates") to be established by 31 December 2020.

In order to determine such Eurorates, the European Commission launched two projects to develop cost models for fixed and mobile networks for all 31 EU/EEA countries. The phases followed for the development of these cost models and the methodology implemented are further described in **Annex 3**. Once the models had been finalized, the European Commission published large volumes of documentation,[26] including:

- Executive summary of study
- Fully accessible public versions of models[27]
- Detailed documentation on methodology
- Descriptive technical manual on models

22 BEREC. Termination rates at European level – January 2018 (BoR (18) 103).
23 European Union (EU). Recommendation 2013/466/EU of 11 September 2013, on consistent non-discrimination obligations and costing methodologies to promote competition and enhance the broadband investment environment.
24 ITU-D SG1 Document 1/233 from Turkey
25 EU. Directive (EU) 2018/1972 of 11 December 2018, establishing the European Electronic Communications Code (Recast).
26 Public information available for both the mobile network model (ITU-D Study Group 1: Guidelines on cost modelling) and the fixed network model (European Commission: Finalisation of the fixed cost model for the delegated act on a single EU-wide fixed voice call termination).
27 The information included in the models represents a generic operator for reasons of confidentiality.

- User manual
- Final results of models under different scenarios
- All presentations made at the workshops held with regulators and operators.

Regulatory initiative to assist national telecommunication/ICT operators in Burkina Faso[28]

The *Autorité de régulation des communications électroniques et des postes* (ARCEP) (Regulatory Authority for Electronic Communications and Posts) of Burkina Faso started initial market analysis in 2015 on accounting and financial data related to the national telecommunication/ICT market. ARCEP was assigned to support operators in the challenging process of introducing cost accounting by providing them with guidelines, founded mainly on the activity-based costing (ABC) method, on the basic principles to be observed in order to meet regulatory requirements. As a result, each operator has subsequently endeavoured to introduce cost accounting in line with the aforementioned guidelines. The various systems have been audited for the first time, using ARCEP resources, in order to assess conformity with the guidelines issued and, based on developments, propose possible changes or make recommendations.

Determination of the wholesale tariff in Gambia[29]

In 2013, when the African Coast to Europe (ACE) cable was being laid across the west coast of Africa with the help of the World Bank, Gambia, like most countries in the region, was able to obtain a landing station for the first time in its history. To operationalize the station, a special purpose vehicle (SPV), the Gambia Submarine Cable Co. Ltd (GSC), was created comprising government, the incumbent fixed-line operator and all the GSM operators. Coincidentally, the African Development Bank (AfDB), through its ECOWAS Wide Area Network (ECOWAN) project,[30] also funded the Gambia national fibre network, with three main objectives, namely to ensure national connectivity; to ensure terrestrial regional connectivity; and to ensure connection with ACE.

Determination of a pricing scheme for the international capacities was undertaken with due respect for principles of fairness, taking into account four major issues:

a) The regulatory framework imposes open access and non-discrimination, in particular in the context of GSC being the sole landing station in the country.
b) Prices have to be cost-oriented, which means no excessive margins are to be allowed.
c) Prices must be based on a mid- to long-term perspective, which is the only way to take into account the fast-changing market, with the result that we need to determine consistent and robust projections for the development of the market (fixed and mobile broadband).
d) The issue of the GSC members being shareholders and potential customers who will be buying capacities, to the extent that the price will include a fair margin equal to a reasonable cost of capital.

In regard to the economic outcome, based on market projections for volumes, price assumptions, CAPEX and OPEX forecasts and economic indicators for the profitability of the investment, the following result was obtained:

a) Positive net present value (NPV) in 2028

[28] ITU-D SG1 Document SG1RGQ/205 from Burkina Faso
[29] ITU-D SG1 Document SG1RGQ/179 from Gambia
[30] On 29 November 2016, senior officials of the Economic Community of West African States (ECOWAS) validated the report of the study on the market analysis and business model for the ECOWAS Wide Area Network (ECOWAN) project.

b) The internal rate of return (IRR) will be 10 per cent in 2023 and 19 per cent in 2028
c) The payback period is in 2020.

The prices derived from the model basically elaborate on a reference price for STM-1 to Telvent and a set of ratios for the calculation of other capacities and destinations. The price for STM-1 to Telvent was set at GMD 260 000 per month (USD 5 200). This could be further broken down to GMD 1 800 per Mbit/s per month, equivalent to USD 36 per Mbit/s per month.

Regulation of interconnection charges in Paraguay[31]

The Paraguayan telecommunication market has four mobile-network operators (Tigo, Claro, Personal and Vox) and one fixed-telephone operator (Copaco).[32]

One of the features of local regulations governing interconnection has been to delegate the setting of interconnection charges for the fixed (Copaco) and mobile (Tigo, Claro, Personal and Vox) services. The rationale was that costs would be incremental and representative, proposed to operators by an efficient operator; although the regulator, the *Comisión nacional de telecomunicaciones* (CONATEL) (National Telecommunication Commission), reserved the possibility of regulating such charges in the event of disagreement. In fact, experience shows that the operators never established the applicable interconnection charges through such agreements, but it was CONATEL that took steps to progressively reduce these charges.

The specific features of local regulations meant that interconnection charges in Paraguay were updated less frequently than usual. In particular, in early 2018, it was observed that fixed interconnection charges had remained constant since 2009.

In 2018, ITU conducted a technical assistance project to support CONATEL in reviewing its regulatory and legal framework, as well as in determining the increased costs of mobile and fixed interconnection services using a cost model. In line with international best practices, two bottom-up models were developed to determine the incremental costs associated with the provision of fixed and mobile interconnection services in Paraguay (more details on this project are given in **Annex 1** to this report).

It emerged from application of the cost models that regulatory measures were required for setting wholesale fixed and mobile interconnection charges.

In particular, it was concluded that mobile interconnection costs for the period 2018-2022 were between 66 and 72 per cent below current wholesale rates, while in the case of fixed termination they were between 36 and 48 per cent below current rates. On the basis of these results, on 26 July 2018, CONATEL issued Resolution 1180/2018, which "updates the ceilings for interconnection charges for voice call and SMS services to cellular-mobile telephony networks (STMC and PCS), as well as the ceilings for interconnection charges for voice call services to the basic telephony network".[33] The resolution provides for a glidepath until September 2020, with the aim of achieving convergence of regulated rates with the costs of providing these services in the country.

[31] ITU-D SG1 Document SG1RGQ/144 from Axon Partners Group Consulting (Spain)
[32] There are other operators providing other fixed services, such as Internet or television, e.g. Tigo or Claro.
[33] STMC: *Servicio de telefonía móvil celular* (cellular-mobile telephony service); PCS: personal communications service

Overview of new methods applied to determine costs for products in relevant wholesale markets in Brazil[34]

In view of the need to encourage full, free and fair competition among companies that provide telecommunication services, and in order to promote diversity and quality in services at affordable prices to the population and improve regulation governing the establishment of regulatory asymmetries determined on the basis of SMP in a given relevant market, the *Plano geral de metas de competição* (PGMC) (General plan of competition goals) was established on 8 November 2012, by Resolution No. 600.[35]

With the aim of eliminating abuses of market power, PGMC, as the primary telecommunication regulatory tool for promoting competition, establishes the guidelines for identifying groups with SMP, defines relevant markets and prescribes the asymmetric regulatory measures to be adopted by the regulator, the *Agência nacional de telecomunicações* (Anatel) (National Telecommunications Agency) in search of competitive equilibrium in the markets.

Following the PGMC regulatory review in 2018, a number of relevant wholesale markets were identified.[36] With the exception of the traffic exchange market, groups with SMP in these markets are required to present a wholesale reference offer for the product, complying with reference values set by Anatel; and, as of the latest revision of the PGMC, these reference values, except in the first three markets, are cost-oriented, based on a top-down FAC-HCA cost model (TD-FH).[37]

For cases where it is not possible to extract values directly from the cost model, the PGMC prescribes alternative methods for setting the reference values, in the following order of priority:

a) Calculated values for similar wholesale products
b) Calculated values for similar retail products, minus retail costs
c) Average values calculated from the costs, operating expenses and cost of capital at an intermediate step of the cost allocation
d) Calculated values for other groups with SMP in the same relevant market
e) Benchmark.

An overview of the methodologies adopted for estimating costs in the regulated wholesale markets in Brazil is presented in §3 of **Annex 3** to this report.

34 ITU-D SG1 Document 1/335 from Brazil
35 *Agência nacional de telecomunicações* (Anatel). Resolution No. 600 of 8 November 2012.
36 a) Traffic exchange; b) Leased lines; c) Termination rates (fixed and mobile); d) High-speed leased lines; e) National roaming; f) Full unbundling; g) Bitstream; h) Duct rental
37 Established through Anatel Resolution No. 396 of 31 March 2005. [in Portuguese]

Chapter 2 – Different models for infrastructure sharing, including commercial negotiation

2.1 Different types/models of infrastructure sharing (passive, active)

There are different types of infrastructure sharing, such as passive infrastructure sharing; active infrastructure sharing (including through the aggregation of frequency bands assigned to operators who have acquired property rights over the spectrum so as to enable the implementation of active infrastructure sharing); national roaming; and access to essential facilities.

Passive infrastructure sharing

Passive infrastructure sharing refers to the sharing of civil-engineering works without any electronic telecommunication elements, whereby several operators share the passive network components in order to reduce the costs related to the leasing and acquisition of property items such as real estate, civil engineering, access rights/rights of way and site preparation.

Examples of passive infrastructure are physical space on the ground, steel towers, masts, rooftops, ducts, poles, dark fibre, shelters, main and backup power supplies (e.g., generators, batteries, inverters), air conditioning, fire extinguishers, security cabins and other passive and non-electrical equipment. Passive sharing is commonly used for mobile networks; however, it can also be employed for fixed networks, such as in the sharing of ducts and trenching required to deliver FTTH.

Implementation of the passive infrastructure-sharing model does not necessarily require changes to the regulatory framework. Telecommunication operators may enter into commercial agreements on passive infrastructure sharing within their respective legal frameworks.

Member States are encouraged to consider the appropriate regulatory framework for infrastructure sharing bearing in mind the principles of minimum intervention and proportionality.

Active infrastructure sharing

Active infrastructure sharing is an advanced technical model and a more complex type of sharing, whereby operators share not only passive elements but also the active layer of their networks.

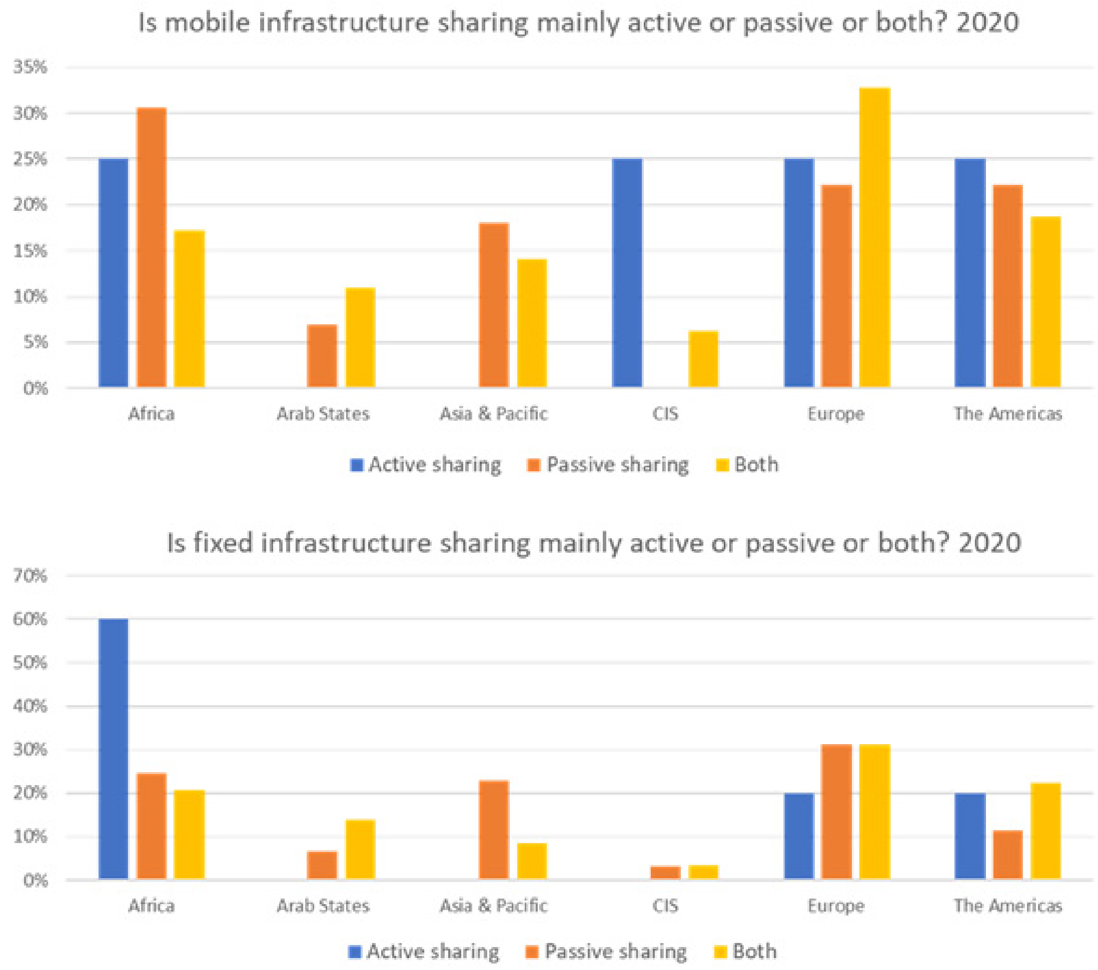
It may involve all electronic elements such as base station, radio access network (RAN), microwave radio equipment, access nodes, antennas, transceivers, switches, servers, backhaul and backbone transmission.

Active sharing can be extended to joint management systems, combined with maintenance arrangements, and single backhaul, whereby an operator can negotiate access to its mobile switching centres and/or its packet-switching core network with other operators. However, operators sometimes prefer not to share certain core network components and service infrastructures that provide customers with differentiated services, applications, rate plans, etc.

Implementation of the active infrastructure-sharing model might require some changes to the regulatory framework. Telecommunication operators may enter into commercial agreements on active infrastructure sharing within the rules allowing registration of a radio system or a high-frequency (HF) device for two or more operators and the rules governing applications for telecommunication equipment sharing RANs, for example for Global System for Mobile communications (GSM), universal mobile telecommunications system (UMTS) or long-term evolution (LTE).

The ITU Tariff Policies Database[38] gives a breakdown of active and passive infrastructure sharing worldwide for both mobile and fixed networks, as shown in Figure 2.1.1.

Figure 2.1.1: Active and passive sharing for mobile and fixed networks across regions, 2020



Source: ITU Tariff Policies Survey

38 ITU. ICT Eye database.

National roaming

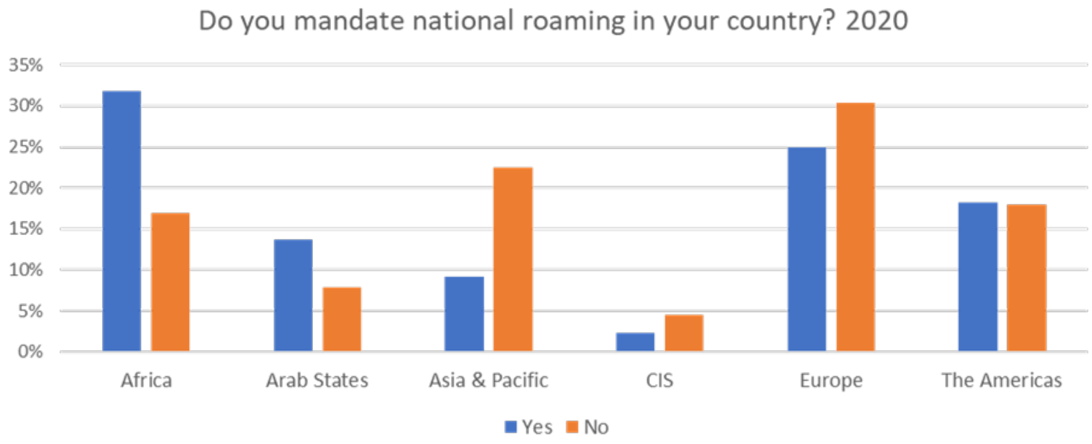
Roaming can be considered as a type of sharing that allows a network operator's customers to use mobile services when they are in an area not covered by their own network operator. Thus, it is a means of virtually extending an operator's geographical coverage.

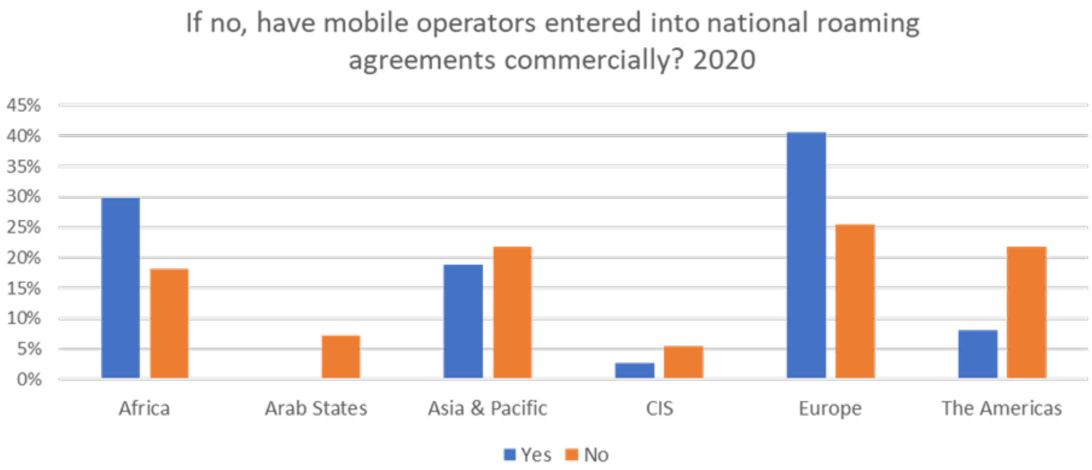
Usually, national roaming constitutes an initial sharing of infrastructure during the early stage of network deployment that enables new entrants to penetrate all geographical areas of the market by using the networks of the existing operator or operators and at the same time allows the existing operator(s) to generate additional revenue streams from leasing their networks to new entrants.

National roaming can be used for a limited fixed period of time, usually the first few years of network deployment for the new entrant; or it can be used to expand coverage on a permanent basis throughout the licence period.

According to the ITU Tariff Policies Database, around 33 per cent of countries mandate national roaming. Moreover, operators often enter into national roaming agreements under commercial arrangements even if national roaming is not mandated by the regulator.

Figure 2.1.2: Availability of national roaming across regions, 2020





Source: ITU Tariff Policies Survey

Internet exchange points

Internet exchange points (IXPs)[39] provide an additional example of local infrastructure sharing. IXPs are organizations allowing Internet service providers (ISPs) to share the IXP infrastructure so as to route their upstream traffic in a cost-effective and technically efficient way. This routing may be achieved through public peering at IXPs, where member providers are connected to each other. Peering between two members of an IXP is based on mutual willingness to peer (to interconnect), as there is no obligation to do so. Traffic sharing through peering at IXPs is cost effective since, once an ISP is a member of an IXP, it will have no extra interconnection costs for exchanging traffic, neither to reach the peer, as they are already co-located at the IXPs, nor to pay for the costs of interconnection, as public peering is often free, being based on reciprocity. IXPs facilitate the exchange of Internet traffic in a cost-effective manner[40].

Peering at an IXP can be between multiple providers, based on multilateral peering and taking place through an IXP's route server; or can be merely bilateral, like private peering, but taking place at an already shared location and hence at a reduced cost in comparison with linking two providers at two different locations. In essence, the participants place their router at the IXP and advertise their IP routes that they are willing to share with their peers.

The key cost-saving feature of IXPs is that every member has to deploy just one link, to the IXP, rather than a number of links equal to the number of premises of all other ISPs.

The key benefits of infrastructure sharing at IXPs are the following:

- Local traffic stays local, instead of being re-routed, possibly over international routes, by upstream transit providers.
- Quality of service is particularly enhanced by virtue of the reduction of routing and hops, and by keeping local traffic exchanges at the local IXP.

Benefits like reduced transit costs, reduced investment costs and improved QoS for consumers are all major success factors in local ICT ecosystems, whereby IXPs become physical interconnection centres representing the core hubs where exchanges of digital commodities take place. It is, however, essential to note that not all members of an IXP will have peering access to all other members' routes. The real effectiveness that can be achieved by an IXP in terms of reducing ISPs' costs will therefore vary according to how effective it is in providing actual interconnections, based on members' mutual willingness to peer; and the extent to which interconnection decisions are based on ISPs' characteristics, and notably the differences between its members in terms of routes advertised, membership size or traffic routed.[41]

IXPs provide shared infrastructures among different types of members. These might include private ISPs, national research and education networks (NRENs), Internet infrastructure operators,

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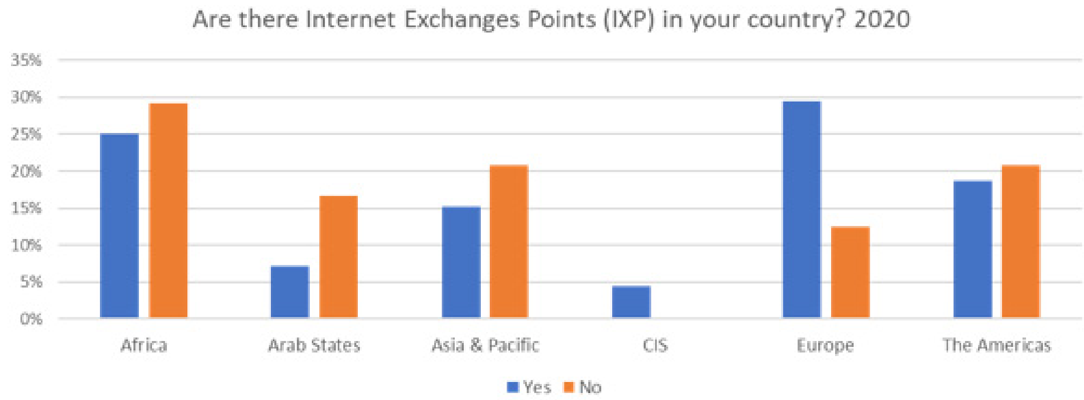
39 The formal definition of IXP reads: "An Internet Exchange Point (IXP) is a network facility that enables the interconnection and exchange of Internet traffic between more than two independent Autonomous Systems. An IXP provides interconnection only for Autonomous Systems. An IXP does not require the Internet traffic passing between any pair of participating Autonomous Systems to pass through any third Autonomous System, nor does it alter or otherwise interfere with such traffic. 'Autonomous Systems' has the meaning given in BCP6/RFC1930, "Guidelines for creation, selection, and registration of an Autonomous System (AS)". 'Independent' means Autonomous Systems that are operated by organizational entities with separate legal personality". Source: Euro-IX. What is an IXP?

40 World Bank. World Development Report (2016) – Digital Dividends, page 220.

41 On the differences in internal connectivity and competitiveness conditions in 195 IXPs across the world, see Alessio D'Ignazio and Emanuele Giovannetti (2014). Continental differences in the clusters of integration: Empirical evidence from the digital commodities global supply chain networks. *International Journal of Production Economics* (IJPE). Volume 147, Part B, pp. 486-497.

over-the-top (OTT) providers, application service providers (ASPs), online service providers (OSPs) or content and application providers (CAPs) and possibly governmental e-government networks (more information is provided in **Annex 2** to this report). One of the key issues in comparing their impact on reducing transit costs is the fact that the distribution of IXPs across countries remains uneven, as seen for example in Figure 2.1.3 below, obtained from the ITU Tariff Policies Database:

Figure 2.1.3: Availability of IXPs in regions, 2020



Source: ITU Tariff Policies Survey

It can be seen that the Africa region records the largest percentage of reporting countries (29 per cent) that do not have an IXP, followed by Asia and the Pacific (21 per cent) and the Americas (21 per cent). It is also interesting to note the gap between, on the one hand, the CIS region (0 per cent) and Europe (13 per cent), and, on the other hand, the Arab States region (17 per cent), probably due to the different organizational features of the Internet in the countries of these regions.

The internal governance of IXPs will clearly also matter in shaping the key costs of accessing these shared facilities for their individual members, and the new data collected in the annual ITU Tariff Policies Survey since 2018, further discussed **Annex 2**, present novel evidence on how this governance varies across Member States and regions.

Access to essential facilities (unbundling)

Access to and sharing of essential facilities is another critical concept, which is related to – but different from – infrastructure sharing. Essential facilities are elements that are provided by a sole operator (or very few operators) in the market and that, on account of economic and technical limitations, cannot be replicated by other competitors, who nevertheless need these facilities as an important input to their retail services.

A prime example of access to an essential facility is local loop unbundling (LLU), which addresses the part of the network between the end subscriber's telephone socket and the local exchange to which the subscriber is connected. There are different types of unbundling: full unbundling, shared access, and bitstream access. In full unbundling, the incumbent provides full access to raw copper local loops and sub-loops. In shared access, the incumbent provides access only to the non-voice frequencies of the local loop. Bitstream access requires the incumbent to provide and lease to other competitors links capable of accommodating high-speed services.

From a practical point of view, the incumbent operator or operators that control essential facilities have the upper hand and enjoy more bargaining power than other operators and new entrants seeking to access these essential facilities. In addition, the incumbent operator(s) can skew the commercial rationale of sharing agreements, overprice wholesale services or even refuse supply of essential facilities. Such practices will hinder the development of infrastructure and market growth, as well as undermining fair competition in the market.

