Wireless Broadband Spectrum Awards and Auctions in Africa

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Concerns about Auctions

1. Following digital dividends (DD) 1 & 2, is the demand higher than supply?
2. **Mozambiqu**e attempted to auction the 800, 1800z & 2600 MHz 2018. Only the 800 MHz was sold due to the relatively higher reserve prices set for the other two bands
3. In 2016 **Nigeria** attempted to auction the 2.6 GHz band. Only one operator acquired spectrum at the **reserve** price. For the others, the reserve price was deemed too high
4. 2018 **Tanzania** successfully auctioned the 700 MHz band, with a particular focus on placing coverage obligations
5. **Ghana**, between November and January 2018, also auctioned the 800 MHz
6. **South Africa** is currently actively preparing to host a spectrum auction

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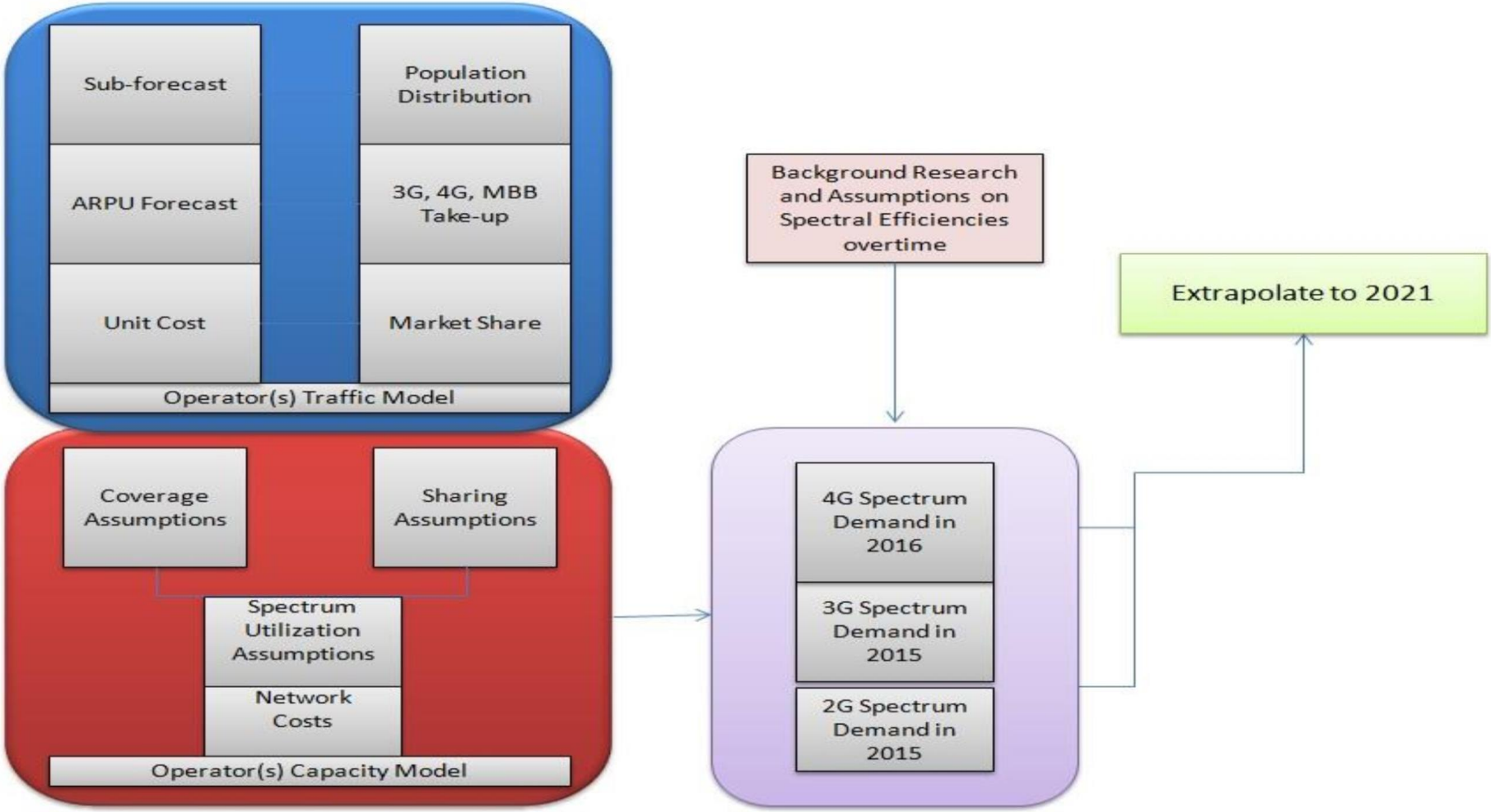
Main References of the Auctioning

1. Reference[1] ITU-D Resolution 9 Final Report; 2014
2. Reference[2] ITU-D Guidelines for the Review of spectrum pricing methodologies and the preparation of spectrum fees schedules; 2016
3. Reference [3] ITU-D ITU Statistics; June 2019
4. Reference [4] ITU-R Report SM.2012-6 (06/2018) Economic aspects of spectrum management
5. Reference [5] ITU-D Economic contribution of broadband, digitization and ICT regulation, econometric modelling for Africa; 2019
6. Missing line
7. Reference [7] ITU-D Exploring the value and Economic Valuation of spectrum; April 2012
8. Reference [8] Ofcom, Annual Licence Fees for 900 MHz and 1800 MHz frequency bands; 2018
9. Reference [9] Ofcom Statement on the making of certain regulations in connection with the award of 700 MHz and 3.6-3.8 GHz spectrum; 21 May 2019
10. Reference [10] Mazar H., Wiley book Radio Spectrum Management: Policies, Regulations and Techniques; sub-chapter 4.3 Economic Environment; 2016
11. Reference [11] GSMA Effective Spectrum Pricing: Supporting better quality and more affordable mobile services February 2017
12. Reference [12] GSMA Spectrum pricing in developing countries, Evidence to support better and more affordable mobile services; July 2018
13. Reference [13] GSMA Auction Best Practice GSMA Public Policy Position May 2019
14. Reference [14] Plum Insight, Vorsprung durch Econometrics: what drives spectrum value?; April 2016
15. Reference [15] Mazar H., Common Wealth Workshop, Spectrum Re-Farming: Framework and Methodology; Yaoundé; 2 Nov. 2016
16. Reference [16] Mazar H. Broadband RF Spectrum Audit, Lusaka; 19 April 2017
17. Reference [17] Mazar H. Broadband Pricing Model, Lusaka; 19 April 2017
18. Reference [18] Coleago Consulting Ltd Increasing mobile broadband coverage through spectrum awards; Sept. 2019

Forecast of spectrum demand for cellular services; Reference ITU-D Guidelines [2] fig. 8



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Assignment Methods:
Lotteries, Secondary Trading & Auctions

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Different frequency assignment methods; ReferenceRes 9 2014 [1] pp. 33, 34

	Lottery	Auction	Secondary spectrum trading
Applicability	Rapid dissemination of new technologies and services	Efficient dissemination of new technologies and services	– Transactions in accordance with established procedures – Prior agreement of competent authority is required
Advantages	Speed Transparency	– Price competition alone used to select licensees – Transparency and fairness – Avoids corruption and collusion – Maximization of revenues	– Spectrum efficiency: existence of secondary spectrum trading market may encourage operators to use frequencies intensively & efficiently to sell off part of their allotments on the market – Flexibility of frequency allocations, by establishing a direct re-allocation mechanism
Disadvantages	Large number of applicants	– May involve high license costs, preventing rapid exploitation of spectrum, deployment of new networks & services, & inhibiting competition – Success of auction depends largely on its design	– New administrative arrangements required for resale of RF – Distortions in competition due to price differences between frequencies for competing services – Lack of coordination at borders
Risks	– Random selection of operators – Arbitrary prices obtained for frequencies if no **reserve price** set	Non-simultaneity of auctions may result in non negligible distortions and in cross-subsidies	Speculation by licensees

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Lotteries; Reference ITU-R SM.2012 [4]

1. Lotteries represent a fast, relatively inexpensive & transparent means of choosing between candidates with very similar or equivalent qualification
2. Lotteries should be preceded by an official qualification process to select candidates to participate in it, otherwise recourse to such a method could act as a brake on development of the sector. For example, participants in lotteries may not always intend to operate the telecommunication services, but may wish simply to resell the frequency licenses obtained for a profit
3. Some lottery winners may not have the financial resources to bring a service into operation

Secondary Spectrum Trading; Reference SM.2012 [4]