Therefore, there is a need for asymmetric regulations to redress the consequences of market power and to distinguish between infrastructure-sharing agreements and mandatory obligations in respect of access to essential facilities. This may be achieved by imposing additional requirements on the incumbent operator, especially the obligation to allow access to and share essential facilities, rather than leaving sharing arrangements to commercial negotiation between operators.

2.2 Regulatory frameworks for infrastructure sharing

Infrastructure sharing and investment implications[42]

Beyond the broad benefits of infrastructure sharing, there is a viewpoint that infrastructure sharing is especially critical because of its investment and financial implications. For example, open access to essential facilities and low infrastructure-sharing prices will increase competition at the service level but slow down the deployment of alternative access and backhaul networks, which may then lead to inadequate capacity, lower service quality and slow deployment of new technologies in the future.

Thus, NRAs have to strike the right balance based on specific national circumstances. In other words, regulatory authorities have to encourage infrastructure sharing and access to facilities but at the same time promote investment that enables infrastructure-based competition and deployment of new networks and services. They have to ensure that infrastructure-sharing policies do not deter competing market players from installing their own independent facilities. For example, NRAs can impose certain requirements to ensure that each network operator must cover a certain percentage of the population with their own network infrastructure before seeking infrastructure-sharing agreements with other operators.

Level of regulatory intervention

The level of intervention to regulate infrastructure sharing differs from one country to another. Some authorities have no specific regulations governing infrastructure sharing, and allow operators to negotiate sharing agreements freely without any obligations, while others have detailed regulatory frameworks that mandate infrastructure sharing. Some authorities may decide to encourage sharing just by subjecting sharing agreements to approval, while others intervene only in cases of dispute or when operators cannot reach an agreement, in order to resolve the dispute or to set fair terms or prices for infrastructure-sharing services. The level of regulatory intervention should be determined in the light of national circumstances and the level of competition in the market.

42 ITU-D SG1 Document SG1RGQ/183 from Egypt

Where there is little or no intervention, the regulator tends to rely on operators to engage in commercial negotiations to set the terms, conditions and prices for infrastructure-sharing services. Such commercial agreements may include technical and financial aspects of infrastructure sharing, access to essential facilities and wholesale services.

Types of infrastructure-sharing agreements

There are different kinds of infrastructure-sharing agreements negotiated between operators. They may be unilateral, whereby one operator agrees to provide access to its facilities to other operators; bilateral, whereby two operators agree to share their own facilities together; or multilateral, where the sharing agreement involves several operators. The scope of a sharing agreement could be a single site, several sites or general agreement for all sites in a given geographical location.

Bottlenecks as a new form of essential facility

In the past, it was easier to identify essential facilities in telecommunication/ICT networks, due to the fact that incumbent operators usually owned the main public switched telephone network (PSTN). This was clearly an essential facility, as it reached the homes of all potential end consumers through fixed lines.

However, liberalization, competition and technological progress, for example through unbundling, have opened up different forms of access. This, in turn, can often be dealt with by regulating the terms of infrastructure sharing, as discussed in different sections of this report.

More recently, mobile operators have acquired a new role as "bottlenecks" (a form of access control similar to an essential facility) owing to their control over access to end users. The strength of their grip on these consumers depends on effective competition in the mobile market and on national regulatory frameworks. Number portability, including how easy it is for the consumers to benefit from it and on what terms, is an effective regulatory instrument for overcoming these bottlenecks and reducing potential monopolistic behaviours. Clearly, best practice should be followed in this regard. Then again, number portability alone may prove insufficient when providers are supplying other value-added services which are not "portable" to a competitor just by transferring the same number.

Lately, the emergence of OTT services has significantly altered the landscape. With the impressive new types of benefits OTTs provide to consumers, such as profiles, time maps, contacts, histories, friends and friends of friends, to name but a few, the switching costs associated with changing OTT provider, or digital platform,[43] have become increasingly significant. Moreover, the costs involved in switching OTT may differ, for example between younger and older consumers or more/less digitally skilled ones. This raises new regulatory questions, as a market can have different levels of contestability for different socio-economic demographics. Therefore, while number portability has made it easier for end users to change mobile provider, this is not sufficient to deal with the new bottlenecks in telecommunication/ICT networks, because of the

43 ITU-D SG1 Document 1/367+Annex from Anglia Ruskin University (United Kingdom), reporting on results published by Paolo Siciliani and Emanuele Giovannetti (2019). Platform competition and incumbency advantage under heterogeneous switching cost – exploring the impact of data portability. *Bank of England Staff Working Paper*, No. 839 (2019).

captivity/loyalty of end consumers that stems from the most useful features and innovations introduced by OTTs.[44]

These new realities, brought about by fast and welcome technological progress, deliver incredible new benefits for consumers and societies. However, as they also introduce new types of essential facilities, they likewise pose new regulatory questions regarding access to complex forms of infrastructure/platform sharing, on platforms that are digital as well as physical. While the technologies, services and benefits are recent, the challenges arising from the presence of bottlenecks remain the same, insofar as they are linked to incentives to raise barriers to entry into digital infrastructures, barriers that may be based either on pricing or on quality of access.

In order to provide high-quality and tailored services, but also to increase customer loyalty and, as a result, targeted advertising revenue, OTTs need to feed large amounts of personal data into their algorithms. Such algorithms support the high-quality services, but also generate higher, and asymmetric, switching costs, potentially leading to the emergence of new digital essential facilities. These new digital bottlenecks, by providing increased personalized choices within a platform, eventually reduce consumer choice between platforms, potentially affecting contestability and innovation in the markets concerned. Regulatory scrutiny of access to sharing of these digital infrastructures (platforms) poses new challenges for regulators, who need to invest in the required analytical and digital skills in order to stay ahead of the emerging technological, strategic and behavioural challenges, within a time-frame that is constantly accelerating because of the key role played by the use of artificial intelligence (AI) in building the smart services the platforms offer. The challenges raised by these new forms of algorithmic service provision by OTTs can only be addressed by equipping NRAs to adopt best-practice prioritization procedures capable of mimicking providers' algorithms and assessing their market impact; and this can only be achieved by investing in developing the necessary skills to implement new forms of algorithmic, just-in-time regulatory scrutiny.[45]

2.3 Commercial terms and conditions for infrastructure sharing[46]

The deployment of fibre technologies in the access network is necessary in order to enhance consumer benefits and meet future bandwidth needs. In this context, telecommunication/ICT network providers are currently formulating their business plans to expand their fibre networks. In addition, NRAs are elaborating their strategies to improve access to fibre technologies and raise the capacity and speed of Internet connections all across their countries in order to make high-speed broadband readily accessible.

ITU has highlighted the vital importance of a solid national regulatory framework for accelerating broadband roll-out and stimulating the development of new digital goods and services.[47] As an example of this, in Turkey, LLU, bitstream access and resale services had been regulated since 2005 by determining operators with SMP and imposing on them relevant remedies within the framework of market analysis for both the wholesale physical network infrastructure access market and the wholesale broadband market. When the development of fibre technologies in

44 ITU-D SG1 Document 1/339+Annex from the Rapporteurs for Questions 3/1 and 4/1, on the Question 3/1 and Question 4/1 joint annual deliverable for the period 2019-2020: Economic impact of OTTs on national telecommunication/ICT markets.
45 ITU-D SG1 Document 1/228 from Anglia Ruskin University (United Kingdom)
46 ITU-D SG1 Document 1/233 from Turkey
47 ITU (2012). Trends in telecommunication reform 2012: Smart regulation for a broadband world. Geneva, 2012.

Turkey was analysed in 2010, due to the limited coverage of fibre infrastructure, which was not considered as a substitute for copper, Türk Telekom, the fixed incumbent, was determined as the SMP operator and obliged to provide ADSL/VDSL access products, but not fibre products. In other words, no remedy was imposed on the incumbent operator with regard to fibre access services (FTTH/B).

2.4 Infrastructure-sharing considerations related to transition to 5G[48]

In the era of digital transformation, fifth generation (5G) is the future of information delivery, supporting the implementation of many disruptive technologies such as cloud computing, Internet of Things (IoT), smart antennas and AI, among others. Rather than being merely an incremental advance over the fourth generation (4G), 5G is a new way of communicating that allows massive bandwidth and extreme node densities, maintaining high energy efficiency. To get ahead of 5G implementation, many providers in developed countries are building their networks, and some are already commercializing 5G plans.

Even if it is well advanced in a number of countries, 5G implementation is experiencing some financial and regulatory challenges. Significant investments in poles, ducts and towers may be required to support high-speed and low-latency traffic data, entailing an adaptation of the current network infrastructure to offer the new technology. One of the main barriers for telecom providers to overcome is the capacity to monetize the legacy infrastructure from old technologies (2G, 3G and 4G). The regulatory sector may also need to address certain challenges, such as defining the frequency band to be used in 5G and encouraging the exchange of infrastructure to create a competitive balance in the national market.

Provision of 5G Internet via radio requires both fixed (poles, ducts, ditches and cables) and mobile infrastructure. To carry 5G data traffic, some adjustments have to be made to long-distance fixed infrastructure, mainly in terms of more robust equipment to support higher data capacity. For mobile infrastructure, it will be necessary to adapt existing towers, currently acting as 3G/4G stations, for 5G signal emission, by installing new antennas. Furthermore, since 5G operates at higher frequencies and hence on a shorter wavelength, the distance between devices and towers has to be shorter, too; and the signals have difficulty overcoming obstacles. As a result, smaller intermediate towers will also have to be installed to receive and transmit the 5G signal and minimize signal interference due to physical barriers.

Finally, for the end user to access and enjoy the 5G signal, devices must have technology capable of capturing this signal, which is already being made available by some brands in the market.

Since fixed infrastructure is the most expensive component in the operation of mobile networks and it needs to be expanded for 5G deployment, it is essential to find ways of optimizing passive infrastructure costs. One means of adapting and expanding the infrastructure to meet the demand for new technologies is co-building or sharing between operators.

By and large, infrastructure sharing facilitates the entry of new players and consequently facilitates coverage of underserved areas, improved customer services and product innovation – since providers will try to differentiate themselves from competition and will be more willing to invest in innovations given the lower initial perceived risks compared to a non-sharing scenario.

[48] ITU-D SG1 Document SG1RGQ/218 from ADVISIA OC&C Strategy Consultants (Brazil)

Overall, infrastructure sharing is attractive from the perspective of reducing risks and cutting costs for the companies involved.

Besides the practice of sharing, infrastructure costs can be reduced through partial replacements in network configuration. Depending on the complexity of the existing network in a municipality, fixed backhaul, for example, can be replaced by satellite broadband (although this could represent a bottleneck in terms of latency). This substitution is advantageous when the city in question has no fibre point of presence, calling for the launch of a fixed network with greater capillarity to access homes. In this scenario, the required total investment in the fixed network is estimated to be much higher than the cost of deploying satellite Internet, which is already around USD 200 to 300 per new access. Thus, satellite broadband has the potential for new applications and may be a viable solution for smaller cities (around 25 per cent of the Brazilian population) where the fixed network is less sophisticated or even non-existent.

This type of practice may be widely observed in cases such as the United Kingdom, where the regulator, Ofcom, has encouraged cooperation among 3UK, T-Mobile, O_2 and Vodafone, reinforcing the notion that infrastructure sharing could be interesting both for operators and for the regional population, who would obtain better coverage and better-quality service. In Brazil, partnerships between market leaders are also emerging. For example, TIM has 3G/4G coverage-sharing agreements with other major operators (Claro, Vivo and Oi) and some local providers. In the evolution to 5G, it is expected that these operators might follow the trend of sharing their infrastructure.

In the case of Spain, it should be noted that *Telefónica de España* (TdE) is only required to offer wholesale services for FTTH in those municipalities in which there is no competition in NGA networks.[49] Even if it does not have the obligation to do so, however, TdE has signed commercial agreements with its two main competitors (Vodafone[50] and Orange[51]) to offer its FTTH network in the unregulated municipalities, too.

2.5 Spectrum-sharing framework within infrastructure sharing

In implementing active infrastructure sharing, aggregation of frequency bands assigned to operators who have acquired property rights over the spectrum may be employed in order to improve network capacity and optimize radio access network (RAN) capital expenditures (CAPEX), as described in most recent version of Report ITU-R SM.2404-0.[52]

The active infrastructure sharing model may also require an enabling regulatory framework allowing spectrum assigned to one of the telecommunication operators to be used by the other operators, based on authorization from the regulator, where required, and commercial agreements between the operators.

When analysing regulatory interventions resulting from the active infrastructure sharing model, including when the implementation of active infrastructure sharing is enabled by the aggregation

49 There is considered to be competition in a municipality when there are at least three NGA fixed networks (FTTH or DOCSIS 3.0). In the latest review (in 2016), 66 out of more than 8 000 municipalities were found to have competition in NGA.

50 Expansión. *Telefónica y Vodafone firman un acuerdo histórico para el acceso a las redes de fibra*. Updated 17 March 2017. [in Spanish]

51 Telefónica. *Telefónica firma con Orange un acuerdo comercial de acceso mayorista para fibra óptica*. Madrid, 22 February 2018. [in Spanish]

52 Report ITU-R SM.2404-0 (06/2017). Regulatory tools to support enhanced shared use of the spectrum.

of frequency bands assigned to operators who have acquired property rights over the spectrum, Member States should consider a number of factors, including technical, competition and licensing aspects, in order to avoid potential negative impacts of such interventions on the telecommunication market.

2.6 The impact of infrastructure sharing

Network sharing is a form of partnership between operators in the telecom and related sectors to reduce capital investment in network and infrastructure deployment and decrease operating expenses. The various aspects of the impact of infrastructure sharing are summarized below:

2.6.1 Investment aspects

Promoting rapid and efficient network deployment

Most countries have formulated national plans for the development of mobile and fixed broadband and NGN, which will depend on the deployment of 4G and fibre, as the technologies able to accommodate the increased data traffic.

These deployments are very expensive and entail a long payback period before the required return on investment is obtained. Infrastructure sharing among network operators can however reduce the huge capital investments involved and shorten delivery times. Infrastructure sharing has been considered as a means of improving broadband access and narrowing the digital divide.

Reducing capital and operating expenses and increasing capacity

Up to 50 per cent of sites in mobile networks capture no more than 10 per cent of mobile service revenues. For this reason, infrastructure sharing has become a widely used strategy that is attractive to network operators and helps them cut their capital and operating expenditure. For example, infrastructure sharing can reduce CAPEX elements such as site acquisition and administration costs as well as OPEX elements such as rental and maintenance costs.

The exact level of saving resulting from infrastructure sharing is difficult to assess, because it differs from country to country and from one operator to another, and also depends on the particular level of sharing and on geographical deployment strategies.

However, a recent study by the Inter-American Development Bank (IADB) and the World Bank estimates that a 10 to 40 per cent cost reduction in CAPEX and OPEX can be achieved, depending on the scale or type of sharing (e.g. site sharing, infrastructure sharing, telecom equipment sharing, national roaming, full sharing).[53] Another study states that the sharing of sites and antennas can reduce CAPEX costs by an average of 20 to 30 per cent, while the sharing of radio network may save between 25 and 45 per cent.[54]

Moreover, infrastructure sharing is also used to provide additional capacity in urban areas where it is difficult to find suitable new sites or obtain permission for new towers.

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53 ITU and UNESCO (2014). Report by the Broadband Commission for Digital Development. The State of Broadband 2014: Broadband for all. Geneva, 2014, p. 77.

54 Djamal-Eddine Meddour et al. (2011). On the role of infrastructure sharing for mobile network operators in emerging markets. *Computer Networks*, May 2011.

Enhancing investment decisions and improving financial viability in rural and underserved areas

Low population density and high cost of network deployment can hinder investment and constrain business decisions in rural and underserved areas. The return on investment from these remote areas does not sustain commercial operations. With this is mind, infrastructure sharing will serve to facilitate improved coverage and service by allowing operators to share the risk of investment in rural and remote areas.

This aspect was mentioned during the Webinar on the economic implications of COVID-19 on national telecommunications/ICT infrastructure (see **Annex 7** to this report), where speakers highlighted the importance of infrastructure sharing for bridging the connectivity gap.

2.6.2 Provision of telecommunication/ICT services aspects

Reducing retail prices and enhancing the quality of telecommunication/ICT services

The cost reduction achieved by infrastructure sharing can bring long-term efficiencies, which in turn enable more innovative products and services and ultimately benefit consumers.

It affects operators' pricing strategies, allowing them to lower the prices of retail telecom services and hence make the services more affordable to consumers. This benefit has a significant impact in promoting ICT services, especially in developing countries.

Similarly, sharing resources and cutting down on individual infrastructure allows each operator to deploy new technologies more rapidly and to focus on innovation of services, which improves the quality of services as operators compete more on service differentiation than coverage differentiation.

2.6.3 Market competition aspects, including local loop unbundling

Preventing anti-competitive conduct

Mandating infrastructure sharing and access to essential facilities for incumbent operators or operators with SMP is an important *ex ante* regulatory obligation that prevents anti-competitive practices.

Without such obligations, it is unlikely that incumbent operators who control essential facilities would have any incentive to offer access to these facilities on commercially fair terms and conditions at reasonable prices. Thus, infrastructure sharing enables competing operators – especially new entrants – to compete more effectively with incumbent operators who control a significant amount of infrastructure which it is not economically feasible to replicate.

Likewise, infrastructure-sharing agreements that are signed on a commercial basis between operators – even without any regulatory obligation – aim to achieve the economic and technical benefits of sharing and also to reduce the risk of interconnection disputes arising between operators.

2.6.4 Other aspects

Optimizing usage of scarce resources

Infrastructure sharing can help in optimizing the use of scarce and limited resources. For example, active sharing can optimize the use of spectrum, while passive sharing can foster efficient use of rights of way and help to access real-estate properties such as rooftop sites.

Bringing substantial environmental benefits

Furthermore, infrastructure sharing plays a prime role in protecting the environment, achieving sustainable growth, reducing consumption of resources (such as land, energy and raw materials) and reducing electromagnetic interference and radiation.

Infrastructure sharing can help in creating an environmentally friendly society by reducing the number of sites and telecom constructions and protecting the natural environment and landscape. In addition, infrastructure sharing can offer a way to overcome planning and other regulatory restrictions and to meet environmental concerns.

2.7 Country experience and case studies

Alternative model for common infrastructure in Turkey[55]

In May 2018, the incumbent operator Türk Telekom, the mobile operators Turkcell and Vodafone, the satellite and cable operator Türksat and the Turkish Competitive Telco Operators' Association (TELKODER) signed a cooperation protocol for the leasing of fixed electronic communication infrastructure.

This protocol was designed to help achieve the strategic objectives of the National Broadband Strategy and Action Plan for 2017-2020, such as expanding broadband and fibre infrastructure, boosting Internet usage and achieving "broadband from everywhere to everyone" faster. The joint use of fixed infrastructure will also play a crucial role in increasing the amount of investment flowing into the information and electronic communication sector. The main objectives and the benefits of the protocol are as follows:

- Ensuring effective utilization of infrastructure
- Minimizing civil-engineering costs (the major cost element of infrastructure), through the protocol and bilateral agreements
- Accelerating new investments
- Preventing duplicate investments and rapidly widening infrastructure coverage
- Better addressing environmental issues through the joint use of one fixed infrastructure
- Instilling synergy and a culture of cooperation among all stakeholders
- Improving infrastructure, both in national and international terms.

All these would be addressed by non-discriminatory commercial agreements open to all operators and based on long-term lease contracts. The general approaches are as follows:

- In locations with existing infrastructure, favourable prices will be offered for a long-term leasing commitment.

[55] ITU-D SG1 Document 1/233 from Turkey

- In areas without suitable infrastructure, Türk Telekom will extend its existing network to meet the new coverage areas requested. It will own all of the infrastructure under this scheme. Incremental CAPEX requirements will be financed by the operator(s) requesting the new infrastructure, without impacting on Türk Telekom's cash flow. In return, these operators will have a "right-of-use" in respect of the newly built passive infrastructure.
- The terms of the first "pilot" project will be considered as the "main model".

Türk Telekom and Vodafone signed an infrastructure lease contract in the capital Ankara (Sincan district) as a pilot project aiming to ensure efficient use of existing infrastructure and to speed up new investment. The project was launched and completed in the second and fourth quarters of 2018, respectively. Under the pilot project, the incremental CAPEX for the project was financed by Vodafone, Türk Telekom became the owner of the new infrastructure under the agreement, and Vodafone leases the infrastructure for a period of time with discounted prices in the locations with existing infrastructure. In the wake of this first pilot project, various projects for the leasing of fixed infrastructure are being evaluated.

In order to further operationalize the protocol, which is still being implemented as a pilot, it is foreseen that updating the right-of-way and facility-sharing legislation and improving the processes of municipal right of way, excavation and fees would prevent duplication of investments and help ensure that fibre technologies become more widespread and more easily accessible throughout the country.

To gauge take-up, the effects of the regulatory framework can be observed from the numbers, at the second quarter of 2019, revealed in the Turkish Information and Communication Technologies Authority (ICTA) 2019 Q2 Market Data reports and Türk Telekom's Investor Presentations:

- The number of fibre subscribers rose from about 220 000 at Q3 2011 to more than 2.9 million at Q2 2019. FTTH/B network homepass coverage in Turkey climbed from less than 2 million at end 2011 to approaching 8.5 million at Q3 2018.
- The total length of all operators' fibre has reached 364 549 km, up 8 per cent from 338 068 km a year ago.
- Türk Telekom has 289 197 km of fibre in all 81 cities of Turkey. Of this, 124 196 km has been used as trunk and the remainder for access.
- Alternative operators have 75 352 km of fibre, of which 43 000 km belongs to Superonline in 21 cities.

Hence, following the ICTA Board's Decision 2011/511, the numbers relating to NGA-fibre technology have also increased in parallel with the increase in number of subscribers. On the other hand, the fibre networks and services were not yet regulated with wholesale market analyses as at end 2018, and analyses for the wholesale broadband markets are ongoing.

Infrastructure sharing initiatives in Brazil[56]

In Brazil, a country of vast geographical area, viable infrastructure competition is essential. It would thus be very important to take this into account when developing all public policies to promote the expansion of telecommunications/ICTs in the country.

[56] ITU-D SG1 Document 1/217 from Brazil

Standout infrastructure-sharing policies

Among public policies that have fostered the sharing of infrastructure and networks, the following stand out:

- Decrees in respect of the Plano geral de metas para a universalização (PGMU) (General plan for universal service goals) for the PSTN, which promoted universal and equal access to the fixed-telephone service and subsequently the broadband service for the majority of the country's population. This made it necessary to use electricity poles to provide the service.
- Spectrum bidding documents for the personal mobile service (PMS) that obliged players interested in radio frequencies to purchase frequencies not only in the areas in which they could generate economic returns, but all over Brazil, and included service obligations in respect of all Brazilian municipalities. This made it necessary to share mobile base stations in order to provide the service.
- Brazil implemented some infrastructure sharing, including radio base station sharing, RAN sharing, national roaming, mobile virtual network operators (MVNOs) and the sharing of electricity distribution poles.
- Following promulgation of the Antenna Law (Law 13,116/2015), later regulated by the NRA, the sharing of excess capacity in passive infrastructure is mandatory, except where there are justified technical reasons for refusing. Moreover, the obligation established takes into account aspects of urban, historical, cultural and touristic conservation. The aim was to find a way of organizing municipalities without unnecessary redundancy of infrastructure.

Increased use of RAN sharing, benefiting ICT sector development

Radio access network (RAN) sharing has been increasingly employed on account of its clear benefits for development of the sector, as a means of optimizing use of the scarcest resource the sector possesses: radio frequencies. Radio-spectrum sharing throughout the spectrum is one of Anatel's spectrum-management goals.

Spectrum sharing is regulated by the Regulation on use of the radio-frequency spectrum[57] and the regulations governing the conditions of use of radio frequencies, in order to guarantee efficient, rational and adequate use of the resource, within the bounds of technical feasibility, public interest and economic order.

National roaming is also established in infrastructure-sharing bidding documents, and competition is guaranteed within municipalities when the incumbent does not have an economic or financial advantage over new entrants. This gives the consumer the power to choose a different operator from the sole operator who is physically present at the location.

Regulation has also been adopted for MVNOs. This allows the existence of a greater number of PMS providers in the market, with innovative offerings in terms of facilities, conditions and relationships with mobile users. Establishing a larger set of PMS providers is conducive to competition within the sector, which can bring down the end costs for users.

Joint regulations for sharing electricity distribution poles

The sharing of electricity distribution poles by telecommunication/ICT service providers has always been a sensitive issue for the sector, since they constitute an essential infrastructure for the construction of networks, besides obviously being essential to the energy sector, too,

[57] Anatel. Resolution No. 671/2016 of 3 November 2016. *Regulamento de uso do espectro de radiofrequências*. [in Portuguese]

which uses them to distribute energy in municipalities. Thus, the Brazilian telecom and energy regulatory agencies have issued joint regulations to address the main issues of inter-sector relations and technical or commercial aspects.

It should be pointed out that, this being an essential infrastructure to support the construction of networks, the amount that electricity distributors charge telecommunication/ICT service providers for the use of each attachment point on the distribution poles directly affects the prices charged to users of the telecommunication/ICT service using the infrastructure.

This specific point is a constant source of debate between the sectors. It is important that the price be fair and equitable and that it not harm those involved: neither the distributors, who need to receive a reasonable rent value, nor the providers, who should not have to pay an exorbitant amount for use of the infrastructure.

Therefore, all the forms of infrastructure sharing observed in Brazil will entail a regulatory burden, to either compel or promote some sharing, but the regulator nevertheless aims to establish the necessary basis for infrastructure sharing in such a manner as to benefit of all stakeholders.