1. Spectrum trading was firstly proposed in 1959 by Ronald Coase where he suggested that spectrum assignments should be treated in a way similar to property rights.
2. Secondary spectrum trading is a market-based mechanism whereby the purchase and sale of equipment
3. Licenses or spectrum utilization (with associated rights and obligations) previously allocated by the spectrum manager can take place between different parties for a given fee
4. Operation may be effected directly between parties or via an intermediary

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Auctions; Reference SM.2012 [4]

1. In auctions, it is ultimately the market that determines the spectrum license holder
2. In many auctions, bidders pre-qualify based on criteria similar to those applied in the comparative evaluation methods. Thus, participation in some auctions is restricted to those bidders with proven technical and financial resources
3. Auctions organized to allocate frequencies show that it is important to apply strict criteria at the technical, financial and commercial levels in order to determine the eligibility of bidders
4. Some successful bidders may subsequently find themselves unable to finance their overly ambitious bids. Other bidders may have neither the technical means nor the intention to operate the telecommunication services using RF for which they made a bid which was ultimately successful

Economic Theories of **Auctions**: Econometrics & Benchmarks

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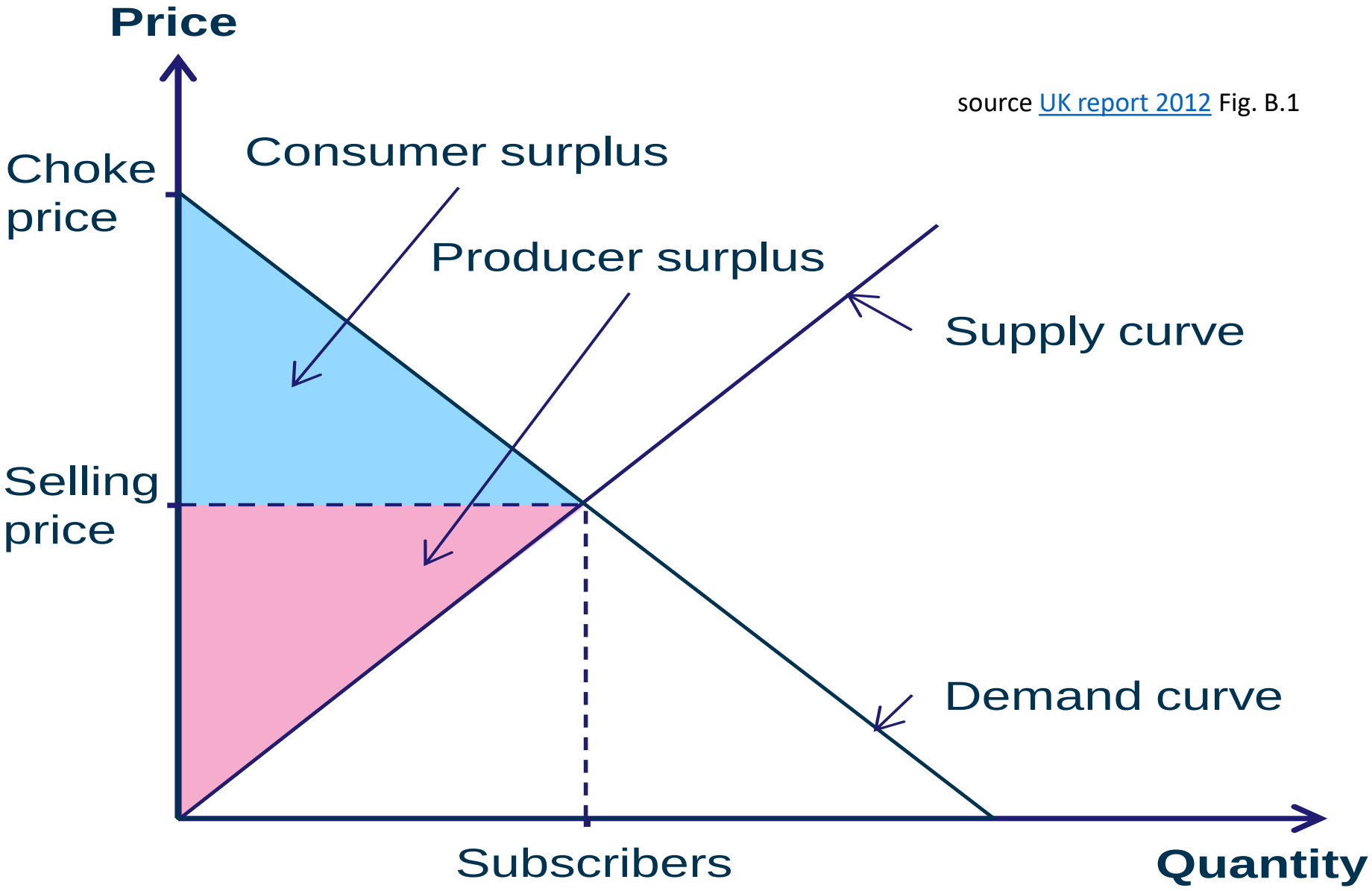
Vision of Ronald Coase : see Mazar 2016 4.1.2.2 p. 117 [10]