More importantly, it is always advisable to foster competition in the sector, thus favouring the end consumer, either through an improvement in the quality of the service provided or through a possible reduction in the prices charged by the sector.

Spectrum sharing

Brazil has a total of 5 570 municipalities. Of these, 4 411 have up to 30 000 inhabitants, for a collective total of 46 990 419 inhabitants. These municipalities are spread throughout Brazil, but a lot of them are in rural and remote areas. It should be noted that, as a result of the spectrum auction obligations referred to above, many municipalities would be underserved, i.e. by only one mobile-service provider.

To address that situation, and incentivize competition, bring down prices and increase service quality, the Brazilian regulatory agency has injected some spectrum-sharing obligations into its spectrum auctions. The obligations were imposed on service providers who were required to serve a municipality with fewer than 30 000 inhabitants. They referred to the authorization to share the auctioned spectrum in those cities with other service providers, two years after the auction and availability of the service in the municipality. As noted above, the spectrum sharing also involved other infrastructure sharing as well, which will be detailed below.

Infrastructure sharing – a necessity on the road to 5G[58]

It is estimated that 5G will call for five times more antennas than 4G; in the case of Brazil, to cover the whole country with 5G, more than 130 000 antennas will be required.

A comparison of the costs of construction and sharing of fibre cables, ducts, poles and towers shows that the cost of deployment is 10 to 200 times higher than the monthly cost of sharing the same structure. Moreover, the estimated investment required for 5G antennas to cover a country like Brazil is extremely high – between USD 3 billion and USD 7 billion (around 130 000 antennas with a unit cost of between USD 20 000 and USD 50 000). The CAPEX per km of duct is estimated to be USD 75 000, and the cost of sharing is estimated to be USD 40 to 60 per month. Thus, sharing infrastructure is an attractive alternative for cost savings.

[58] ITU-D SG1 Document SG1RGQ/218 from ADVISIA OC&C Strategy Consultants (Brazil)

The main benefit for an operator of launching its own infrastructure is coverage monopoly in certain regions. Nevertheless, trends in mobile telecommunication/ICT networks point to overlapping networks to serve the population: for instance, the three largest mobile operators in Brazil currently offer 4G almost all over the country (covering between 80 and 90 per cent of the population). Thus, infrastructure monopoly is no longer a competitive advantage, making the sharing option even more attractive.

Infrastructure sharing in Egypt[59]

In the past two decades, the ICT sector in Egypt has witnessed remarkable growth, as the Egyptian administration strives to support the development of the ICT sector through a bundle of measures to create the digital society, enabling government authorities to exchange and share information effectively and safely and enhancing the efficiency, quality and affordability of services provided to citizens.

The Egyptian telecommunication sector is not insulated from global industry challenges such as rapid change in consumer demand towards higher bandwidth and speed; limited spectrum and other scarce resources; difficulties in obtaining the required rights of way in some countries; shrinking levels of average revenue per user (ARPU); and increasing pressures from environmental groups to reduce the number of telecommunication sites owing to health concerns.

These industry challenges prompted the Egyptian Government to encourage the sharing of infrastructure as one of the main trends in network deployment. The National Telecommunication Regulatory Authority (NTRA) believes that infrastructure sharing can bring considerable benefits, including, but not limited to, fast network deployment, optimizing usage of scarce resources and reducing the cost of telecommunication services. Accordingly, NTRA is currently promoting infrastructure sharing through different approaches, which are briefly highlighted in the following sections.

Deployment of 4G mobile networks

In October 2016, NTRA approved a new regulatory framework for the Egyptian telecom market, including the provision of 4G, which serves to increase Internet speed, improve the quality of services and introduce new services for the benefit of all citizens.

In its efforts to ensure smooth implementation of this regulatory framework, NTRA has been cooperating effectively with all licensed operators to enable market players to capitalize on new wholesale and infrastructure leasing services such as fibre to mobile sites, infrastructure sharing, national roaming, etc. Such services are considered essential for the introduction of 4G services to the end user.

Pursuant to the 4G licence document, a mobile network operator is obliged to cover at least 85 per cent of the population with basic 4G services with its own network or by sharing infrastructure with other licensees. This gives mobile operators the right to negotiate and sign commercial infrastructure-sharing agreements between them on a reasonable, fair and non-discriminatory commercial basis in order to roll out their networks and reduce costs. In addition, such infrastructure-sharing agreements have to be reviewed and approved by NTRA.

[59] ITU-D SG1 Document 1/325 from Egypt

National roaming

Besides this, national roaming is employed to accelerate the coverage of a new entrant until it establishes its own network. Usually, national roaming is an initial infrastructure-sharing mechanism implemented in the early stage of network deployment to enable new entrants to penetrate all geographical areas in the market using the existing operators' networks, while at the same time allowing existing operators to generate additional revenue streams from leasing their networks to new entrants.

Egypt has two success stories in this regard. The first dates back to 2006, when Etisalat, the third mobile operator, launched its 3G service, depending mainly in the first three years on national roaming agreements with the two existing mobile operators at the time (Orange and Vodafone). Secondly, in 2016, the fourth mobile operator, Telecom Egypt, signed national roaming agreements to launch 3G and 4G service using the other three mobile operators' networks while continuing to build its own network.

National roaming agreements in Egypt are subject to written regulatory approval before they come into force. NTRA not only ensures that such agreements encompass all technical, commercial and organizational aspects between the parties, but also that they are based on fair and non-discriminatory terms. Moreover, in case of dispute among network operators, NTRA can intervene in order to set national roaming fees on the basis of fair financial considerations and international best practices in this regard.

New licences for tower companies

Siting and building a new base station is a relatively complex and difficult process, requiring the permission and approval of various state agencies. Consequently, in the past few years, NTRA has granted five new licences for tower companies which allow them to build their own towers and lease passive infrastructure to multiple mobile operators sharing the same tower.

Tower sharing can substantially reduce CAPEX and OPEX for mobile operators, speed up network roll-out, improve coverage and help meet the capacity demands stemming from increased data traffic. It can also enable new players to join and leapfrog larger ones, and provide an opportunity for existing operators to consolidate or expand in markets that are already saturated or underserved.

Universal service projects

Infrastructure sharing is currently widely implemented in Egypt, and especially in its universal service projects. The government believes that all citizens have an equal right to access information and telecommunication services at affordable prices. Accordingly, Egypt's Telecommunication Regulation Law No. 10 of 2003 prescribes the establishment of a universal service fund to compensate operators for their provision of telecom service in economically unprofitable areas such as rural regions and roads.

Owing to the high cost of covering these rural areas and remote roads, NTRA is currently encouraging mobile operators to share their active and passive infrastructure, especially in universal service projects. Sharing infrastructure among operators in these remote areas helps to ensure access to information for citizens countrywide. Moreover, infrastructure sharing is conducive to efficient management of the universal service fund, as it means more universal service projects can be funded with the same amount of government investment, which consequently benefits more citizens.

Sharing essential facilities

As described in §2.1 of this report, essential facilities are elements that are provided by a sole operator (or very few operators) in the market and that, on account of economic and technical limitations, cannot be replicated by other competitors, who nevertheless need these facilities as an important input to their retail services.

In Egypt, the incumbent operator, Telecom Egypt, provides essential facilities and wholesale services to other licensed network operators, including mobile, data and other companies. The incumbent operator's wholesale service portfolio includes several services, such as co-location, full unbundling, shared access, bitstream access, domestic transmission links, international call origination and termination, IP transit, fibre-to-the-site and, currently, fibre sharing.

One of NTRA's main responsibilities is to ensure fair access to these diversified wholesale services in order to allow competitors to enter the market, roll out services with fewer sunk costs, and offer competing services to end customers at affordable and competitive prices.

Accordingly, NTRA has obliged the incumbent operator to prepare its reference interconnection and access offer, clearly setting out a technical description of each service, the planning and operational procedures, and other commercial aspects including the price charged for each wholesale service. This offer is subject to periodic regulatory review, and NTRA can also intervene in case of dispute between network operators to hand down a final decision on the matter.

Chapter 3 – Consumer price evolution and impact on ICT service usage, innovation, investment and operator revenues

3.1 Impact of infrastructure and spectrum sharing on prices to consumers[60]

Recommendation ITU-T D.264 (Shared uses of telecommunication infrastructure as possible methods for enhancing the efficiency of telecommunications)[61] suggests that reductions in CAPEX and OPEX as a result of shared use of spectrum and/or telecommunication/ICT infrastructure could present an opportunity for mobile operators to increase efficiency in the use of telecommunication/ICT infrastructure and reduce tariffs for their subscribers. Report ITU-R SM.2404-0 (Regulatory tools to support enhanced shared use of the spectrum)[62] provides additional details on regulatory aspects of spectrum sharing.

According to GSMA, the goal of infrastructure-sharing initiatives is to widen access to high-speed Internet in the most remote regions and lower the price of mobile communications.

The will of administrations to improve access to telecommunication services may be reflected in their infrastructure- and spectrum-sharing practices. In 2018, out of 195 countries that responded to questions on sharing of infrastructure and spectrum in the ITU Tariff Policies Survey, 119 administrations reported that in their countries there was an obligation to share infrastructure (towers, base stations, poles, ducts, etc.), while 32 administrations practised spectrum sharing.

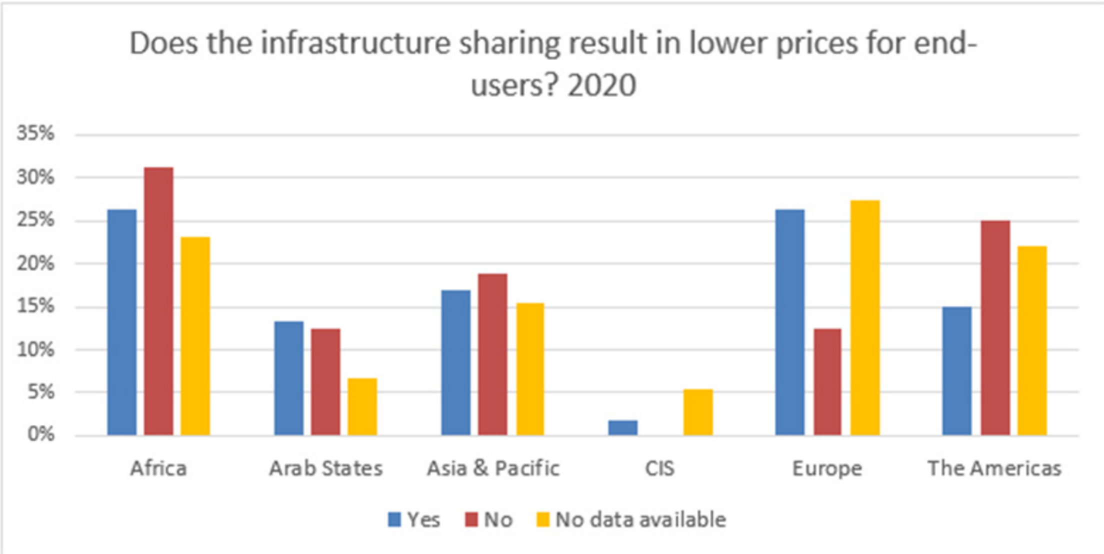
Every year, ITU sends the ITU Tariff Policies Survey to each Member State's administration. The results are available in the ICT Eye database.[63] One of the survey questions is intended to ascertain whether sharing infrastructure and spectrum results in lower prices for end users. Infrastructure and spectrum sharing enables operators to make CAPEX and OPEX savings, and these potential savings reduce the cost of infrastructure, which in turn can lead to improvements in terms of the price of telecommunication services. The Union's ICT Eye database reports the survey results on infrastructure development and sharing.[64] The statistics for 2020 show that 33 per cent of countries that took part in the survey said that infrastructure sharing had resulted in lower prices for end users; 10 per cent said the opposite. However, several countries in each region said that data were not available or that national regulatory authorities did not monitor prices. Europe and Africa (both 26 per cent), followed by Asia and the Pacific (17 per cent),

60 ITU-D SG1 Document SG1RGQ/199 from Madagascar
61 Recommendation ITU-T D.264 (04/2020), on shared uses of telecommunication infrastructure as possible methods for enhancing the efficiency of telecommunications.
62 Report ITU-R SM.2404-0 (06/2017), on regulatory tools to support enhanced shared use of the spectrum.
63 ITU. ICT Eye database.
64 ITU. ITU-D. Infrastructure Development and Connectivity Portal.

were the regions where awareness of the positive impact of infrastructure sharing on price was greatest.

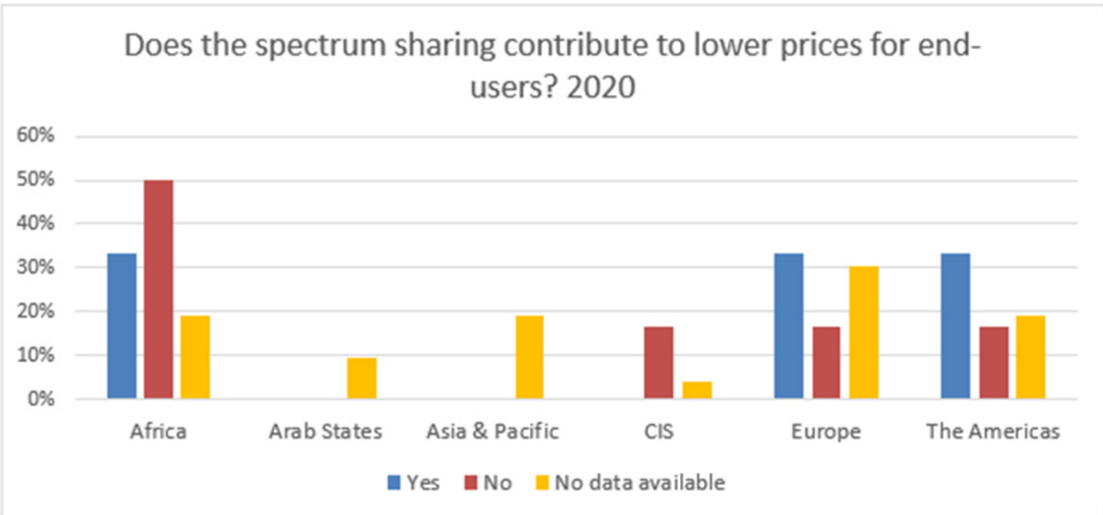
As for spectrum sharing, few data are available as the practice of spectrum sharing is relatively uncommon (see Figures 3.1.1 and 3.1.2).[65]

Figure 3.1.1: Does infrastructure sharing result in lower prices for end users? Distribution by region, 2020



Source: ITU Tariff Policies Survey

Figure 3.1.2: Does spectrum sharing contribute to lower prices for end users? Distribution by region, 2020



Source: ITU Tariff Policies Survey

65 ITU. ICT Eye database.

3.2 Impact of bundled telecommunication/ICT services on ARPU ("zero rating")[66]

Tariffs for early generations of mobile communication services were based on a prepayment model, with per-minute or per-second billing for voice traffic and per message billing for SMS, with or without a monthly subscription fee. This kind of tariff was widely used during the development of 2G mobile communication, when voice services accounted for the lion's share of the volume of telecommunication/ICT services provided. New generations of mobile communication, together with the subsequent decrease in the share of consumption of traditional mobile services (voice services) and the increase in the share of consumption of value-added mobile services, including mobile broadband, made it necessary for mobile operators to reconsider approaches to the design of tariffs for mobile services. In particular, this prompted the widespread introduction of bundle tariffs, charging a subscription fee for a specified volume of services.

The process of tariff modernization towards the emergence of convergent tariffs has also been influenced by the partial consolidation of mobile- and fixed-broadband access models, the emergence of additional services such as mobile television, the spread of various OTTs and the transition to large operator business models (from mobile operators to multiservice operators).

During the Webinar on the economic implications of COVID-19 on national telecommunication/ICT infrastructure (see **Annex 7** to this report), the representative from Türk Telekom reported how the evolution of demand towards bundles, including notably fixed broadband, during the COVID-19 pandemic had prompted the company to review revenue forecasts upwards.

Convergent tariffs

This type of tariff involves moving from a model whereby individual services are provided by operators offering a single type of communication service (for example, a mobile operator) to one in which a number of different services are supplied for a unified bundle tariff. The most common models are:

- voice services + SMS (basic bundle tariff, typical for 2G mobile communications);
- voice services + SMS + mobile broadband (more contemporary bundle tariff, typical for 3G mobile communications);
- voice services + SMS + mobile broadband + mobile television (contemporary bundle tariff, typical for at least 4G mobile communications);
- voice services + SMS + mobile broadband + fixed broadband + television (contemporary convergent bundle tariff, typical for at least 4G mobile communications and optical fibre communications).

Targeted tariffs

Unlike the above tariff model involving a subscription fee for a set of services (voice services + SMS, or voice services + SMS + mobile-broadband access), which in essence is an amalgamation of tariffs corresponding to different volumes of the services provided, greater use has recently

66 ITU-D SG1 Document SG1RGQ/81 from the Russian Federation

been made of targeted tariffs, in the following categories (some examples are provided in §3.7 of this report):

- Tariffs according to device, e.g. smartphones, tablets and mobile broadband routers.
- Tariffs according to type of service, e.g. voice services or data transfer. For example, the operator PJSC MTS[67] uses such a categorization to select the optimal tariff for voice calls or for Internet access.
- Tariffs according to content, e.g. music, video, social networking or messaging. Tariffs in this category are often supported by "zero rating", meaning that Internet traffic for some types of content is unlimited.
- Tariffs according to territory, which aim to provide primarily voice services for subscribers in different countries.

Custom tariffs

Custom tariffs allow the subscriber to choose the bundles of voice services and data traffic that suits him/her personally. For example, in the Russian Federation, the operator Tele2 offers the option to build such bundles on its website and, if necessary, to convert voice traffic to data traffic and vice versa via its mobile application.[68]

Interactive promotional offers

In addition to the above-mentioned types of tariffs, operators can provide interactive promotional offers whereby a subscriber can access additional bundles of services or particular content for free under specific conditions.

Influence of modern tariff models for telecommunication/ICT services on the services market

The Russian Federation's experience in introducing modern tariffs for telecommunication/ICT services on the market shows that the implementation of convergent tariffs increases the sustainability of the subscriber base, as well as ARPU. Currently, all significant Russian operators have implemented tariffs aiming to provide telecommunication/ICT services for entire households. The household receives multiple services from a single operator at a lower price than they would pay to purchase fixed-broadband, mobile and television services separately. This also simplifies troubleshooting, with all telecom/ICT service issues being handled by the one operator's technical support desk.

For individual users, real-time customized tariffs can be the most effective solution, geared to the subscriber's needs in various life situations.

The Russian Federation's mobile market grew by 3.4 per cent in 2017 compared with 2016, which was the strongest growth recorded since 2013, against the background of a fall in 2014-2016.[69] This growth confirms the efficacy of using the tariff models described.

67 Public joint-stock company MTS. Mobile tariff and subscription catalogue. [in Russian]
68 Tele2. Tariffs. Build your tariff. [in Russian]
69 Beeline. Russia's communications market in 2017. [in Russian]

3.3 ICT price baskets

Whenever assessing the affordability of ICTs, and/or the impact of different regulatory regimes, such as for example infrastructure sharing, on affordability, it is imperative to define the appropriate metrics. These are of major importance, first in order to understand which prices are actually relevant for end users and secondly to allow international comparisons of ICT affordability.

ITU price data are collected in the fourth quarter of each year. Except for data on mobile-broadband prices, which are collected by ITU directly from operators' websites, all data are collected through the ITU ICT Price Basket questionnaire, which is sent to the administrations and statistical contacts of all 193 ITU Member States.[70]

A key issue in this process is that different operators may charge different retail prices. This is addressed by ITU by collecting prices from the operator with the largest market share. In the ISP market, however, the dominant market share is not always clearly identifiable, so ITU collects prices offered by the (former) incumbent telecommunication operator. In some cases, especially when prices are not clearly advertised or are described only in the local language, and when operators do not respond to queries, alternative operators are chosen.

All prices used to construct the different price baskets are converted into USD using the International Monetary Fund (IMF) average annual rate of exchange, and into a purchasing power parity (PPP) value using World Bank conversion factors. Prices are also presented as a percentage of countries' monthly gross national income (GNI) per capita (p.c.) using GNI p.c. values from the World Bank (Atlas method) or the latest available year adjusted with the international inflation rates. This is essential for better understanding of the impact on affordability of ICTs.

Not only are price baskets indispensable, one also needs to have a range of them, as different baskets can have different relevance/impact for different countries or regions, or different demographics within these regions.

ITU collects three key ICT price baskets:[71]

- The mobile-cellular sub-basket
- The fixed-broadband sub-basket
- Mobile-broadband prices.

Table 3.3.1. below compares the three ICT price baskets for developed, developing and least developed countries (LDCs), and at world level.

The immediately striking feature is the differences in affordability: the fixed-broadband basket costs 1.4 per cent of the GNI p.c. in the developed countries, as against 54.4 per cent in the LDCs. Since these are averages, it is obvious that people on lower incomes in the LDCs would probably have to spend nearly their entire per capita incomes to afford fixed broadband.

Differences in the mobile-cellular basket are much smaller, but it still represents a percentage of GNI p.c. which is 10 times higher in the LDCs compared to the developed countries; and the price of mobile Internet access, assessed through the mobile-broadband prepaid handset-based

[70] ITU. ITU data. ICT Price baskets (IPB).
[71] This section is based on ITU's own ICT price-basket methodology.

(500 MB) basket, is more than 17 times higher in LDCs than in developed countries in terms of GNI p.c.

Table 3.3.1: ICT price baskets for developed, developing and least developed countries, and at world level, 2018

Countries	Developed	Developing	LDCs	World
Fixed-broadband basket				
% of GNI p.c.	1.4	42.7	54.4	39.2
USD	27.1	23.2	25.8	25
PPP$	31.7	42.7	54.4	39.2
Mobile-cellular basket				
% of GNI p.c.	1	4.5	9.8	3.4
USD	15.8	11.1	8.5	12.6
PPP$	20.1	20.7	20.2	20.5
Mobile-broadband prices, prepaid handset-based (500 MB)				
% of GNI p.c.	0.6	4.8	10.4	3.6
USD	11.5	8.4	7.1	9.3
PPP$	13.5	16.7	16.2	15.7
Mobile-broadband prices, postpaid computer-based (1 GB)				
% of GNI p.c.	0.8	6.3	14.8	4.6
USD	15.4	13.2	12.3	14.2
PPP$	17.3	25	26.1	22.5

The European Union approach[72]

In the European Union, countries have mainly used the methodology defined by the European Commission.[73] In October 2018, BEREC published methodological guidelines proposing a series of changes or improvements to the existing methodology, as follows.[74]

Definition of convergent fixed-mobile baskets

Even though the increasing trend towards users' purchasing packages (e.g. a combination of fixed telephony, fixed broadband and even pay TV) was already covered in the European Commission's methodology, the latter did not include convergent fixed-mobile packages.

[72] ITU-D SG1 Document 1/281 from Axon Partners Group Consulting (Spain)
[73] European Commission. Shaping Europe's digital future. Fixed broadband prices per country (as of February 2015) and Mobile Broadband Prices in Europe 2017.
[74] BEREC. European benchmark of the pricing of bundles – methodology guidelines (Document BoR (18) 1714). October 2018.

As reported by BEREC, this type of package has been gaining ground in Europe, with 34.9 per cent of fixed-broadband lines being sold in combination with mobile services.

BEREC proposes to adopt a "household" approach, which measures the price associated with both the mobile and fixed telecommunication services sought by typical households (baskets). Annex 5 to this report includes a description of the methodology proposed, as well as a list of proposed baskets.

For the purposes of selecting the prices associated with households, BEREC proposes the lowest-price option, taking into account both convergent tariffs and combinations of non-convergent tariffs, even if this means combining the tariffs of different operators.

Review of basket consumption parameters

The BEREC report proposes to review the household basket consumption parameters (e.g. fixed-broadband connection speed, maximum mobile-broadband data consumption, voice consumption, etc.). In the analysis, however, BEREC does not propose specific consumption values, simply that these be updated using the most recent data possible.

Review of other aspects of the methodology

Lastly, BEREC proposes various changes to several aspects of the methodology in terms of contract duration, discount rate, selective discounts and calculation of country result.[75]

3.4 New business models for the provision of accessible and affordable ICT services to achieve the Sustainable Development Goals (SDGs) and World Summit on the Information Society (WSIS) action lines

The international Internet connectivity model using IXPs described in §2.1 could provide relevant expected results for the fulfilment of WSIS Action Lines 2 and 6, especially in relation to the affordability of Internet access.

In particular, under WSIS Action Line 2 (Information and communication infrastructure), one of the expected results of Outcome J (Optimize connectivity among major information networks by encouraging the creation and development of regional ICT backbones and Internet exchange points, to reduce interconnection costs and broaden network access) is "Promoting the establishment of national and regional Internet exchange points (IXPs)", and this is addressed by ITU activities on "Assistance for the establishment of Internet exchange points (IXPs) in regions/countries".

Likewise, an expected result of Outcome K (Develop strategies for increasing affordable global connectivity, thereby facilitating improved access. Commercially negotiated Internet transit and interconnection costs should be oriented towards objective, transparent and non-discriminatory parameters, taking into account ongoing work on this subject) is "Promoting the development,

[75] It is proposed that contract duration be reduced from 36 to 24 months, a discount rate of zero be applied in order to distribute non-recurring costs and thus maintain the present net value, and selective discounts not be applied to voice and/or SMS traffic associated with certain contacts (e.g., frequent contacts); and two options are proposed for country result: simple average for each operator, or weighted average based on market share. BEREC also comments on a third option (weighted average based on number of users per tariff plan), but proposes that this not be used.

as appropriate, of national, subregional and regional IXPs, subject to national decision", and this is addressed by ITU activities on "Affordable global connectivity".