1. Auctions are applicable only when the demand for spectrum exceeds the available supply.
2. Ronald Coase famously noted the inflexibility of spectrum allocation and the near-certainty of suboptimal allocation; 'the allocation of resources should be determined by the **forces of the market** rather than as a result of government decisions' Ronald Coase, 1959; Nobel Laureate 1991.
3. Coase's solution was not to move away from exclusive-use licensing, but to extend it further and treat these licences as **property rights** that could be **bought and sold**. Coase claimed that no matter how these rights were initially allocated, mutually beneficial trades would lead to an **economically efficient allocation**.
4. Auctions have become the most common way in which spectrum rights have been assigned in the developed world and many countries have permitted the **trading** of spectrum licences

Illustration of consumer and producer surplus

source UK report 2012 Fig. B.1



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Three different methodologies to estimate the relative value of spectrum bands

1. Benchmarking indicates the mean or median value of the observations
2. Econometric analysis uses statistical methods for pure comparison between bands
3. ITU Indicators

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Econometric variables; Reference [11]

Variable	Description
Constant	Constant term (included as standard in regression analysis)
Bandwidth sold	Quantity of spectrum being auctioned. More contiguous bandwidth is expected to be more valuable.
Licence duration	Length of the licence
GDP per capita	Measure of the country's wealth
TDD spectrum	Dummy variable9 for time-duplexed spectrum
Region	Dummy variables for regions
Year	Dummy variables for years
BW	Bandwidth sold per operator (can indicate auction competitiveness)
>3 GHz spectrum	Dummy variable to indicate spectrum above 3 GHz
Population density	Country's population divided by its land area
Spectrum stock	Quantity of spectrum already released or mobile broadband
Cell radius	Maximum cell radius a frequency can support
Supported devices	Number of distinct mobile devices supported by a spectrum band
Auction format	Dummy variables for the auction's format
Mobile market HHI	Herfindahl-Hirschman Index (HHI) measures market concentration