Finally, under WSIS Action Line 6 (Enabling environment), in the first item of Outcome C, governments are invited to "facilitate the establishment of national and regional Internet exchange centres" and the results of activities in this area include "A more effective use of Internet through … the deployment of facilities such as Internet exchange points (IXPs) to make better use of the infrastructures at the regional level…" and "Increased capacity in Member States through the development of guidelines, resources and material to facilitate the establishment and running of national and regional Internet exchange points".

All these actions and initiatives directly address SDG 9 Target 9.c (Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020).[76]

3.5 Methods to encourage the adoption and use of advanced ICT services

To encourage the adoption and use of advanced ICTs by operators, regulatory authorities may implement a number of economic mechanisms. For example, the regulator could allow operators access to licences through a simplified procedure, or compensate some of the operator's CAPEX for infrastructure development. Also, implementation of new ICTs could be incentivized by reducing spectrum fees.

For example, the methodology for calculating one-time and annual spectrum fees in the Russian Federation contains specific coefficients to take account of technology relevance and socio-economic effect. Fees for the same radio station using the same frequency range in the same territory may vary by a factor of between 3 and 10 depending on the technology used and the services provided.[77]

Section 4.8 of Report ITU-R SM.2012-6 (Economic aspects of spectrum management), on opportunity cost and administrative incentive pricing: simple, functional and linear equations, quantifies a model that optimizes use of spectrum by encouraging minimum spectrum bandwidth and maximum operating frequency, thereby reducing interference to other wireless applications.[78]

In a digital sector strategy prepared for the Cambridge and Peterborough Combined Authority (CPCA) in 2019,[79] Cambridge Wireless and Anglia Ruskin University explored a unique evidence base founded on primary research and secondary data, and extensive consultation with experts, in order to create and adopt the technologies of tomorrow, offer businesses exceptional talent at all levels and provide a highly networked ecosystem that has global impact, helping to establish the region covered by CPCA as the preferred base for firms from across the world. CPCA has set a target of doubling its economic output as measured by gross value added

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76 See Table A6.1 – Examples of use of IXPs to fulfil WSIS action lines, in **Annex 6** to this report

77 Roskomnadzor (Russian Federation). Methodology for calculating the amount of a one-time fee and an annual fee for use of the radio-frequency spectrum in the Russian Federation. [in Russian]

78 Report ITU-R SM.2012-6 (06/2018), on economic aspects of spectrum management.

79 Cambridge Wireless and Anglia Ruskin University. A Digital Sector Strategy for Cambridgeshire and Peterborough. 15 March 2019.

(GVA) over 25 years, which means an annual growth rate of 2.81 per cent, and the creation and widespread adoption of digital technology are essential to achieving this ambitious goal.

Networking has been identified as an essential feature underpinning the aim of creating and supporting widespread adoption of digital technologies. The astonishing growth of the Cambridge subregion has been enabled in part by a culture of business-driven networks, where local organizations nurture ecosystems of expertise and mutual support. The results of the digital strategy show that it is important to foster a similar approach, albeit adapted to the unique demands and business culture of individual districts, and suggested some of the practical steps that can be taken to quickly grow and support networking activity for the digital sector.

3.6 Trends in prices of telecommunication/ICT services

Case study: Service prices (ARPU) in Turkey[80]

When ARPU data for fixed voice broadband and mobile-broadband services in Turkey for 2011 have been adjusted for inflation, ceteris paribus, and are compared to ARPU data for 2018, it can be concluded that subscribers are now paying comparatively affordable prices for these services. A couple of points should be noted in this connection. Changes in ARPU over the years may have been attributable to a number of reasons. For instance, the components of the services might differ, or new technologies may have emerged, etc. There have also been other industry-specific circumstances, such as Türk Telekom PSTN subscriber numbers falling to one-third, or nationwide actions like special offers which aim to improve broadband penetration rates. These game-changing factors should be taken into consideration when making any comparison of price levels.

3.6.1 Impact of international mobile roaming on prices of ICT services at national level

Case study: Impact of international roaming on domestic market prices in the EU/EEA[81]

Prices for roaming in the EU and the European Economic Area (EEA) have been falling for years as a result of the regulatory measures imposed. The final phase of the regulations was approved in 2015, when the European Parliament and Council decided that retail roaming charges would cease to apply in the EU/EEA countries as from 15 June 2017 (the so-called "roam like at home" (RLAH) policy).[82]

These regulations were accompanied by a set of measures designed to ensure their sustainability:

- a limit on wholesale roaming charges;
- the possibility of applying a fair-use policy to prevent abusive use;
- the possibility of applying temporary derogations should the RLAH policy lead to domestic price increases.

[80] ITU-D SG1 Document SG1RGQ/238 from Türk Telekom A.S. (Turkey)
[81] ITU-D SG1 Document 1/277 from Axon Partners Group Consulting (Spain)
[82] European Union. EUR-Lex. Regulation (EU) 2015/2120 of the European Parliament and of the Council of 25 November 2015.

In December 2018, the European Commission published a report on the implementation of the regulations associated with the RLAH policy.[83] The report included an analysis of the effects of the RLAH policy on domestic market prices.[84]

According to the report, the historical declining trend in prices in the EU/EEA persisted following implementation of the RLAH policy.

Table 3.6.1: Evolution of retail price baskets (Feb. 2017 – Feb. 2018)

	100 MB, 30 calls	500 MB, 100 calls	1 GB, 300 calls	2 GB, 900 calls	2 GB, 100 calls	5 GB, 100 calls
Change in average EU price for voice and data baskets	-14%	-6%	-6%	-5%	-16%	-20%

	256 MB	512 MB	1 GB	2 GB	5 GB	10 GB	20 GB
Change in average EU price for data only baskets	-10%	-14%	-5%	-12%	-4%	-6%	-16%

Source: European Commission study: "Mobile broadband prices in Europe 2018"

Although retail prices decreased, the study identified a few examples of countries in which domestic retail prices increased:

- Voice and data baskets: 5 countries out of 17 exhibited price increases: Bulgaria, Ireland, Latvia, Malta and Sweden.[85]
- Data-only baskets: 5 countries out of 13 exhibited price increases: Croatia, Denmark, Estonia, Lithuania and Malta.[86]

The European Commission also concluded that the trends observed did not present major deviations from previous years.

3.7 Country experiences and case studies

Telecommunication/ICT services tariffs. Experience of the Russian Federation[87]

Examples of different types of modern telecommunication/ICT service tariffs in the Russian Federation are presented below.

Convergent tariffs

The "All-in-One" tariff, which was launched by the public joint-stock company (PJSC) VimpelCom (the Beeline brand) in 2016, is an example of convergent tariff in the Russian Federation.[88]

[83] European Commission (2018). Shaping Europe's digital future. Report on the implementation of the Regulation on roaming on public mobile communications networks within the Union.
[84] Other aspects covered included compliance with the new regulations, the effects of RLAH on end users, the effects of RLAH on operators, and other effects of RLAH on domestic markets.
[85] Countries in which prices decreased: Austria, Belgium, France, Germany, Hungary, Italy, the Netherlands, Poland, Portugal, Romania, Spain and the United Kingdom
[86] Counties in which prices decreased: Finland, France, Ireland, Italy, the Netherlands, Poland, Sweden and the United Kingdom
[87] ITU-D SG1 Document SG1RGQ/81 from the Russian Federation
[88] Beeline. Tariffs. "For you, your family and your home". [in Russian]

This tariff initially proposed a single subscription fee (less than USD 10 per month) for mobile communication, with a range of data traffic volumes, minutes of voice communication and numbers of SMS. The tariff also offered fixed-broadband access with a bandwidth up to 40 Mbit/s for a nominal charge of RUB 1 (USD 0.016) per month. Pay-IPTV services, an antivirus software licence and rental of a Wi-Fi router were additionally available. The tariff has since been updated. The cost of fixed access and television is now included in the basic tariff. Wi-Fi router rental is provided for free in premium versions of the tariff, as well as the possibility to connect additional mobile phone numbers, thus allowing consumers to share the volume of data traffic, minutes of voice communication and numbers of SMS supplied within the tariff.

Targeted tariffs

Targeted tariffs according to territory is a very popular category of tariffs in the Russian Federation because it serves to reduce the cost of voice communication between the CIS countries. PJSC Megafon proposes the "Warm welcome" bundle tariff, which along with a range of volumes of data traffic, minutes of voice communication and numbers of SMS, offers cheaper prices for calls to Tajikistan, Uzbekistan, Ukraine, Kyrgyzstan, Kazakhstan and China.[89]

Interactive promotional offers

A promotional offer "Gigabytes for steps" launched by PJSC VimpelCom (the Beeline brand) is an example of interactive promotions in the Russian Federation. Under this promotional offer, the subscriber receives a bonus 100 Megabytes of Internet traffic for free by completing 10 000 steps per day. Steps are counted using the Health Kit (the "Health" app for IOS devices) or Google Fit applications.[90]

Social tariffs[91]

In April 2019, PJSC VimpelCom (the Beeline brand) announced a special mobile tariff package for Moscow, called the "Social package", for categories of the population entitled to preferential treatment. The package includes free online sign-language interpretation and unlimited traffic on the portal of the mayor and municipal government of Moscow. In June 2019, the offer was extended to the rest of the country. Another operator, Tele2, has launched its own tariff package, called "Social". The package is intended for clients who are entitled to social assistance. It combines low rates, an optimized combination of services and the possibility of remaining reachable even when their account displays a debit balance, thanks to the "SOS package" option. More details on these tariffs may be found in **Annex 4** to this report.

89 Megafon. Tariffs – Warm welcome. [in Russian]
90 Beeline. Gigabytes for steps: Exchange steps for Internet and receive up to 3 GB of data a month! [in Russian]
91 ITU-D SG1 Document 1/318 from the Russian Federation

Chapter 4 – Trends in the development of mobile virtual network operators (MVNOs) and their regulatory framework[92]

The appearance on international telecommunication/ICT markets of mobile virtual network operators (MVNOs) offering mobile services using the network infrastructure of another operator on the basis of a licence for the provision of telecommunication/ICT services is becoming a standard feature for 2G and 3G mobile communications, and indeed for the new generations of mobile, 4G and 5G.

A mobile operator is classified as virtual when it uses the network infrastructure of another mobile operator to provide services to mobile subscribers and sell them under its own brand without creating a radio access network and without owning the rights to use of the radio-frequency spectrum. Therefore, the mandatory requirement for an MVNO is a licence to provide mobile services and an agreement with a mobile network operator (MNO) that makes available network infrastructure and allocated spectrum for the provision of services.

The reasons for the large-scale entry of MVNOs in national mobile markets can be found in the following trends:

- infrastructure redundancy in mobile operators' radio access networks (full coverage of territories with 2G/3G/4G networks and future construction of 5G networks) due to the licence obligation imposing full coverage of the national territory;
- ability of MVNOs to operate in mobile communication segments without creating competition with the MNOs providing the network infrastructure and spectrum;
- high potential of the MVNO services market amid growing demand for mobile communications and IoT in the context of the transformation and development of the digital economy;
- the fact that there are many network infrastructure construction and usage scenarios in which MVNOs can provide mobile services and IoT at lower cost than MNOs.

4.1 Models of MVNOs

There are four main types of network operators in the MVNO ecosystem:[93]

- MNO – mobile network operator: Owns infrastructure and spectrum, provides services to customers and to business.
- MVNO – mobile virtual network operator: Does not own spectrum, partially owns/does not own infrastructure, provides a limited range of services to customers.
- MVNA – mobile virtual network aggregator: Aggregates small MVNOs to interact with an MNO on infrastructure and spectrum matters. Provides such services to business.

[92] ITU-D SG1 Document SG1RGQ/246 from the Russian Federation
[93] ITU-D SG1 Document SG1RGQ/81 from the Russian Federation

- MVNE – mobile virtual network enabler: Could be defined as an MVNA with more capabilities (can provide services to MVNOs such as billing, network element provisioning, administration, operations, operation support systems and business support systems (OSS/BSS)).

As regards business models, an MVNO could rent different parts of the value chain from an MNO, depending on the market situation and the MVNO's missions (see Table 4.1.1).

Table 4.1.1: MVNO business models

	Radio access	Core network	Applications and services	Customer care	BSS	Handset management	Marketing and sales
MNO	+	+	+	+	+	+	+
Full MVNO		+	+	+	+	+	+
Light MVNO			+	+	+	+	+
Service provider MVNO				+	+	+	+
Reseller MVNO							+
MVNE		+	+	+	+	+	

The core differences in the MVNO business models are as follows:

- A "reseller MVNO" can potentially offer its own value-added services, but otherwise has no assets in partnership with the underlying MNO. In particular, a reseller operator does not obtain ownership of the subscriber, infrastructure or SIM cards. The proprietary reseller model affords the MVNO the advantages of working under its own brand (or in conjunction with the MNO). The reseller is responsible for branding, sales and distribution costs, and shares revenue with the MNO partner. Example of a reseller MVNO: Non-telecommunication/ICT enterprises.
- A "service provider MVNO" also does not own the infrastructure. It may own network subscriber management platforms, application platforms and billing platforms. This production activity scenario allows the possibility of owning SIM cards and setting tariffs (prices for services) independently of the tariffs set by the MNO. As in the "reseller" model, a service provider MVNO can be independently branded or co-branded with the MNO. In this production activity scenario, the MVNO may also have ownership of its own subscriber base, so income may flow directly from the outgoing traffic from the provision of services. The virtual operator is responsible for the structure of wholesale tariffs for services, as well as for the costs of its own IT platforms (in addition to the costs of branding, sales and distribution network for the sale of services payable by the MVNO as in the reseller scenario). Example of a service provider MVNO: Digital television (DTV) broadcasters.
- A "light MVNO" does not have the option of owning the entire network infrastructure, but this model affords ownership of the client and the intelligent network platform; and even partial ownership of the VAS platform. The virtual operator's revenues come from both incoming and outgoing traffic, and in this scenario the MVNO is responsible for the same expenses as payable in the service provider model, e.g., tariff structures, IT platforms, branding, sales and distribution. Example of a light MVNO: Local/ethnic operators.
- A "full MVNO" enjoys all of the business advantages of the owner of the core network of a mobile operator, but also covers the costs of creating and operating all elements of its own

core mobile network. When choosing the full MVNO model, the virtual operator must also provide the required level of network performance and QoS in its network. Example of a full MVNO: Big new operators arriving on the national telecom market after all frequencies have already been auctioned/allocated.

4.1.1 Comparison between MVNO business model and OTTs[94]

The major content publishers have rendered digital technology invaluable by making information and knowledge available to all. Their capability to identify and locate the users of their content and to exploit AI to ascertain their interests, tastes and preferences in all areas have turned these personal data into a commodity of prime market value to OTTs. It only remained to massify the related market, which offshore virtual network operators have done by offering consumers "free" applications, such as voice over Internet Protocol (VoIP), immediate messaging (IM), streaming and videotelephony. The table below compares OTTs with MVNOs.

Table 4.1.1.1: Comparison between MVNOs and OTTs

No.	Characteristics	MVNOs	OTTs
1	Have their own customer access network	NO	NO
2	Can use network nodes	YES	YES
3	Offer services, thereby generating investment needs, on the MNO's network from which they have access to consumers	YES	YES
4	The applications offered can be substituted by applications from the relevant market	ALL	SOME
5	Collect payments directly from consumers	YES (in cash)	YES (in kind)
6	Enter into agreements with MNOs concerned to cover their amortization, operating and management costs	YES	NO
7	Are obliged to have a network operating licence	YES	NO
8	Like MNOs, are subject to national regulation	YES	NO

4.2 Regulatory framework in the field of MVNO

The regulatory framework pertaining to MVNO includes the following:

- General principle allowing use of the MVNO model enshrined in national legal documents
- Licensing matters (should MVNO use a general telecommunication service licence or acquire a specific one)
- Implementation of non-discriminatory access to telecommunication and non-telecommunication supplementary infrastructure (e.g., electricity)
- Mechanisms of interaction between MNO/MVNEs and MVNOs
- Obligations of MVNOs (e.g., QoS obligations).

The case study of Senegal in this area is contained in §4.5.

[94] ITU-D SG1 Document 1/147 from Tactikom-Africa (Senegal)

4.3 Commercial agreements in the field of MVNO[95]

A competition-based market is the order of the day, and regulatory frameworks for telecommunications/ICTs have been heading in that direction by design. Competition is considered a factor for growth, i.e., innovation.

Impact of MVNOs on price

The arrival of a new player (MVNO) in the market does not automatically change the price structure unless the NRA is inclined to work to that end by regulating wholesale prices. It has been observed in previous studies that competition has increased among mobile operators in countries where such a regulatory framework has been put in place: the number of operators in the market (MNOs and MVNOs) has risen and the price of basic products, such as voice and messages, has fallen. These outcomes contribute to objectives of consumer well-being.

Impact on products

If competition is not based solely on price, MVNOs may contribute to the development of a market in services, including a mobile-data market, by offering different sorts of innovative and bundled services. The latter may prove capable of getting the market moving again more quickly. This remarkable effect of MVNOs may bring added value to mobile data.

Impact on quality of service (QoS)

Having a larger number of operators results in innovative services that challenge the status quo and encourage the entire market to become more competitive. Consequently, all operators – both MNOs and MVNOs – have an incentive to improve what they can offer in terms of price, content, transparency and QoS.

4.4 Impacts of MVNO on market competition[96]

The arrival of a new player such as MVNOs improves market dynamics. Competition shakes up the market and revitalizes technical partners and service providers, in turn improving the mobile value chain.

Agreements between MNOs and MVNOs should focus on the potential benefits for the market. In this context, it is in the NRA's interest to step in. For greater flexibility, an MVNO may use two or more operators' networks, thereby becoming more competitive by virtue of the combined coverage secured by the two or more networks in question.

Competition should not be based on price alone; neither should it have a negative impact on trade opportunities or market investment. Competition should lead to innovation or the launch of a new service on the market.

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[95] ITU-D SG1 Document SG1RGQ/198 from Madagascar
[96] Ibid.

4.5 Country experience and case studies

Country case: Senegal[97]

The Government of Senegal, in order to continue with the process of liberalization of the ICT sector, has decided to grant authorizations to MVNOs, with the objective of increasing the ICT sector's contribution to GDP in Senegal and facilitating the arrival of new players to enhance competition in the ICT market.

Legal framework for MVNOs

The rigidity of the ICT regulatory framework in Senegal prevented new players from entering the telecommunication market. In 2017 and 2018, the framework was revised to make it more flexible in terms of the regulation applied to all ICT players, such as ICT operators and service providers, and to facilitate the entry of new players, in particular MVNOs, in certain market segments, in order to diversify the offer of ICT services and strengthen competition for the benefit of consumers.

Scope of intervention

In Senegal, MVNOs operate under a regime of prior authorization. This authorization allows "light" MVNOs to use the network of the host operator, which provides minutes of communications, amounts of SMS and wholesale Internet volumes.

After three years of operation, the "light" MVNOs can apply to the *Autorité de Régulation des Télécommunications et des Postes* (ARTP) (Posts and Telecommunications Regulatory Authority) to become a "full" MVNO, which involves revision of the licence agreement and specifications. This authorization is granted in accordance with national and international technical standards and the regulatory provisions in force in Senegal.

MVNO obligations

Continuity of service obligation:

Pursuant to Decree No. 2014-770 of 14 June 2014, the MVNO has the obligation to inform consumers and to ensure continuity of service.

Quality of service and confidentiality:

The MVNO is required to make the necessary arrangements to ensure QoS and to respect the service contract with its clients. To this end, it is required to:

- ensure neutrality of services, confidentiality and integrity of personal data, in conformity with current regulations;
- keep any information relating to customer privacy confidential and report it only in cases prescribed by law, and comply with the provisions of Law No. 2008-12 of 25 January 2008 relating to data protection;
- guarantee the right of any customer to object to the use of billing data for commercial prospecting purposes;
- take the necessary measures to deliver emergency calls free of charge.

[97] ITU-D SG1 Document 1/341 from Senegal [in French]

Obligation to be transparent and to maintain analytical accounting:

MVNOs operate under the conditions of transparency and fair competition in accordance with EU rules and current legislation. In Senegal, MVNOs must apply analytical cost accounting, with separation of activities. MVNOs freely set tariffs for services in accordance with the principles of equal treatment of users and cost-oriented rates. Tariffs for services shall be set without collusion with other operators, in order to maintain healthy market competition. ARTP may, however, require an MVNO to modify tariffs for services, promotions or terms of sale, if it appears that these offers do not comply with fair competition and pricing rules.

Other obligations:

- Submit the contract and any amendments concluded with the host operator to ARTP for approval
- Comply with the provisions of Law No. 2008-41 of 20 August 2008 on cryptology, including the supply, export, importation or use of cryptology services
- Provide technical and commercial assistance to customers, with a free customer service
- Register users at the time of subscription and establish a system for collecting and archiving registration data in accordance with current regulations.

Licence renewal

An MVNO licence may be renewed for an additional period of no more than five years, at the request of the MVNO, 12 months before the end of the authorization. ARTP notifies the MVNO of the conditions for renewal of the licence, or the reasons for refusal, no later than six months before the expiry date of the authorization. In deciding on renewal of the licence, ARTP will assess whether the MVNO has:

- fulfilled all obligations under the licence agreement and specifications;
- complied with the laws and regulations in force in Senegal.

Chapter 5 – Best-practice guidelines

5.1 Promoting appropriate infrastructure sharing

The following paragraphs summarize the key regulatory issues (set of recommendations) to be taken into consideration by NRAs when dealing with infrastructure sharing:

- Consider issuing guidelines or codes of conduct for infrastructure deployment, especially in greenfield areas, that ensure coordination of civil-engineering work and mandate the deployment of empty ducts for sharing in high-demand areas
- Develop regulatory guidelines that ensure infrastructure sharing takes place on a fair, transparent and non-discriminatory basis; such guidelines should clearly define sharing, standards, procedures for sharing requests, methods of infrastructure sharing, and guidelines for infrastructure cost (e.g. cost-based pricing applied in some cases for enterprises with significant market power)
- Ensure that infrastructure-sharing agreements do not contain exclusivity clauses prohibiting operators from concluding similar agreements with third parties
- Establish a database for all elements that are available for infrastructure sharing and make this list available for all network operators in order to facilitate infrastructure sharing among them
- Consider licensing new market players who set up passive infrastructure elements that can be used by other operators, such as mobile tower companies
- Review and facilitate the procedures for granting rights of way, coordinating common approaches and avoiding disparities in administrative formalities due to local or regional rules
- Encourage commercial negotiations among market players to conclude proper infrastructure-sharing agreements; in the case of access to essential facilities, however, there is a need for clear regulatory intervention to ensure fair access to essential facilities rather than leaving this aspect to commercial negotiation between operators
- Implement a proper, efficient mechanism for dispute resolution that settles disputes within a reasonable time-frame; in addition, develop the other necessary enforcement tools to ensure successful adoption of and compliance with infrastructure-sharing regulations
- Review wholesale and infrastructure-sharing prices regularly to ensure that price (including both one-off and recurrent fees) and non-price terms and conditions are not a barrier to sharing; prices for shared facilities should strike the right balance between encouraging infrastructure sharing and investment incentives, based on specific national circumstances
- Consider the introduction of incentives (e.g. regulatory exemptions or financial subsidies) for market players who implement infrastructure sharing in order to expand and deploy networks in rural, remote and underserved areas
- Cooperate with other governmental authorities and utilities providers to implement infrastructure-sharing initiatives between telecom networks and other utilities such as gas, electricity, water and sewage infrastructures
- Support more effective use of Internet through the deployment of facilities such as Internet exchange points to make better use of infrastructures at the regional level
- Increase regulatory capacity, through the development of guidelines, resources and material to facilitate the establishment and running of national and regional Internet exchange points
- Facilitate and incentivize the emergence of fair and non-discriminatory internal governance at Internet exchange points, based on cost-sharing agreements, membership fees, peering rules and cooperative memberships

- Contribute to the ITU Interactive Broadband Maps,[98] adding network links from all regions, and use them to disseminate information on national and regional backbone connectivity (optical fibre, microwave links, satellite earth stations and Internet exchange points)
- Contribute to and use the results of ITU's ICT Tariff Policies Survey on the ICT Eye platform, in order to show and adopt best practices in infrastructure sharing and regulatory approaches
- Facilitate the interconnection of local, regional, national and international multilateral data-exchange infrastructures
- Incentivize and promote fair conditions for interconnection of national research and education networks s to regional Internet exchange points, in order to reduce the costs of disseminating research and education activities
- Develop skills and use digital technologies, data analysis and artificial intelligence in order to assess the rapid evolution of the critical shared infrastructures connecting telecommunication/ICT networks and over-the-top (OTT) providers and to avoid applying outdated regulatory approaches to markets when they have already changed
- Weigh up potential social and financial efficiencies from infrastructure sharing against possible competitive concerns arising from the decrease in network competition.

5.2 Determining appropriate wholesale charges

Determining appropriate wholesale charges is a complex but very common task for a telecommunication regulator. Despite the variety of methodological approaches that can be followed, there is a clear trend towards cost models (whatever the final option chosen), which are widely used in one form or other in almost all the countries of the world.

Once the decision to build a cost model is taken, there is a need to decide on the particular methodology to be followed. We have observed that, on a number of aspects, there are clear regional or in some cases even global trends (see §1.4 and **Annex 1**). Therefore, it is important to refer to international practice in order to identify the best choice. Nonetheless, it should not be forgotten that every country is different and, thus, the methodological options should be carefully selected on the basis of local realities and specificities so as to achieve the right balance in line with prevailing public policy and regulatory objectives (e.g., promoting competition, encouraging investment).