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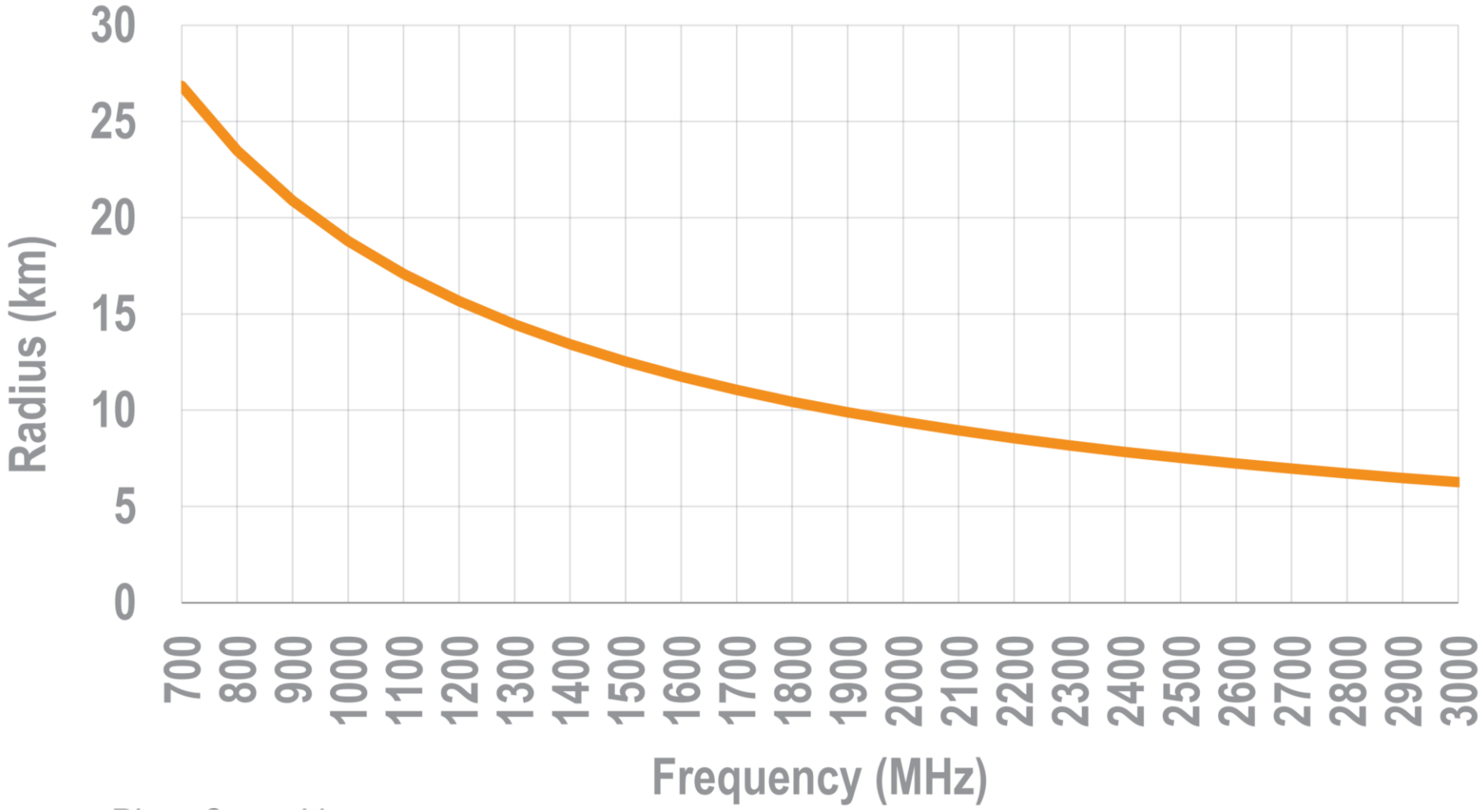
Maximum cell radii, by frequency band; Reference Plum [11]



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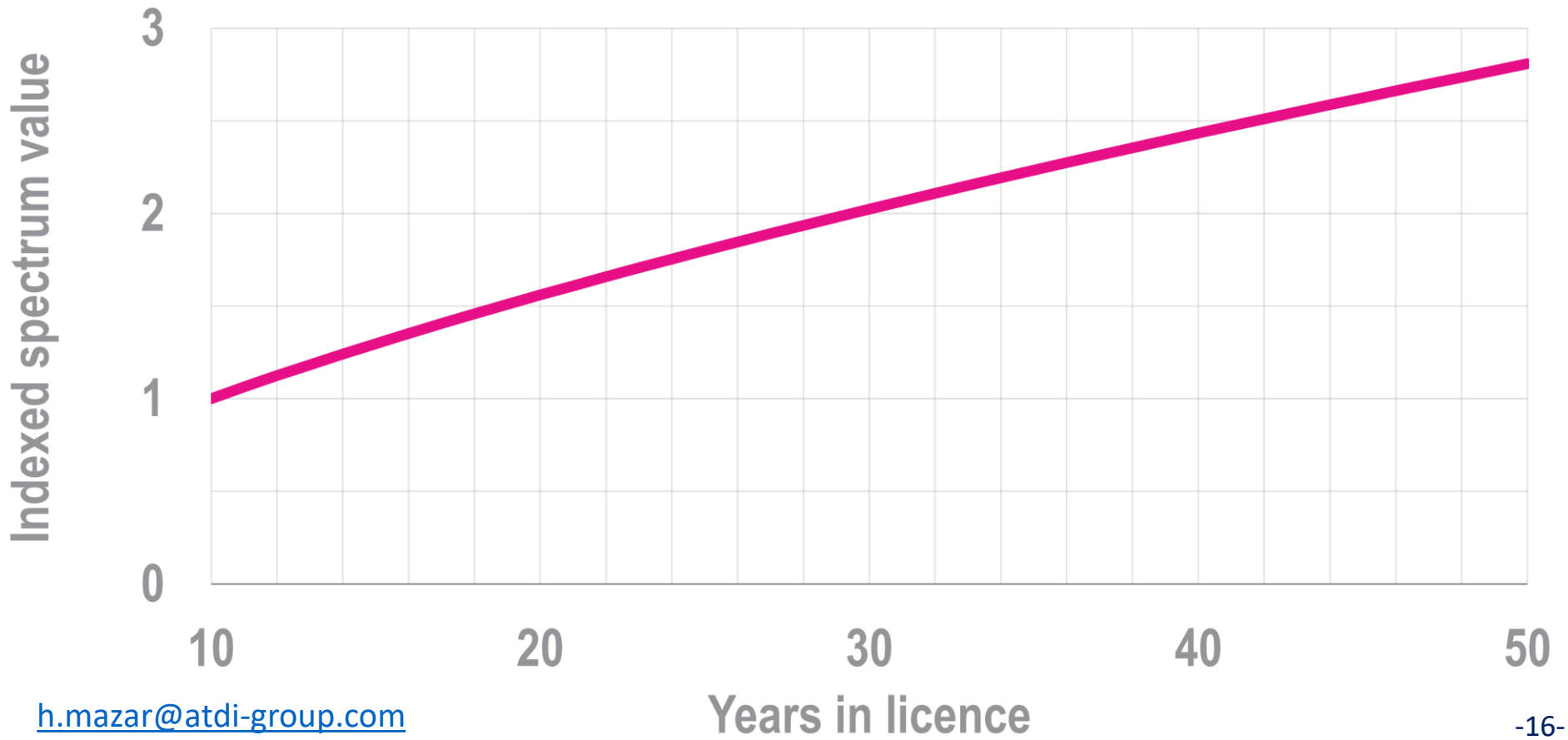
Value of spectrum vs. years in licence; Reference Plum [14]