Additionally, the development of a cost model is known to be a long and complex project that involves several stakeholders with conflicting interests. Therefore, proper advance planning of the activities, the level of interaction with stakeholders (and the public) and the timeline is crucial for successful and smooth implementation. There are plenty of sources cited throughout this document, in international practice and in the Guidelines on cost modelling that can be reviewed as illustrative references in respect of how to lead and organize this kind of project.

98 ITU's Broadband Maps are a cutting-edge ICT-data mapping platform taking stock of national backbone connectivity: optical fibres, microwave links, satellite earth stations and IXPs as well as other key metrics of the ICT sector.

Chapter 6 – Conclusions

Work undertaken in the ITU-D study period 2018-2021 has underlined the continuing importance of considering economic aspects in national telecommunications/ICT.

With the emergence of new types of telecommunication enterprise, such as MVNOs, and the convergence of traditional telecom businesses, regulators and operators are having to adapt their policies and strategies to this new digital reality. Finding suitable cost and governance models and using relevant regulatory tools such as infrastructure sharing should be primary goals for NRAs in order to help their national markets thrive, as shown in contributions received from both NRAs and operators and considered by the Rapporteur Group for Question 4/1 in the current study period.

At the same time, further global forces pushing towards increased digitalization, as well as national economic and global emergencies like the COVID-19 pandemic, are throwing up many new relevant issues that call for additional study and investigation in the next ITU-D study period.

Annex 1: Regulation of interconnection charges in Paraguay[99]

Introduction and background to the Paraguayan telecommunication market

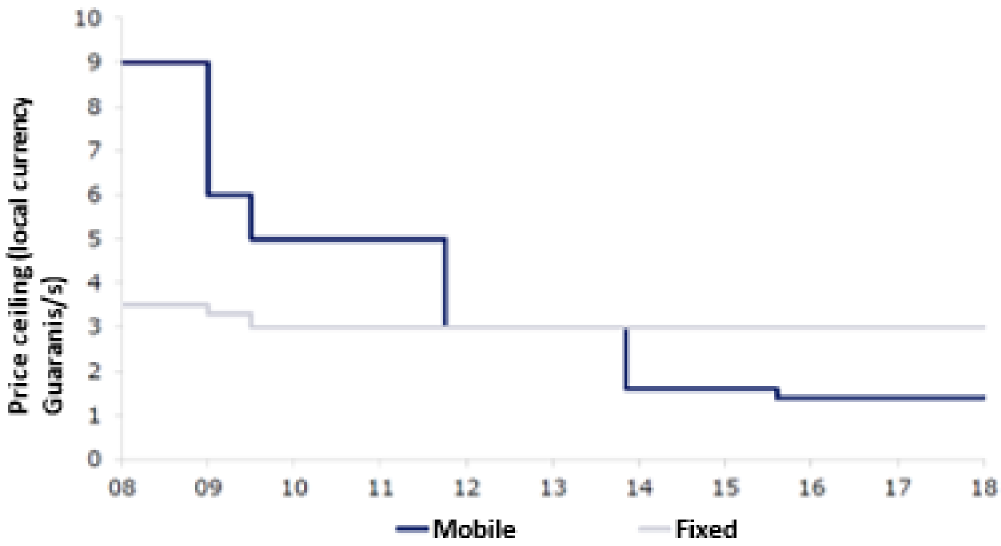
The Paraguayan telecommunication market has four mobile-network operators (Tigo, Claro, Personal and Vox) and one fixed-telephone operator (Copaco).[100]

One of the features of local regulations governing interconnection has been to delegate the setting of interconnection charges for the fixed (Copaco) and mobile (Tigo, Claro, Personal and Vox) services. The rationale was that costs would be incremental and representative, proposed to operators by an efficient operator; although the telecom regulator, CONATEL, reserved the possibility of regulating such charges in the event of disagreement. In fact, experience shows that the operators never established the applicable interconnection charges through such agreements, but it was CONATEL that took steps to progressively reduce these charges.

Need for regulation of fixed and mobile interconnection charges

The specific features of local regulations meant that interconnection charges in Paraguay were updated less frequently than usual. In particular, in early 2018, it was observed that fixed interconnection charges had remained constant since 2009, as illustrated below:

Figure A1.1: Evolution of fixed and mobile interconnection charges in Paraguay since 2008



In addition, since the costing exercises for setting applicable charges carried out in the sector were not very transparent to CONATEL, it was extremely difficult for it to understand the factors and assumptions taken into account for quantifying long-term incremental costs.

As a result, CONATEL decided that it was necessary to have a costing tool which would furnish information on the incremental costs of providing fixed and mobile interconnection services.

99 Document SG1RGQ/144 from Axon Partners Group Consulting (Spain)
100 There are also operators providing other fixed services, such as Internet or television, like Tigo or Claro.

Involvement of ITU

With a view to helping CONATEL achieve its regulatory objectives, ITU managed an international bidding process through which a consulting firm (Axon Partners Group Consulting) was selected. The project, which was carried out between January and June 2018, was designed to support CONATEL in reviewing its regulatory and legal framework, as well as in determining the increased costs of mobile and fixed interconnection services using a cost model.

ITU assigned a specific team that assisted CONATEL as from the project conceptualization stage, then with preparation of the bidding documents, budgetary advice and support in evaluation of the bids received, right through to the project finalization stage, with presentation and approval of the results by CONATEL's presidency.

Furthermore, the ITU team:

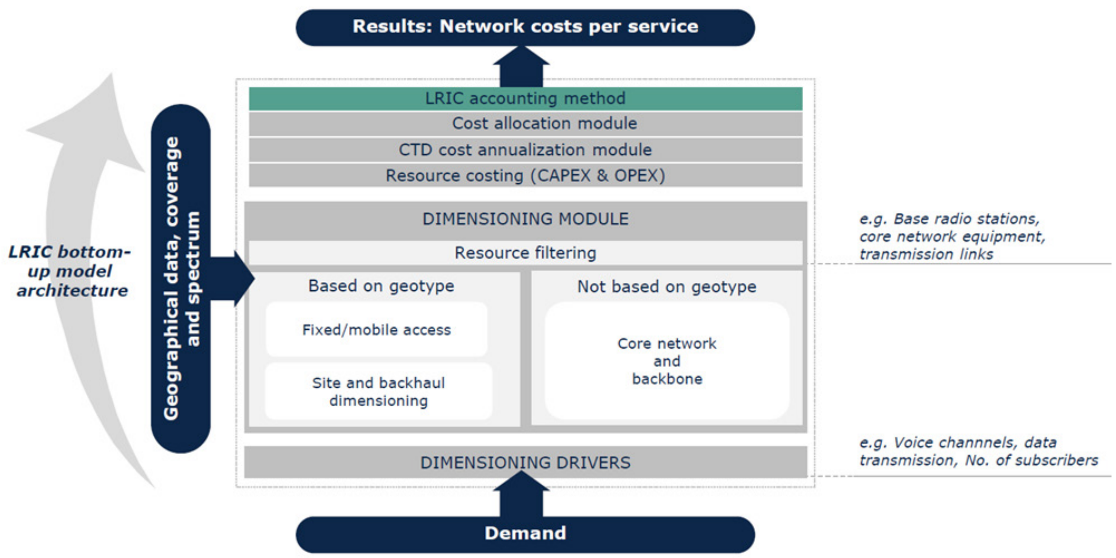
- monitored the agreed work plan weekly, avoiding delays at each stage of the project and ensuring timely completion;
- participated in all missions to CONATEL's premises in Asunción;
- carried out an exhaustive review of all deliverables provided by Axon throughout the project;
- provided expert advice on the methodological approaches and considerations for implementation of the proposed solution.

Description of the solution adopted

In line with international best practices, two bottom-up models were developed to determine the incremental costs associated with the provision of fixed and mobile interconnection services in Paraguay.

The following is a high-level view of the bottom-up architecture used for implementation of the cost models (one model for fixed networks and the other for mobile networks).

Figure A1.2: Overview of the architecture of the cost models implemented



Methodological approach

The first step towards the implementation of these models was an exchange of ideas between the CONATEL and ITU teams on the methodological approach for implementing the models. In particular, it was agreed to adopt the following assumptions:

- **Aspects common to both cost models**
  - Categories of costs to be considered: Operation and maintenance costs of providing the interconnection; amortization of the capital used to provide the interconnection and the cost of that capital applying an appropriate rate of return; financial costs and regulation costs; common and joint costs resulting from the interconnection.
  - Cost annualization method: Variable amortization scheme under which annualization is calculated according to the trend in unit prices for equipment.
  - Cost standard: LRIC+ approach (taking into account common costs) for all modelled services.
  - Network common cost allocation: Required capacity approach based on the routing factors defined in the model.
  - Non-network common cost allocation: Based on an equi-proportional mark-up (EPMU) on the network costs related to the services.
  - Modelled time period: Multi-year approach from 2015 to 2022 inclusive.
  - Network topology: Scorched-earth approach reconciled with data available from the real reference operator.
- **Specific aspects of the bottom-up model for fixed networks**
  - Operator to be modelled: Hypothetical operator in the fixed-telephony market, with national coverage and with its own networks throughout the country.
  - Technologies to be modelled:
    - *Access*: This section of the network was not included in the model since it has no impact on the determination of fixed interconnection costs.
    - *Transmission*: All available technologies taken into consideration (microwave, SDH fibre, Ethernet fibre, DWDM fibre, dedicated lines), according to the extent of their use by the reference operator.
    - *Core network*: Inclusion of both TDM and NGN-IP solutions based on the IMS architecture.
- **Specific aspects of the bottom-up model for mobile networks**
  - Operator to be modelled: Hypothetical operator entering the market with a market share of 33 per cent.
  - Technologies to be modelled:
    - *Access*: 2G, 3G and 4G with SingleRAN solutions.
    - *Transmission*: All available technologies taken into consideration (microwave, dedicated lines, optical fibre, satellite links), according to the extent of their use by the reference operators.
    - *Core network*: Traditional/legacy solutions for the provision of services over 2G and 3G and NGN solutions for the provision of 4G services.

4.2 Implementation scheme

Once the reference methodological approach had been defined, implementation of the cost models involved the following key steps:

a) **Information collection**. The information provided by CONATEL was used and a set of information request forms was prepared, which were filled out by the operators and gave an overview of the status and operation of the telecommunication/ICT networks in the country.

b) **Collating and processing inputs**. The information collected at the previous stage underwent an exhaustive quality-control procedure in order to ensure that it was representative. After filtering inputs of dubious quality, the information was processed so that it had the required format for the cost model.

c) **Geographical analysis of the country**. All the municipalities of Paraguay were described in terms of location, population and population density in order to accurately portray the specific geographic/demographic features of the country.

d) **Adapting the prototype model to the agreed methodology**. The consultant's prototype model was adapted to the agreed methodology and to the services required by CONATEL in order to ensure that the NRA's needs were met.

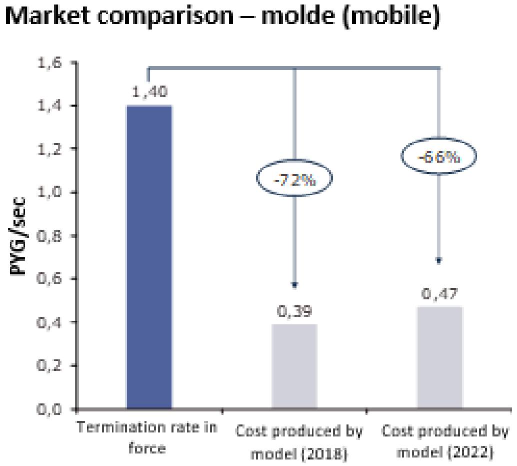
e) **Inputting and results verification**. Lastly, the inputs were fed into the model, a first set of results was generated, and refinements were made through quality-assurance exercises such as reconciliation of dimensioned network sites or the calculated cost base.

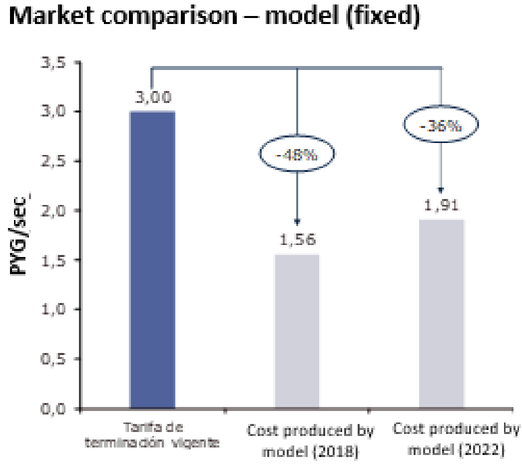
Results and regulatory measures

It emerged from application of the cost models that regulatory measures were required for setting wholesale fixed and mobile interconnection charges.

In particular, it was concluded that mobile interconnection costs for the period 2018-2022 were between 66 and 72 per cent below current wholesale rates, while in the case of fixed termination they were between 36 and 48 per cent below current rates, as illustrated below:

Figure A1.3: Comparison between the rates in force when the models were finalized and the cost results produced by the models





On the basis of these results, on 26 July 2018, CONATEL issued Resolution 1180/2018, which "updates the ceilings for interconnection charges for voice call and SMS services to cellular-mobile telephony networks (STMC and PCS), as well as the ceilings for interconnection charges for voice call services to the basic telephony network". The resolution provides for a glidepath until September 2020, with the aim of achieving convergence of regulated rates with the costs of providing these services in the country.

Annex 2: Infrastructure cost sharing at IXPs

Internet exchange points (IXPs) should be independent infrastructures where digital traffic is shared (routed) through a physical infrastructure (Ethernet switch), forming a local area network (LAN).

The governance of an IXP is therefore of critical relevance to maintaining neutrality of the traffic-sharing practices in this shared infrastructure. Governance requires members of an IXP to agree on its management, through memoranda of understanding, funding and expansion strategies and infrastructure cost-sharing agreements. This is a typical problem of building the necessary institutions to promote cooperation among potential competitors, to the benefit of the local digital ecosystem.

Relevance of IXPs

The world distribution of participating members can be seen from the different continental IXP associations bringing together the IXP operators from each region: the African IXP Association (AFIX); the Asia-Pacific Internet Exchange Association (APIX); the European Internet Exchange Association (Euro-IX); the Latin American and Caribbean Association of IXP operators (LAC-IX) and the North American IXPs.

Figure A2.1: IXP map[101]

Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of ITU and of its secretariat concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The table below shows the geographical distribution of world IXP connections by region.

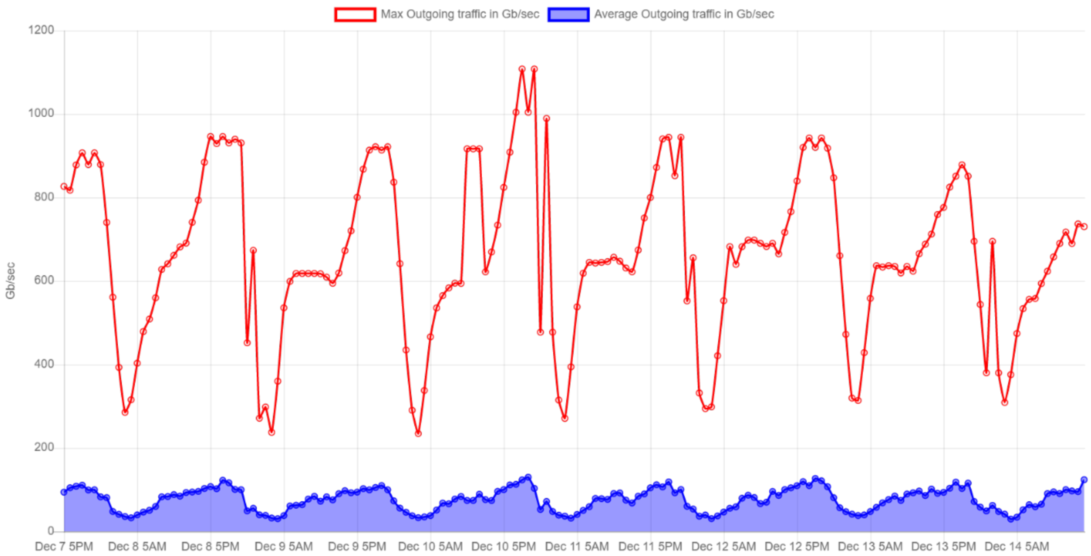
[101] Source: IXP toolkit. Maps and Data.

Table A2.1: World IXP statistics

	AFIX	APIX	EURO-IX	LAC-IX	North America
Total connections	1 116	3 807	12 383	1 219	2 661
Unique ASNs[102]	413	1 513	3 109	808	1 045

To fully understand the importance of these cost-sharing infrastructures, a snapshot of the aggregate outgoing traffic through IXPs worldwide, in a given week (December 2019), extracted from the IXP database, is provided in Figure A2.2 below.

Figure A2.2: Traffic aggregated by IXPs[103]



Typical cost-sharing rules and practices

Like any other shared infrastructure, IXPs require governance rules, methods, agreements and protocols for allocating common costs and responsibilities. For instance, one critical issue in infrastructure sharing is security. An example of a security protocol on sharing of IXP infrastructures is the Mutually Agreed Norms for Routing Security (MANRS), a global initiative supported by the Internet Society that provides fixes to curb the most common routing threats. MANRS is a prime example of infrastructure-sharing governance to achieve cost reductions (by addressing functional and security threats) that requires collaboration among participants and shared responsibility for the global Internet routing system.

Example of Rwanda: Interconnection policy and fee structure at the Rwandan IXP

To be a member of the Rwandan IXP (RINEX),[104] an entity has to have a valid licence to operate in Rwanda as an Internet or data-service provider. RINEX management will provide a layer-2

102 ASN: autonomous system number
103 Source: IXPDB. The IXP database.
104 Rwanda Internet Exchange (RINEX). RINEX – Resources.

Ethernet switch fabric for interconnection. Each member will be given a port at the RINEX facility, through which they will peer with other members.

- Each member is responsible for providing at least a 10 Mbit/s link to the RINEX facility.
- RINEX members shall announce only those routes that belong to their autonomous system and their customers.
- Members shall exchange routes with each other without bias or disregard.
- All members will have to use a RINEX-assigned IP address (currently in the range of 196.223.12.0/24) for connecting and exchanging routes with each other.
- Every member will keep its RINEX link connected at all times (24/7) for the purpose of facilitating efficient routing and interconnection of IP transit networks within Rwanda.

The fee structure is set out below.[105]

Table A2.2: RINEX fees

Port speed	Fee (USD) Monthly charge	Fee (USD) Quarterly charge	Fee (USD) Bi-annual charge
≤ 10 Gigabit Ethernet/SFP	750	2 250	4 500
≤ 1 Gigabit Ethernet/SFP	530	1 589	3 178
≤ 100 Megabit Ethernet/SFP	377	1 131	2 263
≤ 50 Megabit Ethernet/SFP	195	585	2 339
≤ 10 Megabit Ethernet/SFP	free	free	free

Table A2.3: RINEX additional fees

Description	Fee (USD)	Fee (RWF) – One-off fee
VLAN set-up fee – One-time payment (one-off fee)	50	N/A

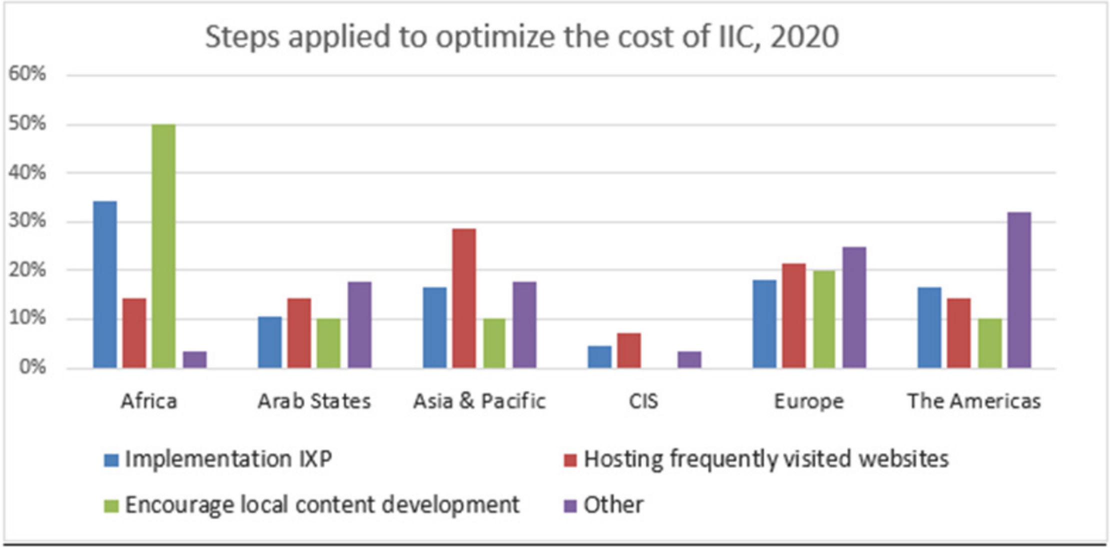
IXPs and the cost of international Internet connectivity

The ITU Tariff Policies Survey provides key insights into the current role of IXPs in reducing the costs of international Internet connectivity across countries and continents.

As can be seen in Figure A2.3, implementation of an IXP is the most common measure applied to optimize the costs of international Internet connectivity across all continents in 2020.

[105] Test period/discount: Two (2) months – only at the beginning of the contract (i.e., for new clients). Monthly invoices can be issued in either Rwandan francs (RWF) (local currency) or United States dollars (USD) (foreign currency). The Rwanda Internet Community and Technology Alliance (RICTA) uses the official National Bank of Rwanda exchange rate at the time of invoicing. The prices quoted in the table are VAT exclusive - VAT is 18%. MRC stands for monthly recurring charges/fees.

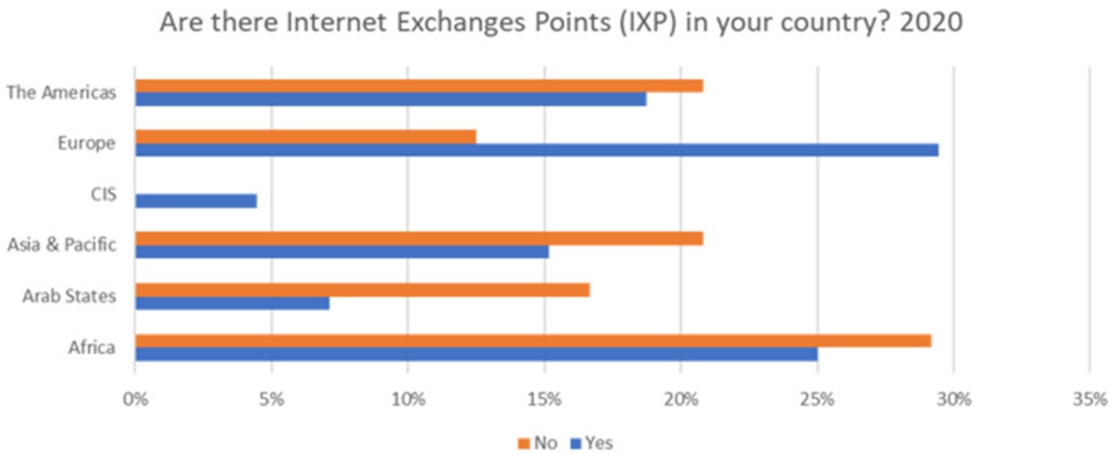
Figure A2.3: Steps applied to optimize international Internet connectivity in regions, 2020



Source: ITU Tariff Policies Survey

However, the distribution of IXPs across countries remains uneven, as seen for example from the data in Figure A2.4.

Figure A2.4: Availability of IXPs in regions, 2020



Source: ITU Tariff Policies survey

In particular, it is noticeable that the Africa region records the largest proportion of reporting countries (29 per cent) that do not have an IXP, followed by the Asia and the Pacific region and the Americas (21 per cent).

It is also interesting to note the gap between, on the one hand, the CIS region (0 per cent) and Europe (13 per cent), and, on the other, the Arab States (17 per cent), probably due to the different organizational features of the Internet in these countries.

Size of IXP infrastructure

The national and regional impacts of each IXP as a shared infrastructure become increasingly relevant as the IXP acquires significant membership. IXP membership levels vary from country to country.

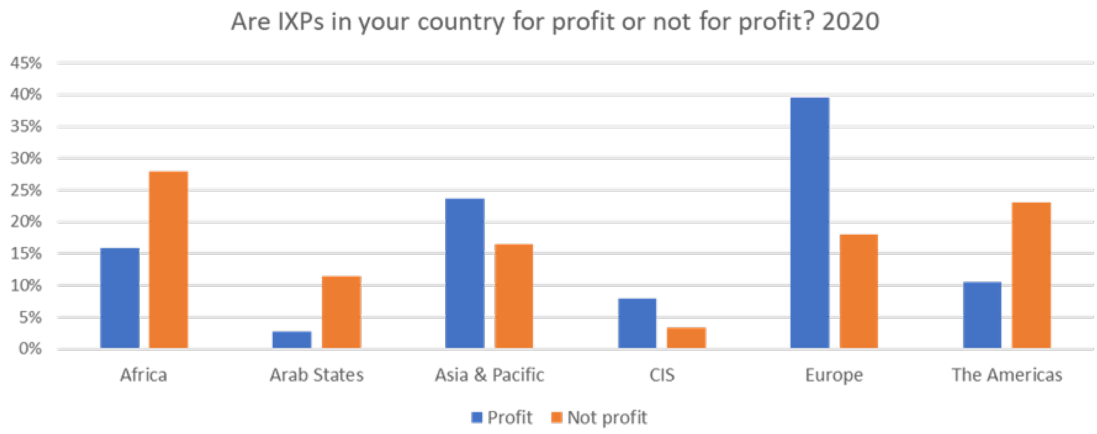
This is of course of clear relevance in terms of infrastructure-sharing costs when speaking about an infrastructure that is usually based on shared cost among participating members.