- the longer the licence the more valuable it is
- Subject to diminishing returns: doubling the licence duration adds only 56% to the licence value diminishing returns
- Reflects uncertainty about the future: improvements in spectral efficiency (the amount of information that can be carried by the spectrum) make additional spectrum less vital in meeting future demand for data
- The fig is indexed to a 10-year licence



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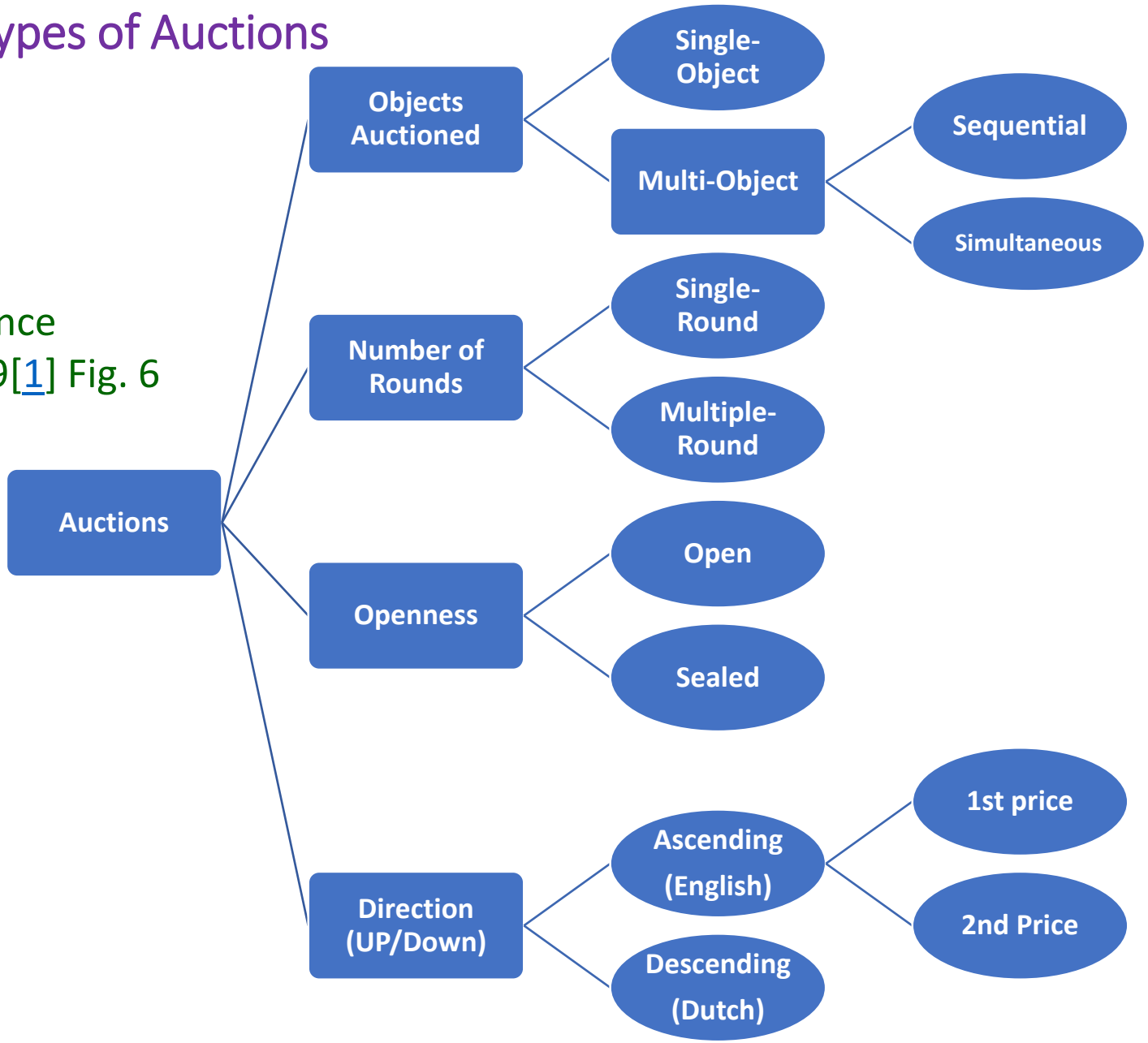
Market-based economic value; Reference ITU-D BC [2] p. 4