IXP governance

Another aspect of paramount importance for the functioning of IXP infrastructures is their governance.

As discussed above, IXPs are usually shared physical infrastructures, whereby competitors who become suppliers of complementary services need to share common costs for the exchanges. The cost decision is by nature critically linked to the question of whether IXPs are profit-driven or are cooperative membership-driven infrastructures aimed at maximizing benefit for the membership as a whole.

Figure A2.7: Commercial use of IXPs in regions, 2020



Source ITU Tariff Policies survey

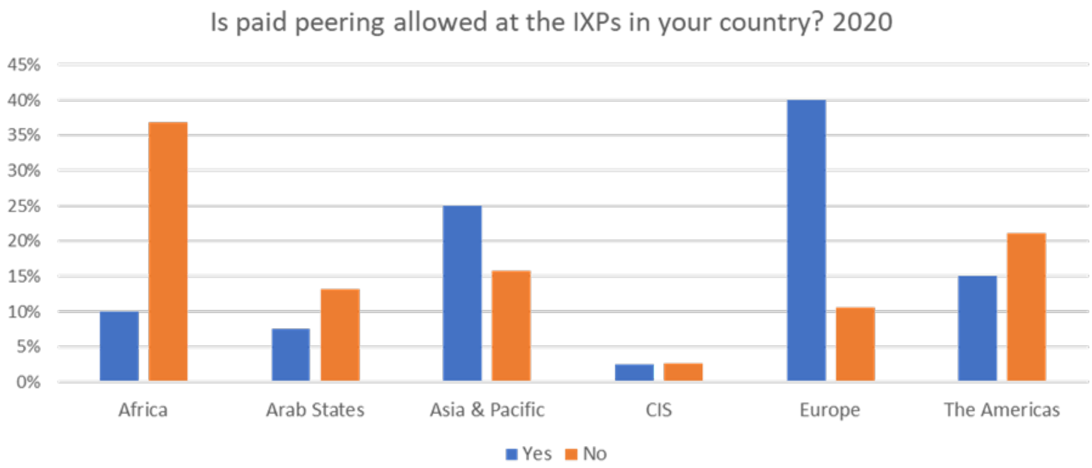
Figure A2.7 shows that there are clearly different patterns across the world, with the largest proportion of profit-driven IXPs found in countries of the Europe region (39 per cent), followed by Asia and the Pacific (24 per cent).

A further key feature of the governance of this infrastructure-sharing mechanism relates to the fundamental issue of whether paid peering is allowed at the IXP.

This is an important issue, since, as soon as paid peering occurs, the paid transactions at the IXP are similar to interconnection fees, as discussed in the previous section, and would then become a possible subject of regulatory relevance.

Figure A2.8 reveals relevant governance differences across continents.

Figure A2.8: Paid peering in IXPs in regions, 2020



Source ITU Tariff Policies survey

Whereas 37 per cent of African IXPs do not allow paid peering, 40 per cent of European IXPs allow it. This range is probably explained by the hybrid nature of many IXPs, which function with both free and paid peering. It suggests the need for further investigation, focusing on case studies concerning how these two different forms of infrastructure cost sharing may co-exist, and with what consequences.

Annex 3: Detailed statistics on methods used by NRAs for determining the cost of wholesale services

This annex provides detailed statistics on the methodological approaches[106] followed by NRAs for advanced wholesale services,[107] based on the information collected by the ITU Tariff Policies Survey 2019-2020.[108] It also contains European Union and Brazil case studies in that field.

1. ITU Tariff Policies Surveys 2019-2020

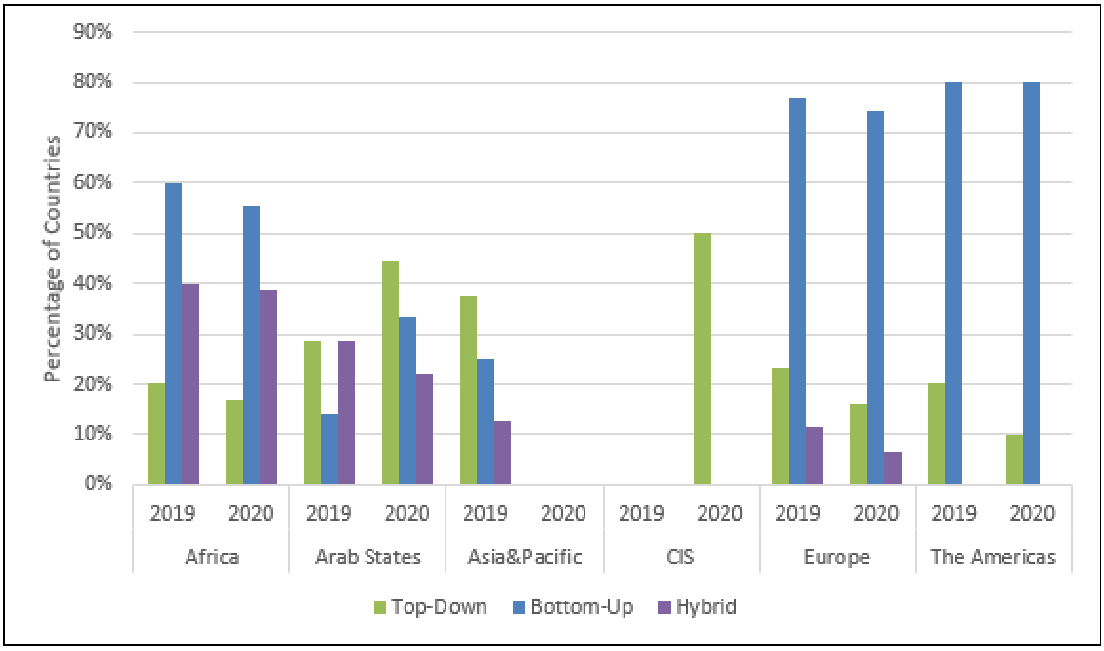
The following methodological aspects are analysed in this annex:

- Modelling approach
- Cost standard
- Costs included
- Asset valuation
- Annualization method
- Network topology design
- Reference operator
- Allocation of common and network costs.

Modelling approach

Fixed services

Figure A3.1: Modelling approach in regions for fixed services, by region, 2019-2020

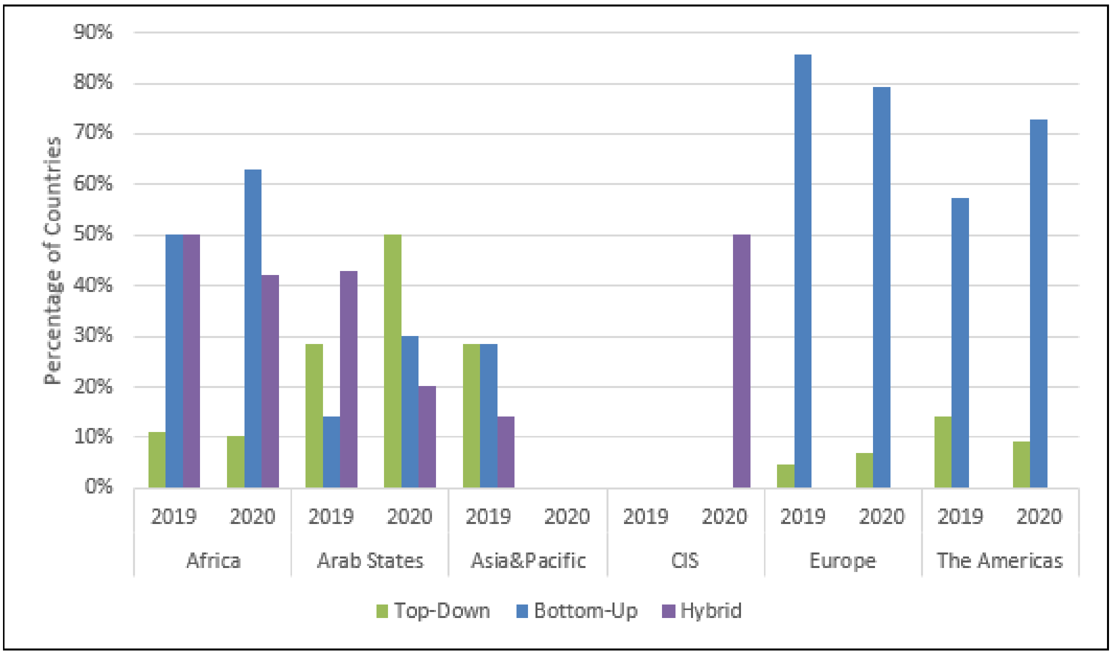


source: ITU Tariff Policies Survey

106 More detailed information on the methodological approaches can be found in the separate Guidelines on cost modelling for telecommunications/ICTs.
107 Advanced wholesale services mean services based on NGN/IP networks.
108 ITU-D. ITU Tariff Policies Survey.

Mobile services

Figure A3.2: Modelling approach in regions for mobile services, by region, 2019-2020

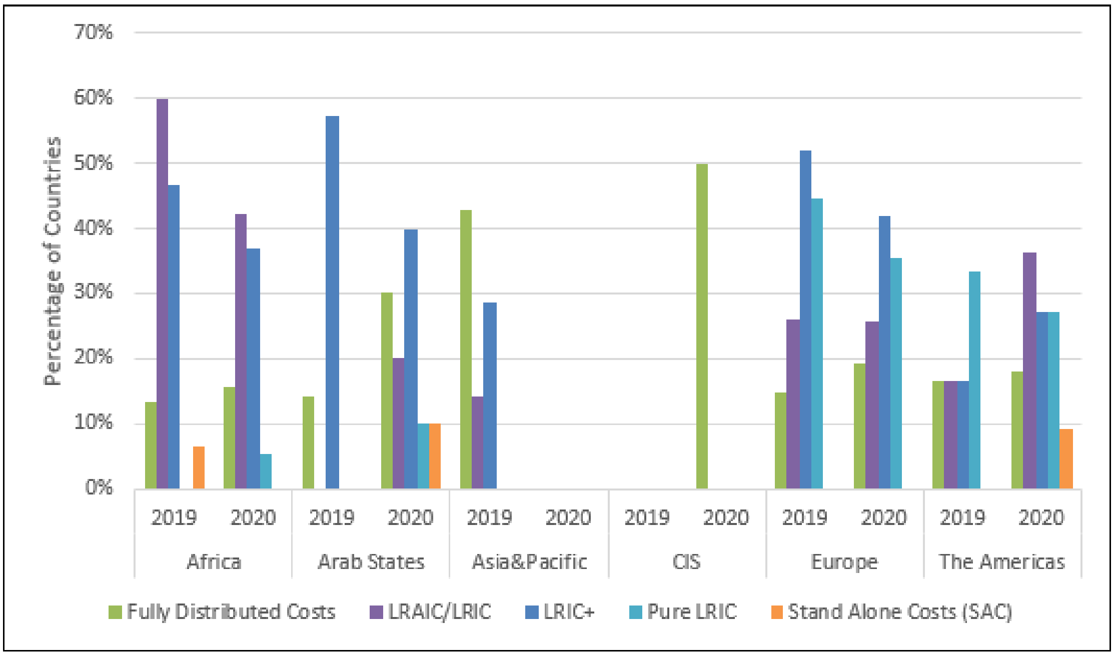


source: ITU Tariff Policies Survey

Cost standard

Fixed services

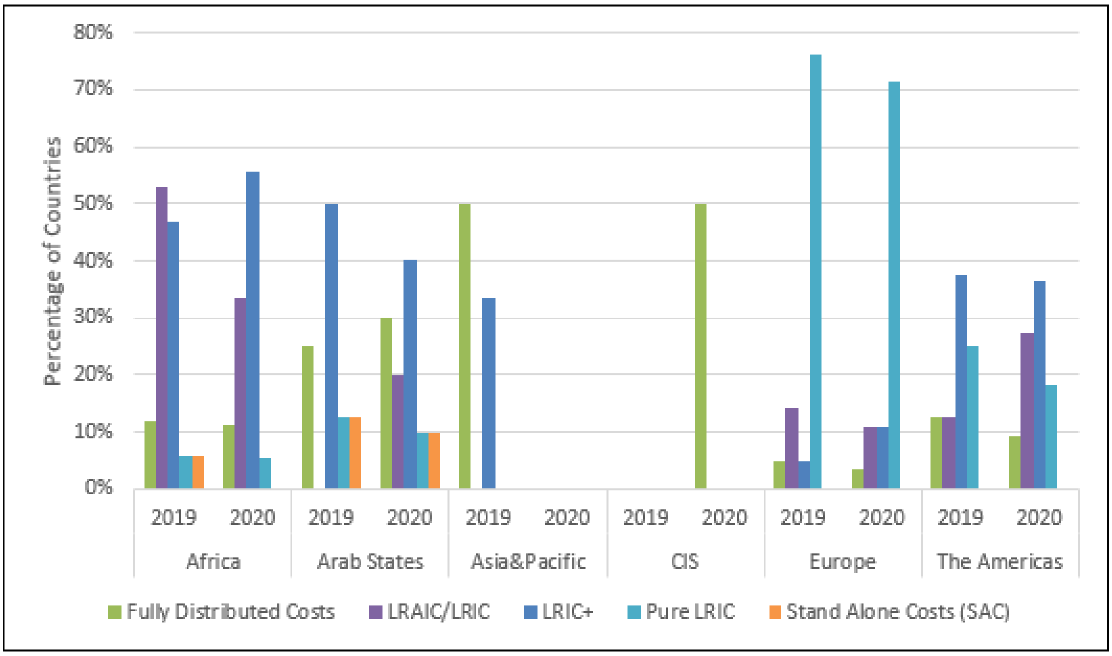
Figure A3.3: Cost standards applied for fixed services, by region, 2019-2020



source: ITU Tariff Policies Survey

Mobile services

Figure A3.4: Cost standards applied for mobile services, by region, 2019-2020

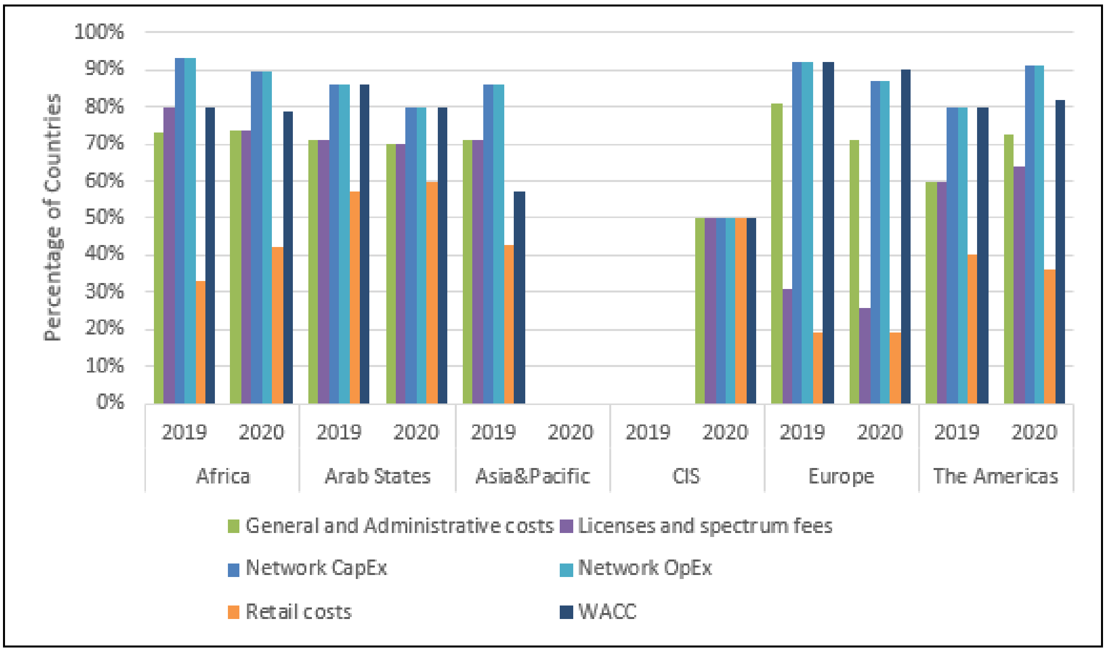


source: ITU Tariff Policies

Costs included

Fixed services

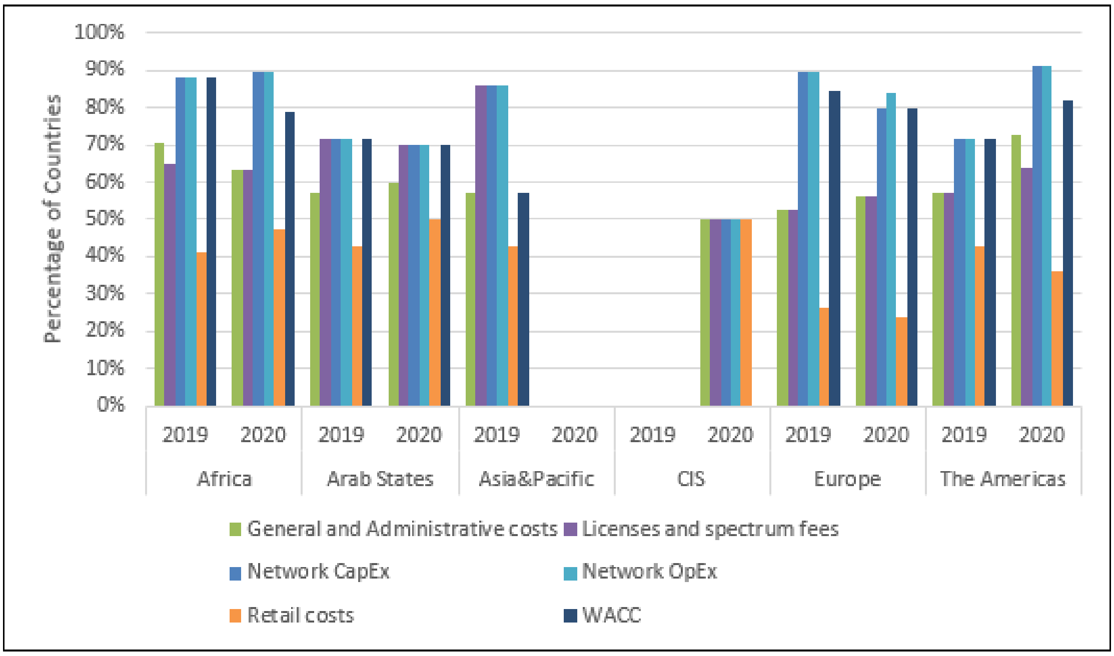
Figure A3.5: Cost items of fixed services, by region, 2019-2020



source: ITU Tariff Policies Survey

Mobile services

Figure A3.6: Cost items of mobile services, by region, 2019-2020

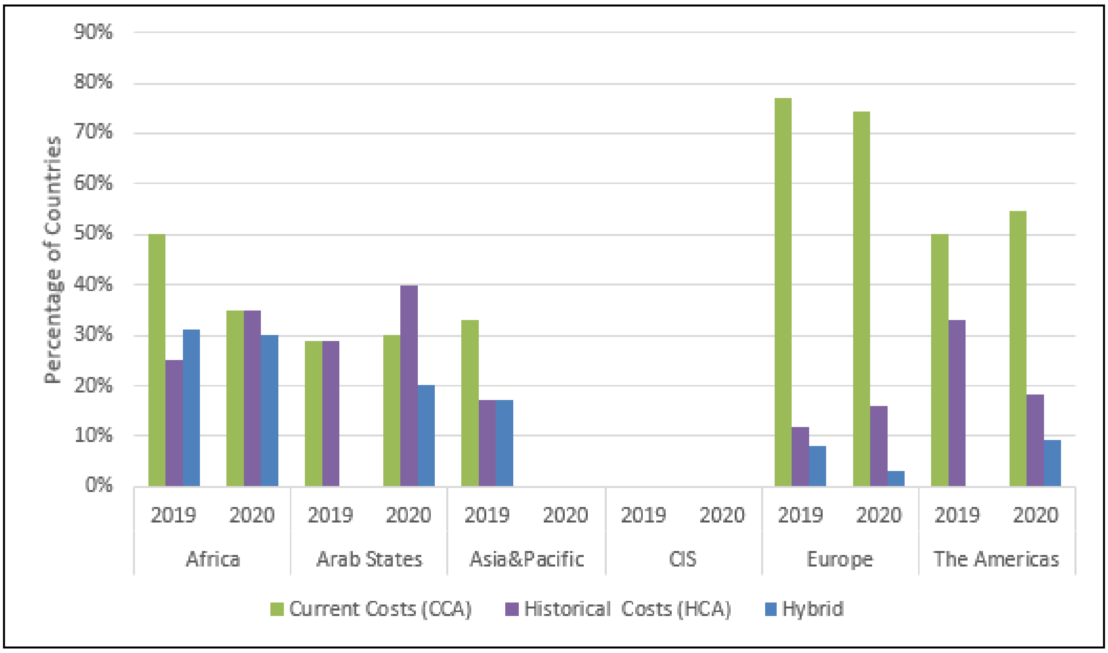


source: ITU Tariff Policies Survey

Asset valuation

Fixed services

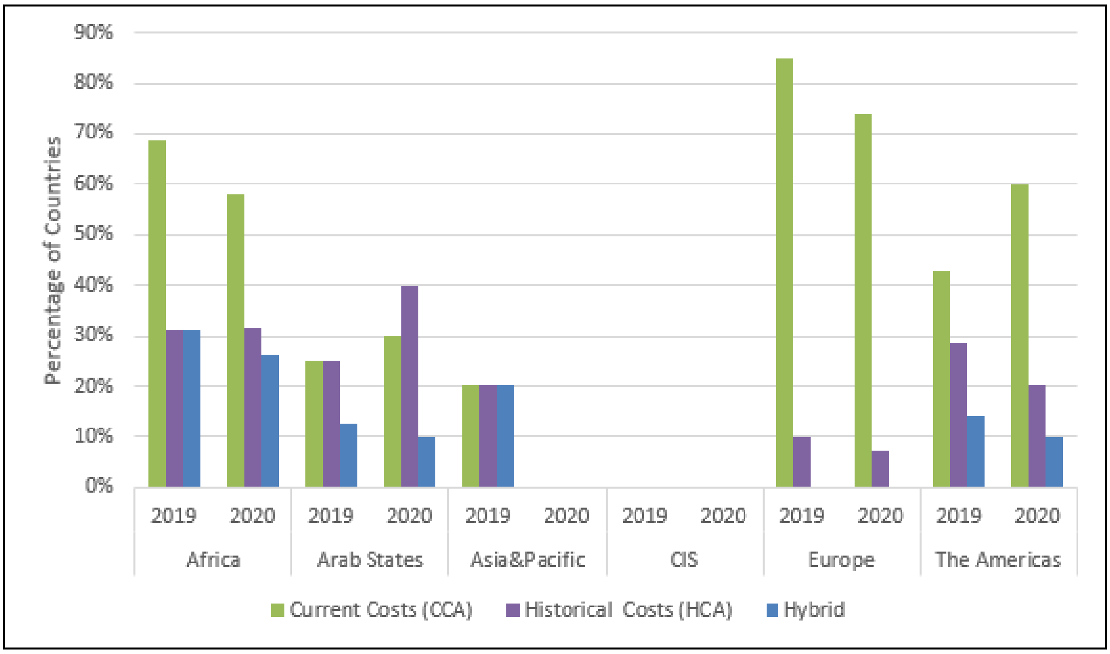
Figure A3.7: Asset valuation for fixed services, by region, 2019-2020



source: ITU Tariff Policies Survey

Mobile services

Figure A3.8: Asset valuation for mobile services, by region, 2019-2020

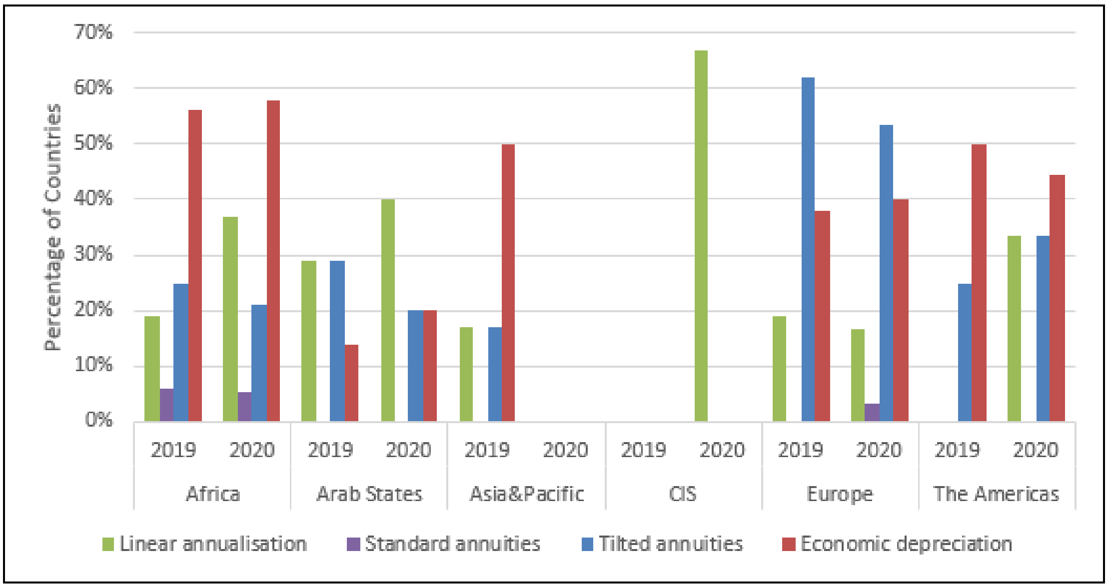


source: ITU Tariff Policies Survey

Annualization method

Fixed services

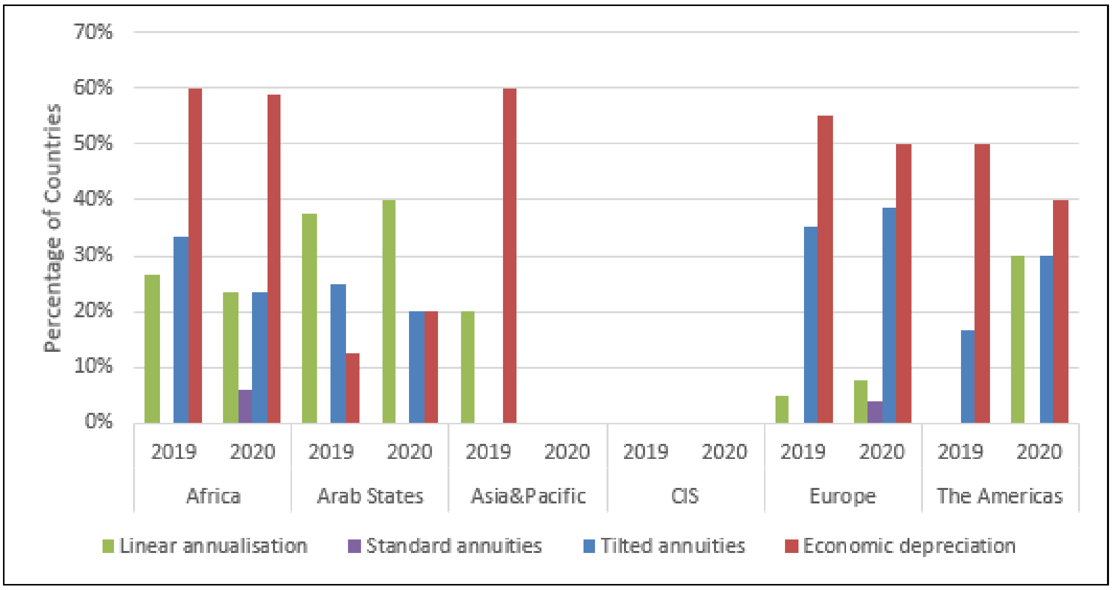
Figure A3.9: Annualization method for fixed services, by region, 2019-2020



source: ITU Tariff Policies Survey

Mobile services

Figure A3.10: Annualization method for mobile services, by region, 2019-2020

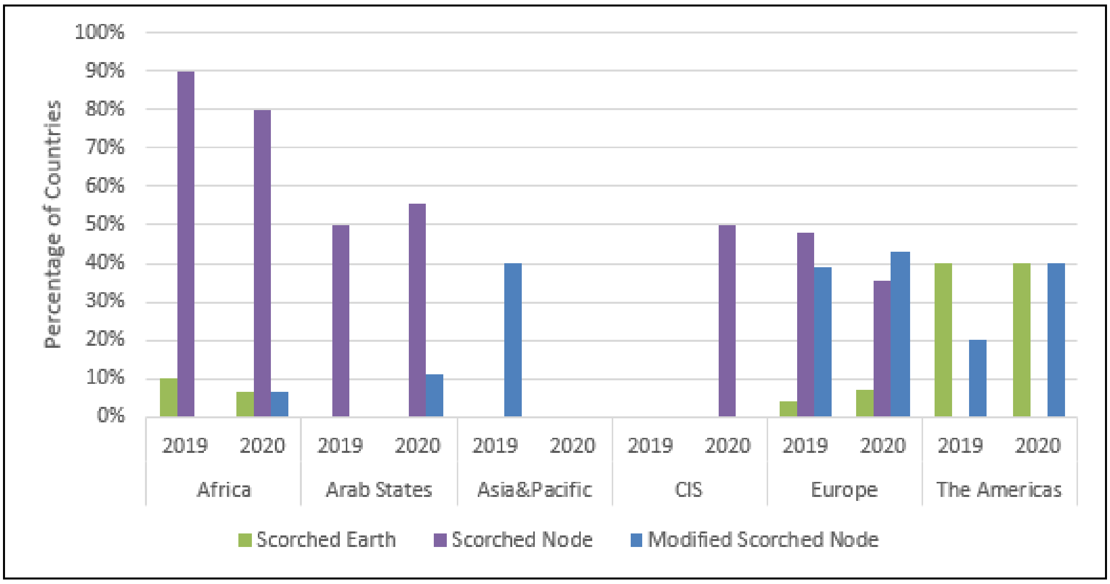


source: ITU Tariff Policies Survey

Network topology design

Fixed services

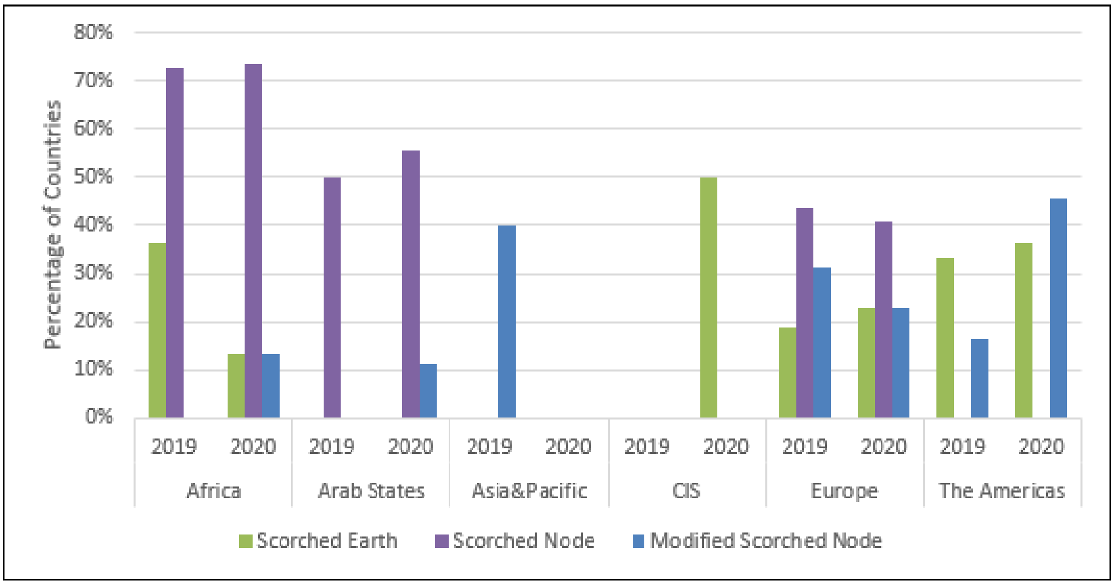
Figure A3.11: Network topology design for fixed services, by region, 2019-2020



source: ITU Tariff Policies Survey

Mobile services

Figure A3.12: Network topology design for mobile services, by region, 2019-2020

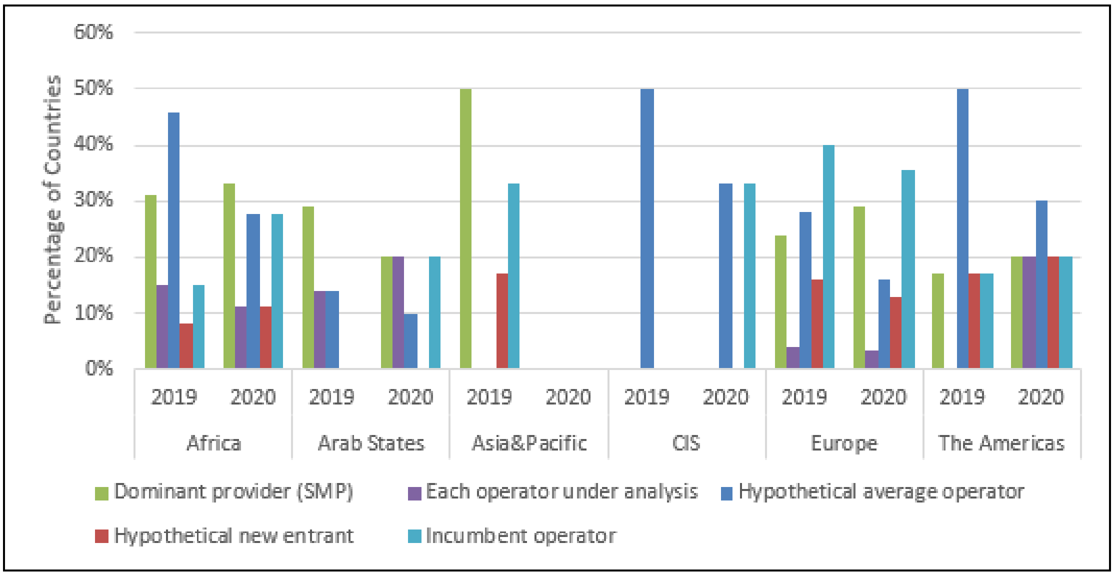


source: ITU Tariff Policies Survey

Reference operator

Fixed services

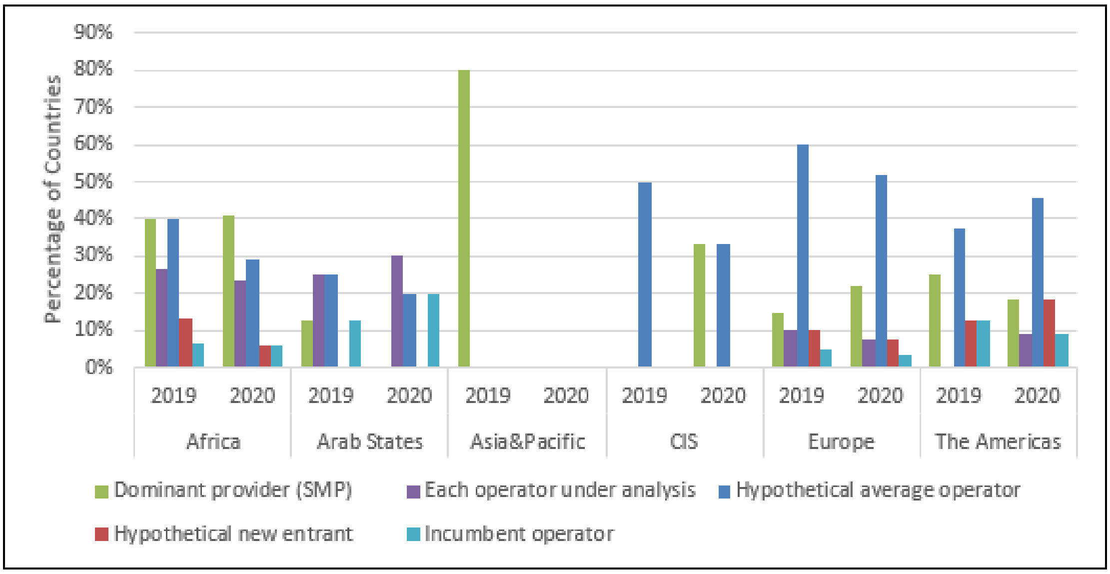
Figure A3.13: Reference operator for fixed services, by region, 2019-2020



source: ITU Tariff Policies Survey

Mobile services

Figure A3.14: Reference operator for mobile services, by region, 2019-2020

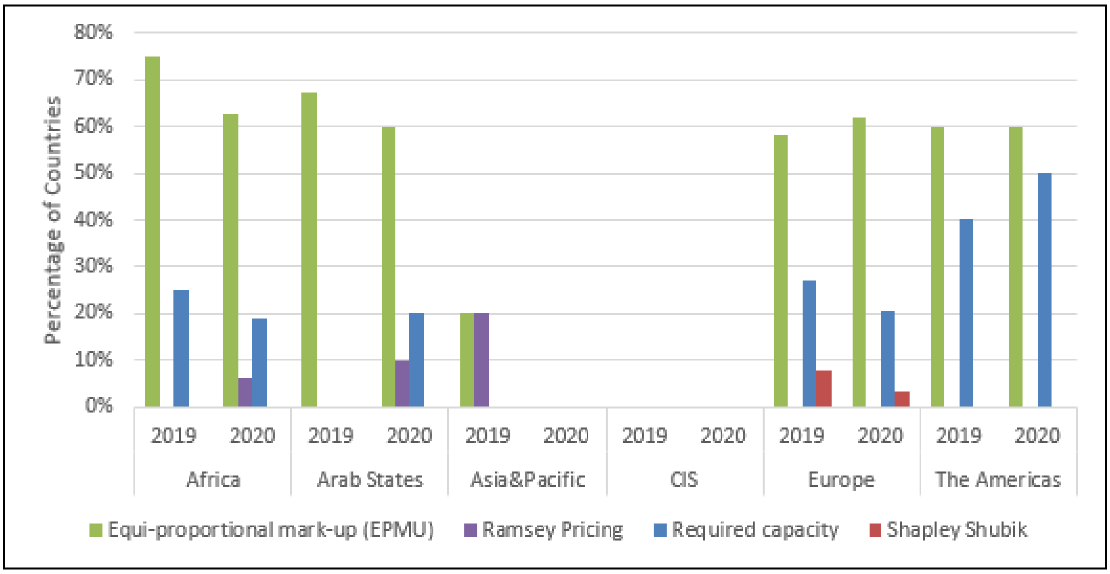


source: ITU Tariff Policies Survey

Allocation of common and network costs

Fixed services

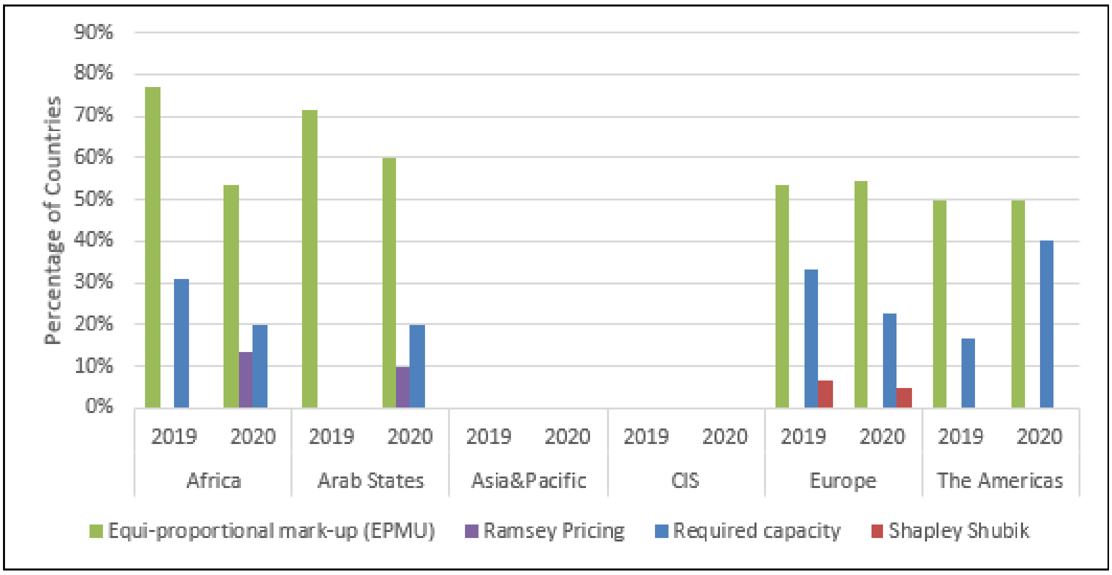
Figure A3.15: Allocation of common and joint costs for fixed services, by region, 2019-2020



source: ITU Tariff Policies Survey

Mobile services

Figure A3.16: Allocation of common and joint costs for mobile services, by region, 2019-2020



source: ITU Tariff Policies Survey

2. EU case study

Table A3.1 presents the methodologies used by regulators across Europe to regulate fixed and mobile termination rates (FTR and MTR, respectively).

Table A3.1: Cost models used in Europe[109]

Country	Cost model used for FTRs	Cost model used for MTRs
Albania	Benchmark (Other)	Benchmark (BU LRIC)
Austria	Pure BU LRIC	Pure BU LRIC
Belgium	FDC/FAC	Pure BU LRIC
Bulgaria	Pure BU LRIC	Pure BU LRIC
Switzerland	BU LRAIC+	Not regulated
Cyprus	Benchmark (Pure BU LRIC)	Benchmark (BU LRIC)
Czech Republic	Pure BU LRIC	Pure BU LRIC
Germany	Benchmark (Pure BU LRIC)	Pure BU LRIC
Denmark	Pure BU LRIC	Pure BU LRIC
Estonia	Benchmark (Pure BU LRIC)	Benchmark (BU LRIC)

[109] Source: NRAs and BEREC Report BoR (18) 103 (op. cit.)

Table A3.1: Cost models used in Europe (continued)

Country	Cost model used for FTRs	Cost model used for MTRs
Greece	Pure BU LRIC	Pure BU LRIC
Spain	Pure BU LRIC	Pure BU LRIC
Finland	FDC	FDC/FAC
France	Pure BU LRIC	Pure BU LRIC
Croatia	Pure BU LRIC	Pure BU LRIC
Hungary	Pure BU LRIC	Pure BU LRIC
Ireland	Pure BU LRIC	Pure BU LRIC
Iceland	Benchmark (Pure BU LRIC)	Benchmark (BU LRIC)
Italy	Pure BU LRIC	Pure BU LRIC
Liechtenstein	FDC/FAC	Benchmark
Lithuania	Pure BU LRIC	Benchmark (BU LRIC)
Luxembourg	Pure BU LRIC	Pure BU LRIC
Latvia	Benchmark (Pure BU LRIC)	Benchmark (BU LRIC)
Montenegro	TD LRIC	TD LRIC
North Macedonia	TD LRIC	TD LRIC
Malta	Pure BU LRIC	Pure BU LRIC
Netherlands	Pure BU LRIC	Pure BU LRIC
Norway	Pure BU LRIC	Pure BU LRIC
Poland	TD-FAC-CCA	Pure BU LRIC
Portugal	Pure BU LRIC	Pure BU LRIC
Romania	Pure BU LRIC	Pure BU LRIC
Serbia	TD-FAC-CCA	Benchmark
Sweden	Pure BU LRIC	Pure BU LRIC
Slovenia	Pure BU LRIC	Pure BU LRIC
Slovakia	Pure BU LRIC	Pure BU LRIC
United Kingdom	Pure BU LRIC	Pure BU LRIC

Table A3.2 presents the WACC premiums used in certain countries for the consideration of the additional risk associated with NGN.

Table A3.2: Detailed WACC ratios in countries where a risk premium is applied[110]

Country	WACC on copper	WACC on fibre	Risk premium
Czech Republic	7.89%	11.20%	3.31%
Italy	8.64%	11.84%	3.20%
Netherlands	6.06%	8.67%	2.61%
Slovenia	7.16%	9.66%	2.50%
Denmark	4.56%	6.56%	2.00%
Croatia	6.28%	8.25%	1.97%
Belgium	7.12%	8.77%	1.65%
Poland	8.82%	10.07%	1.25%
Finland	6.50%	7.60%	1.10%
United Kingdom	7.90%	8.90%	1.00%
Luxembourg	7.10%	7.71%	0.61%
Estonia	10.30%	10.40%	0.10%

Table A3.3 summarizes aspects of the methodology used in the European Commission's BU LRIC models.

Table A3.3: Summary of main aspects of the methodology used by the EC

Aspect of methodology	Mobile	Fixed
Cost standard	– Pure LRIC (termination) and LRIC+ (for the rest)	– Pure LRIC (termination)
Cost categories considered	– Network CAPEX – Network OPEX – General and administrative costs – Specific wholesale costs	– Network CAPEX – Network OPEX – Specific wholesale costs[111]
Operator modelled	– Hypothetical efficient operator with market share equal to 1 vis-à-vis the number of network operators (subject to minimum of 20%).	– Hypothetical efficient operator (options were allowed for the analysis of different market shares)

[110] Cullen International, December 2019.
[111] Note that general and administrative costs are not relevant under a pure LRIC standard

Table A3.3: Summary of main aspects of the methodology used by the EC (continued)

Aspect of methodology	Mobile	Fixed
Cost annualization methodology	– Economic depreciation	– Economic depreciation
Period modelled	– 2015-2025	– 2015-2025
Other relevant aspects	– Radio access network based on single RAN equipment – VoLTE included – Detailed geographic analysis to capture the seasonal variation of demand in certain areas and difficult terrains	– Model based on an IMS core network and with an IP transmission network

Source: Axon Partners Group Consulting

Table A3.4 presents the steps followed by the European Commission for the development of its BU LRIC models.

Table A3.4: Steps followed by the EC for the development of BU LRIC models

Phase	Description
Definition of the methodology	• These aspects were discussed at face-to-face workshops, one for each model, at the European Commission headquarters in Brussels,[112] to which telecommunication operators and regulators from the entire EU/EEA area were invited. Following the workshops, the officials concerned were given the time and opportunity to comment on the methodologies.
Information requirements	• For the purposes of producing the models, information was requested from the operators of all EU/EEA countries (via their regulators). During this phase, all the various players collaborated commendably, making it possible to gather large volumes of relevant information and thus ensure the precision of the algorithms in the models and the plausibility of the results.
Development of the models	• The cost models were developed based on Microsoft Excel. The methodology and algorithms used in them are consistent among all countries, the only changes being to the entry parameters of the algorithms. Only Visual Basic programming was used to manage the computing order, ensuring maximum transparency of the formulae and algorithms used. The models came with extremely detailed documentation on the methodology used, input processing, technical algorithms and user instructions.
Consulting the models	• The models, along with all supporting documentation, were handed over to the regulators of all the countries so that they could be shared with the operators. The operators and regulators had full access to the models and inputs used, ensuring full transparency regarding their analysis. Once the consultation periods were over, more than 3 000 comments for each study were analysed, along with new information from around 80 entities from among operators and regulators. The comments made it possible to implement a series of changes to the models to further improve their representativity and precision.
Finalization of the models	• Once the models had been finalized, workshops were held for each of them to present the results of the consultation processes and of the models

Source: Axon Partners Group Consulting

[112] The workshop for the mobile models was held on 10 April 2018 and the one for the fixed models on 23 October 2018.

3. Brazil case study: Overview of the methodologies adopted to estimate the costs of regulated wholesale markets[113]

High-speed leased lines

As this was not included in the list of products under the top-down FAC-HCA (TD-FH) cost model for which a reference offer is presented by providers with SMP, it was necessary to adopt an alternative method, namely calculated values for products from similar wholesale markets.

Leased lines was chosen as the similar product. However, since it was not possible to extract high-speed leased line costs directly from the cost model and, in the absence of other similar products (wholesale and retail) or an intermediate step able to reflect the costs of this service, the reference values were set on the basis of speed-based cost projections taking into account the leased-line product speed ranges available in the TD-FH cost model.

National roaming

The wholesale roaming product under the TD-FH cost model adopted by Anatel consolidates the costs of all types of roaming services offered, such as voice, data and SMS, so it is impossible to extract the individual costs of each roaming service directly from this model.

Therefore, considering that the cost of offering a wholesale roaming service to an entrant is close to the cost that the incumbent would incur in offering this same service in retail, the approach adopted for setting the wholesale roaming voice, data and SMS reference values was to use calculated values for similar retail products, minus retail costs.

Full unbundling

Only one operator with SMP had commercialized this service when the reference values were being determined, thus preventing the use of values calculated directly by the TD-FH model for the other SMP operators.

Since there are no wholesale or retail products similar to full unbundling and no intermediate step in all costs involved in providing this service, the product cost calculated for this operator was used as the reference value for other groups with SMP in other regions of Brazil.

Bitstream

Although this product exists in the cost model, no provider had commercialized bitstream when the reference values were being determined, thus preventing the use of values calculated directly by the TD-FH cost model.

It may be noted that full unbundling and bitstream services use a similar infrastructure. The main difference between them is that in full unbundling the incumbent gives the entrant control of the copper pair, while in bitstream logical separation occurs, and the incumbent remains in control and can still provide services to consumers, since entrants only lease part of the copper-pair spectrum.

[113] ITU-D SG1 Document 1/335 from Brazil

Since full unbundling and bitstream are related, the products may be expected to exhibit similar cost behaviour. Thus, in setting the reference value for bitstream, the first step was to calculate the ratio between the current prices of full unbundling and bitstream from the wholesale offers of the single provider with SMP that had reported the costs of full unbundling. This ratio was then applied to the full unbundling product costs for this provider under the TD-FH cost model, making it possible to obtain the cost-oriented reference value for bitstream.

Finally, as applied in the full unbundling scenario, this reference value was replicated to the other operators with SMP in this market.

Duct rental

As this was not included in the product list under the TD-FH cost model employed by Anatel, it was necessary to adopt an alternative method.

The cost model adopted by Anatel is based on the activity-based (ABC) costing system, which establishes a cost pool for accumulating costs and expenses associated with ducts which will later be assigned to the telecom services.

Therefore, the reference values for duct rental were defined by the costs allocated to the ducts cost pool of each provider associated with the physical quantity of ducts of the provider in question.

Main results

The table below compares the average wholesale prices prior to the adoption of cost-oriented reference values, and after their adoption following the 2018 PGMC regulatory review.

Telecom services	Prices prior to cost orientation[114]	Prices after cost orientation[115]	Decrease
Full unbundling (BRL[116]/access)	38.58	15.40	60%
Bitstream (BRL/access)	42.52	17.23	59%
Wholesale voice roaming (BRL/min)	0.67	0.07	90%
Wholesale data roaming (BRL/min)	2.30	0.02	99%
Wholesale SMS roaming (BRL/SMS)	0.07	0.04	37%
Duct rental (BRL/m)	32.49	0.18	99%
High-speed leased lines (BRL/Mbit/s)	N/A	3.84	N/A

114 Average price of wholesale reference offer prior the adoption of cost-oriented prices. May vary by speed and operator.
115 Average price of wholesale reference offer after the adoption of cost-oriented prices. May vary by speed and operator.
116 BRL: Brazilian Real

Annex 4: Social tariffs in the Russian Federation[117]

Beeline's "Social package" tariff

For residents of Moscow, the "Social package" costs RUB 150 per month. It includes 200 minutes of calls, 1 000 SMS messages, three gigabytes (3 GB) of mobile Internet communications, unlimited use of the messaging services WhatsApp and Viber, as well as Skype, ICQ and others. The package also includes unlimited traffic on the official portal of the mayor and municipal government of Moscow, <mos.ru>, 60 minutes free sign-language interpretation per month for users with hearing impairments, and free access to maps and to location services popular with visually impaired clients: Yandex Maps, Google Maps, BlindSquare, Be My Eyes.

An important aspect of the product is the catalogue of specialized options and other extras offered to clients. Recommendations for specialized services for clients with specific needs were developed with the active involvement of the inclusive project Everland and the White Cane movement founded by visually impaired persons.

"My Doctor" (16+) is a service for remote consultation with a physician when it is impossible to get to a local health centre quickly. The subscription is only RUB 60 per month for social package subscribers and includes five unscheduled consultations with a paediatrician or general practitioner, one specialist opinion, discounts from partners, and preferential conditions for analyses. The first seven days of coverage are free.

The package includes the "Trusted payment" service, which ensures that subscribers can stay in touch with trusted persons and seek help in an emergency even if there is no credit left on their account. To top up the account in such circumstances, the subscriber dials a code, kept simple for the convenience of persons with disabilities. The account is then automatically credited with RUB 30, to be used within three days, without any added charges for the service.

Social package clients are also eligible for unlimited traffic on the official portals and services of several government bodies and services, including some that are coordinated by the Ministry of Labour and Social Protection of the Russian Federation.

Free access to these resources allows package subscribers to obtain information about employment services via the portals of the Federal Service for Labour and Employment, (https://rostrud.gov.ru/en/; https://www.trudvsem.ru; https://www.онлайнинспекция.рф) pension coverage via the Pension Fund (http://www.pfrf.ru/en/), social welfare benefits (https://www.egisso.ru), recognition of disabilities (https://fbmse.ru) and other questions relating to disabilities and rehabilitation on the portal of the government programme called "Accessible environment" (https://zhit-vmeste.ru).

Persons with hearing disabilities will soon be able to make use of online sign-language interpretation services so as to remove barriers in communicating with physicians, during consultations, when calling the emergency services and so on. The first 60 minutes of the service in each month will be free.

For the visually impaired, free maps are already available from Yandex Maps (6+) and Google Maps (6+); it is expected that specialized services from BlindSquare (6+) and Be My Eyes (18+) will also be offered in the future.

[117] ITU-D SG1 Document 1/318 from the Russian Federation

Tele2's "Social" tariff

The "Social" tariff package is designed for categories of the population entitled to preferential treatment, such as pensioners and persons with disabilities. Military service personnel are also eligible.

The new package offers subscribers 3 GB of traffic, 100 minutes of calls throughout Russia within the network and to other operators' numbers within the region, and 100 SMS messages. Calls to residential Tele2 numbers within the subscriber's region are unlimited and are not deducted from the monthly entitlement. The subscription costs RUB 150 per month in Moscow and RUB 100-120 in other regions.

Other options available to "Social" subscribers include unlimited free access to the social networks VKontakte and Odnoklassniki, and to the messaging services WhatsApp, Viber and TamTam. Subscribers get unlimited use of the navigation services Yandex Navigator, Yandex Maps and Yandex Transport.

As soon as a user's account balance reaches zero or goes into debit, a service called "SOS package" gets automatically activated at no extra cost. This ensures that WhatsApp and navigation services remain accessible. "SOS package" works not just in the subscriber's home region, but also when travelling elsewhere in Russia.

"Social" subscribers benefit from preferential conditions when travelling around the country, with free incoming and outgoing calls for Tele2 numbers in the roaming region. Internet traffic during domestic travel is deducted from the total available under the package.

PJSC Megafon's "Social basket" tariff

The "Social basket" package includes 100-200 minutes (depending on the region) of calls to all domestic fixed and mobile numbers nationwide, unlimited on-network calls, which are not deducted from the total minutes as they are in most such packages, 50 SMS messages nationwide, 5 GB of Internet traffic and unlimited messenger use. The unused balance is carried over for use the following month. A subscription costs RUB 4.8 per day, or RUB 147 per month.

The package is available to military personnel, pensioners, persons with disabilities, families with many children and students, on the basis of one number per passport.

Sberbank Telecom's "Active age" tariff

Sberbank's "Active age" preferential package allows eligible subscribers to communicate at a reduced cost with friends and relatives across the entire country. Bundling a number of services makes it possible to keep users' costs down and facilitates communication.

The package is priced at RUB 149 per month and includes the following preferential rates:

- free calls to Sbermobile subscribers nationwide;
- RUB 1.5 per minute for calls to subscribers of other mobile operators within the home region;
- RUB 5 per minute for other mobile operators nationwide;
- RUB 1 per SMS within the home region;
- RUB 2.5 per SMS nationwide;
- RUB 5.5 per SMS worldwide.

Annex 5: Relevant definitions for the ICT price baskets

Mobile-cellular sub-basket

The mobile-cellular sub-basket refers to the price of a standard basket of mobile monthly usage for 30 outgoing calls per month (on-net/off-net to a fixed line and for peak and off-peak times) in predetermined ratios, plus 100 SMS messages. The mobile-cellular sub-basket is based on prepaid prices, although postpaid prices are used for countries where prepaid subscriptions make up less than 2 per cent of all mobile-cellular subscriptions. The mobile-cellular sub-basket is largely based on the 2009 methodology of the Organisation for Economic Co-operation and Development (OECD) low-user basket, which is the entry-level basket with the smallest number of calls included.[118] Unlike the 2009 OECD methodology, which is based on the prices of the two largest mobile operators, the ITU mobile sub-basket uses only the largest mobile operator's prices.

Fixed-broadband sub-basket

The fixed-broadband sub-basket refers to the price of a monthly subscription to an entry-level fixed-broadband plan. For comparability reasons, the fixed-broadband sub-basket is based on a monthly data usage of (a minimum of) 1 GB. For plans that limit the monthly amount of data transferred by including data volume caps below 1 GB, the cost for the additional bytes is added to the sub-basket. The minimum speed of a broadband connection is 256 kbit/s.

Where several offers are available, preference is given to the cheapest available connection that offers a speed of at least 256 kbit/s and 1 GB of data volume. Where providers set a limit of less than 1 GB on the amount of data that can be transferred within a month, then the price per additional byte is added to the monthly price in order to calculate the cost of 1 GB of data per month. Preference is given to the most widely used fixed-broadband technology (DSL, fibre, cable, etc.). The sub-basket does not include the installation charges, modem prices or telephone-line rentals that are often required for a DSL service. The price represents the broadband entry plan in terms of the minimum speed of 256 kbit/s, but does not take into account special offers that are limited in time or to specific geographic areas. The plan does not necessarily represent the fastest or most cost-effective connection since the price for a higher-speed plan is often cheaper in relative terms

Mobile-broadband prices

ITU has been collecting mobile-broadband prices through its annual ICT Price Basket Questionnaire since 2012. To capture the price of different data packages, covering prepaid and postpaid services, and supported by different devices (handset and computer), mobile-broadband prices are collected for two different data thresholds, based on a set of rules.

For plans that are limited in terms of validity (less than 30 days), the price of the additional days is calculated and added to the base package in order to obtain the final price. For some countries, prices reflect the base package plus an excess usage charge (e.g., a base package including 400 MB plus the price for 100 MB of excess usage for a monthly usage of 500 MB), or a multiplication of the base package price (e.g., twice the price of a 250 MB plan for a monthly

[118] OECD. Working Party on Communication Infrastructure and Services Policy. Revision of the methodology for constructing telecommunication price baskets. March 2010.

usage of 500 MB). The plans selected represent the least expensive offers that include the minimum amount of data for each respective mobile-broadband plan. The guiding idea is to base each plan on what customers would and could purchase given the data allowance and validity of each respective plan.

BEREC's household baskets

For the purposes of defining its household baskets, BEREC proposes that the following main aspects be taken into account:

- Households should include both fixed-voice and fixed-broadband consumption.
- The fixed-broadband speed categories should be simplified (reduced from 8 to 4).
- One single fixed-voice consumer pattern should be used for all baskets.
- International calls and roaming should not be included in the baskets.
- Some households should include mobile broadband (one or two SIM cards).
- The main characteristic that differentiates mobile broadband should be the data consumption cap. Mobile-broadband tariffs should not be differentiated based on access speed, as this is not the focus of the benchmark.
- SMSs should not be considered in the comparison.
- Account should be taken of the fact that there is a positive relationship between the usage of data and that of voice.
- Households should be considered with and without pay TV. A package should be deemed to include pay TV if it includes multichannel TV services with more than five channels.

Based on the above, BEREC defines 17 types of household, as shown in Table A5.1 below.

Table A5.1: Households proposed by BEREC

Representative households		FBB range	FV	Number of SIM cards	Mobile BB range	Mobile Voice range	TV
FBB+FV	HH1	L	yes	0			no
	HH2	M	yes	0			no
	HH3	H	yes	0			no
	HH4	VH	yes	0			no
FBB+FV+TV	HH5	L	yes	0			yes
	HH6	M	yes	0			yes
	HH7	H	yes	0			yes
	HH8	VH	yes	0			yes
Low and Medium FBB+FV+MV+ MBB (+TV)	HH9	L	yes	1	L	L	no
	HH10	M	yes	1	L	L	no
	HH11	M	yes	2	M	M	no
	HH12	M	yes	1	M	M	yes
High and very high FBB+FV+MV+ MBB(+TV)	HH13	H	yes	1	M	M	no
	HH14	H	yes	1	H	H	no
	HH15	H	yes	1	H	H	yes
	HH16	H	yes	2	H	H	yes
	HH17	VH	yes	1	H	H	yes

FBB – Fixed broadband; FV – Fixed voice; TV – Pay-TV; MBB – Mobile Broadband
L – Low; M – Medium; H – High; VH – Very High

Source: BEREC

BEREC also proposes the following non-convergent baskets.

Table A5.2: Non-convergent baskets proposed by BEREC

FBB and MBB stand-alone services						
FBB		Tablet/modem/datacard		Individual handheld Mobile baskets		
				Name	MBB	MV
Name	Speed	Name	Datacap	I1	VL	L
FBB1	VL	MBB1	VL	I2	L	L
FBB2	L	MBB2	L	I3	M	M
FBB3	M	MBB3	M	I4	H	H
FBB4	H	MBB4	H	I5	VH	H
FBB5	VH	MBB5	VH	I6	H	L
				I7	VH	M

FBB – Fixed broadband; MV – Fixed voice; MBB – Mobile Broadband; I – Individual handheld mobile basket
VL- Very low; L – Low; M – Medium; H – High; VH – Very High

Source: BEREC

Annex 6: Examples of use of IXPs to fulfil WSIS action lines

Table A6.1: Examples of use of IXPs to fulfil WSIS Action Lines

WSIS outcomes	Proposed timing	ITU strategic goals and relevant resolu-tions	Linkages with the SDGs	Expected results of ITU activities
WSIS Action Line 2 – Information and communication infrastructure				
J: Optimize connectivity among major information networks by encouraging the creation and development of regional ICT backbones and Internet exchange points, to reduce interconnection costs and broaden network access	2016-2019	Goal 1 Buenos Aires Action Plan Objective 2 Regional initiatives	1, 2, 3, 4, 5, 8, 9, 10, 11, 16, 17	Expected results: – **Promoting the establishment of national and regional IXPs** – Promoting the development of local content and localized access – Promoting IPv4 to IPv6 migration. ITU activities: **– Assistance for the establishment of IXPs in regions/countries**

(continued)

WSIS outcomes	Proposed timing	ITU strategic goals and relevant resolutions	Linkages with the SDGs	Expected results of ITU activities
K: Develop strategies for increasing affordable global connectivity, thereby facilitating improved access. Commercially negotiated Internet transit and interconnection costs should be oriented towards objective, transparent and non-discriminatory parameters, taking into account ongoing work on this subject	2016-2019	Goal 1 Buenos Aires Action Plan Objective 2 Regional initiatives	1, 2, 3, 4, 5, 8, 9, 10, 11, 16, 17	Expected results: – Studies of policies that enable reduction of the prices paid by users for the different telecommunication services – Reduced cost of access to the international fibre-optic network, especially for landlocked developing countries and small island developing states – Promotion of cooperation and information sharing – Implementation of national programmes on conformance and interoperability, establishing cooperation agreements with regional laboratories to assist in this regard, and setting guidelines in accordance with international best practices, including regulatory frameworks that need to be considered – **Promoting the development, as appropriate, of national, subregional and regional IXPs, subject to national decision** – Study of legal and regulatory options and actions at the regional, subregional and local levels to be implemented in order to achieve an effective reduction in the cost of international mobile roaming for the user ITU activities – Affordable global connectivity

(continued)

WSIS Action Line 6 – Enabling environment				
C. Governments are invited to: i**. facilitate the establishment of national and regional Internet exchange centres;** ii. manage or supervise, as appropriate, their respective country code top-level domain name (ccTLD); iii. promote awareness of the Internet.	2018	Goals 1 & 4 ITU-D Objective D.3	9.c: Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020	Results of activities in this area include: – **More effective use of Internet through: (1) the deployment of facilities such as IXPs to make better use of the infrastructures at the regional level, (2) building capacity on ccTLDs and their effective use with the Member States** – **Increased capacity in Member States through the development of guidelines, resources and material to facilitate the establishment and running of national and regional IXPs** – Increased capacity in Member States through direct assistance and capacity-building activities for managing ccTLDs and other Internet resources, so that each country can take the necessary decisions regarding their ccTLD – Improved exchange of technical information between Member States and relevant organizations on issues related to ccTLDs and other Internet resources through events, direct assistance, etc. – Increased capacity in Member States through the provision of tools and guidelines for training policy-makers, regulators and other stakeholders on the benefits of socio-economic development that the Internet and related applications and services can bring to a country; this includes awareness of the related cybersecurity threats

Annex 7: ITU-D study group events on the COVID-19 pandemic

During the COVID-19 pandemic that started at the end of 2019, humanity has had at its disposal a new set of tools that can be brought to bear on the pandemic threat: the global telecommunication and ICT network, encompassing trillions of dollars' worth of infrastructure, billions of personal and corporate digital devices, and a vast stock of human capital in the form of digital skills, knowledge and work practices.

Moreover, the world's ICT infrastructure constitutes a core and indispensable input for global and national economies and the well-being of all societies. It is critical that the functionality of ICTs be maintained, and even extended, through the emergency and recovery phases of the COVID-19 pandemic.

There is no question that telecommunications and digital services are crucial for many people coping with the COVID-19 pandemic worldwide. Online education and remote working possibilities have brought a semblance of normality to uncertain times. Telehealth solutions now offload certain activities from healthcare systems, enabling doctors and nurses to focus on saving lives. Videoconferencing and social networks help us stay in touch with our families and friends. Media services and online games keep us entertained while passing hour after hour at home.

In this context, ITU-D organized a series of webinars, triggered by the rapporteurs and vice-rapporteurs of its study group Questions, to understand the impact, implications and trends associated with this new reality. Under this umbrella, ITU-D Study Group 1 Question 4/1 sponsored two webinars:

- Webinar on the economic implications of COVID-19 on national telecommunication/ICT infrastructure, held on 29 June 2020;[119]
- Webinar on the impact of unequal access to ICT infrastructure on the geography of COVID-19 diffusion, held on 29 July 2020.[120]

This annex provides an overview and summary of the main discussions and key takeaways of both webinars.

1. Webinar on the economic implications of COVID-19 on national telecommunication/ICT infrastructure

This webinar, which took place on 29 June 2020, focused on expert discussion of the economic impact of the COVID-19 situation on telecommunication/ICT providers. The discussion aimed to share analysis from the owners of telecommunication/ICT infrastructure regarding the potential economic repercussions associated with COVID-19.

Speakers

The webinar was addressed by the following expert speakers:

- Opening remarks:

[119] ITU-D. ITU Public Webinar on the economic implications of COVID-19 on national telecommunication/ICT infrastructure, 29 June 2020.

[120] ITU-D. ITU Webinar on the impact of unequal access to ICT infrastructure on the geography of COVID-19 diffusion, 29 July 2020.

  - Mr Stephen Bereaux, Deputy to the Director of the ITU Telecommunication Development Bureau (BDT)
  - Mr Arseny Plossky, Radio Research & Development Institute (NIIR), Russian Federation, and Rapporteur for ITU-D Question 4/1
- Speakers:
  - Mr Gerry Collins, Director of Mobile Network Operator Product Management, Intelsat
  - Mr David Geary, General Counsel, Caribbean and Central America, Digicel
  - Ms Gevher Nesibe Tural Tok, Regulatory Price Modelling Manager, Türk Telekom, Turkey
- Moderator:
  - Mr Jorge Martinez Morando, Partner at Axon Partners Group and Vice-Rapporteur for Question 4/1.

Summary of the discussion

The discussion revealed how the pandemic created massive, and sometimes surprising, impacts on operators' demand, revenue and costs. Here, we will look at the top three takeaways that emerged from the exchange.

1) Demand skyrockets and behaviours change

It is no secret that broadband traffic has surged over the past months due to the COVID-19 outbreak. This trend was fully confirmed by expert panellists, who reported traffic increases of between 20 and 80 per cent, although in some cases traffic has returned to levels closer to, though still above, pre-COVID times.

Gevher Nesibe Tural Tok, Regulatory Price Modelling Manager at Türk Telekom, reported an increase in fixed voice calls, contrasting with typical dips in traffic observed by fixed telecom operators across the world over the past few years.

Relevant changes in international traffic and international mobile roaming were highlighted by **David Geary**, General Counsel, Caribbean and Central America at Digicel. While international traffic had increased to later stabilize, roaming has declined by around 80 per cent. These observations are significant for operators in countries with high levels of tourism, especially smaller countries and islands for which roaming revenues represent a big piece of the economic pie.

Beyond the evolution of overall traffic, there have also been behavioural changes significantly affecting certain networks, remarked **Gerry Collins**, Director of Mobile Network Operator Product Management at Intelsat.

He said that spikes in videoconferencing, gaming, streaming and other media have boosted uplink traffic, which was typically well below downlink levels. He also noted how new geographical movements of people (e.g., to second residences in rural regions) are boosting traffic consumption in certain areas, with some seeing +100 per cent growth rates. According to him, this situation is putting a considerable strain on networks that were designed with pre-pandemic usage levels in mind.

2) Mixed views about revenue trends

The impact is much less uniform among countries and operators when it comes to revenues.

Mr Geary remarked that industry revenues have dropped by 10 to 20 per cent, a situation that may improve slightly to 5-10 per cent decreases for the full year. These results are most likely related to the relevance of lower roaming revenues combined with the sectoral significance of tourism in the economies of most of the countries where Digicel operates, with some of these nations facing the equivalent of an economic shutdown.

Conversely, **Ms Tural** noted how stronger demand for fixed-broadband lines as well as a favourable change in product mix has prompted Türk Telekom to revise its revenue forecasts slightly upward.

3) New infrastructure investments despite economic uncertainties

Despite the global economic recession expected to follow the COVID-19 crisis, telecommunication operators are reporting increased efforts to invest in additional capacity and the deployment of new network infrastructure and technologies.

Ms Tural reported a 10 per cent increase in expected investment for the year, with plans for new FTTH deployments and upcoming launch of 5G remaining intact.

Mr Geary explained that most networks were able to cope with upswings in traffic with relatively simple upgrades (e.g., software upgrades, activating new bands temporarily granted by regulators) that did not require unexpected relevant hardware investments.

He reported that Digicel is accelerating plans to deploy 4G in areas not yet covered as well as fixed wireless solutions, FTTH and undersea capacity, although there are prevailing uncertainties in the general investment climate.

Mr Collins explained, on the other hand, that operational limitations can cause potential delays. Even if software-based upgrades are simple to implement, challenges may arise if provisioning of hardware is involved. Certain devices or parts may be unavailable or late due to supply-chain disruption, or confinement measures may limit technicians' ability to perform outdoor installations.

Finally, it is important to highlight that none of the panellists reported any relevant impact on operational costs.

Looking ahead: The digital divide remains top priority

When the webinar discussion turned to the future, all speakers had one topic in mind: the digital divide. Even if ICT and digital services cushioned the impact of COVID-19 on many businesses and people, we cannot forget the billions of humans who cannot access or pay for them.

Stephen Bereaux, Deputy to the Director of BDT, stressed that 3.6 billion people in the world remain unconnected or without meaningful connectivity.

Many operators voiced their intention to redouble efforts to cover the unserved and to bring the newest technologies to as many people as possible, while improving clients' capacity and providing cheaper and even free tariffs in some cases.

The webinar also heard some examples of public bodies' and international organizations' efforts to provide funding and support for operators in this quest, such as the joint ITU-UNICEF Giga project that aims to connect every school to the Internet.[121]

Mr Geary also highlighted the important work being undertaken by the Broadband Commission for Sustainable Development, whose Working Group on 21st century financial models is examining the crucial question of how all digital ecosystem actors, including platforms, might contribute to financing sustainable broadband coverage.[122]

The expected economic downturn is likely to limit the combined efforts of both operators and governments. Despite these uncertain projections, it was made clear that universal access and affordability of high-quality connectivity must remain a priority for all countries, and that all players in the digital ecosystem must continue coordinating efforts to bridge the digital divide.

2. Webinar on the impact of unequal access to ICT infrastructure on the geography of COVID-19 diffusion

This webinar, which took place on 29 July 2020, focused on the impact of ICT infrastructure on COVID-19, through the role played by digital exclusion in terms of the effectiveness of public health policies.

Epidemiological evidence shows that the pandemic spreads across regions and nations following patterns of underlying social and economic inequalities as well as digital exclusion. At the same time, access to information and compliance with health policies depends on the cost, quality and understanding of online information on distancing modalities, sanctions and health risks. Digital exclusion, due to low quality and costly connectivity, coupled with a lack of digital skills, limits policy effectiveness, thereby driving observed inequalities. The invited experts shared their analysis in regard to:

- Digital exclusion, focusing on how to recognize the most digitally excluded locations and communities, even within otherwise well-connected regions
- Social distancing compliance, through crowdsourcing and social platform mobility data
- Possible links between lack of access to ICT infrastructure (physical, economic and cognitive) and public health policy effectiveness and COVID-19 reproduction rates
- Policy solutions aimed at bridging digital exclusion gaps and making public health policies more effective to reduce COVID-19 diffusion.

An open discussion with all participants explored the related challenges, opportunities and lessons learned.

The webinar was opened by **Ms Doreen Bogdan-Martin**, Director of the ITU Telecommunication Development Bureau (BDT), who emphasized the relevance of ICT infrastructure and bringing connectivity to the disconnected for reducing the disproportionate effects of COVID-19 for the digitally excluded.

Mr Arseny Plossky, from the Russian Federation, Rapporteur for ITU-D Study Group 1 Question 4/1, framed the webinar theme within the wider scope of the activities of the rapporteur group he is leading, and **Mr Emanuele Giovannetti**, from Anglia Ruskin University,

121 UNICEF and ITU. Giga.
122 ITU and UNESCO. Broadband Commission for Sustainable Development. Working Group on 21st century financing models.

United Kingdom, Vice-Rapporteur for ITU-D Study Group 1 Question 4/1, followed up on Ms Bogdan-Martin's global picture by introducing the key aims of the webinar, namely to forge a better understanding of the impact of digital exclusion on COVID-19 diffusion, whereby digital exclusion is reinforced through the multiple dimensions of soft and hard ICT infrastructures, including limited access, affordability, digital skills and cybersecurity.

Five distinguished panellists provided key insights on these issues:

- **Mr Jon Crowcroft**, University of Cambridge, United Kingdom, presented the different types and possible utilization of data sources and affordable connectivity technologies that can be employed to limit the extent of the pandemic and improve the effectiveness of public health policies.
- **Ms Alison Gillwald**, Research ICT Africa, discussed the key issues of affordability and diffusion afflicting African countries and how these constitute high barriers to successful public policies, with the result that incentives need to be devised to facilitate adoption/diffusion.
- **Mr Enrico Calandro**, from the University of Cape Town, South Africa, discussed in detail the impact of weak cybersecurity on the effectiveness of ICT infrastructure, focusing on "infodemic" as a possible factor compromising Africa's COVID-19 response.
- **Ms Jane Coffin**, Internet Society, and **Mr Andrea Pirrone**, OFCOM, United Kingdom, acted as discussants, presenting their combined perspectives on these topics and outlining policies, projects, interventions and regulatory experiences from their respective organizations, a pioneering users group and the often policy-leading UK sector regulator.

A Q&A session accompanied the presentations, with some of the questions put to the speakers by the moderator while others were discussed simultaneously on the webinar chat. Questions focused on the relevance of language, as underlined by **Mr Tim Unwin** through a publication shared in the chat, as well as the relevance of avoiding taxation of essential elements aimed at reducing digital exclusion.

The webinar was closed by **Ms Eun-Ju Kim**, then Chief of BDT's Digital Knowledge Hub Department. Ms Kim linked the results of the webinar to the entire series of study group webinars, drawing lessons learned and possible paths for future activities.

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