1. Auctions and spectrum trading: participants in a competitive auction or engaged in a spectrum trade determine the price
2. Auction: economic value is reflected in the price paid by the successful bidder, which will meet or exceed the **reserve price** established for the auction. It will be composed of **bidding deposits** paid at the outset and the applicable winning price
3. Spectrum trading reflects the economic value
4. Spectrum fee includes transaction costs imposed on the participants in trade
5. Spectrum prices are determined through market mechanisms, price levels at a given time influenced by a number of factors such as geography, competition amongst potential users, advances in technology, the present value of cash flows

Types of Auctions

Different types of Auctions

See Reference
ITU-D Res 9[1] Fig. 6



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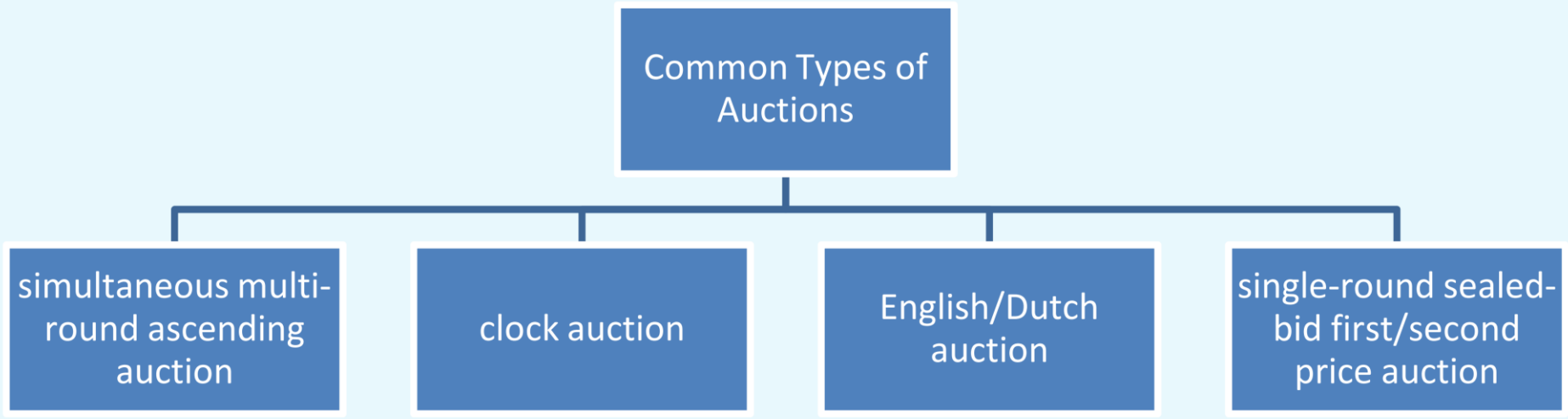
Common types of auction; Reference[1]

Figure 7: Common types of auction

See Reference[1] Fig. 7/1



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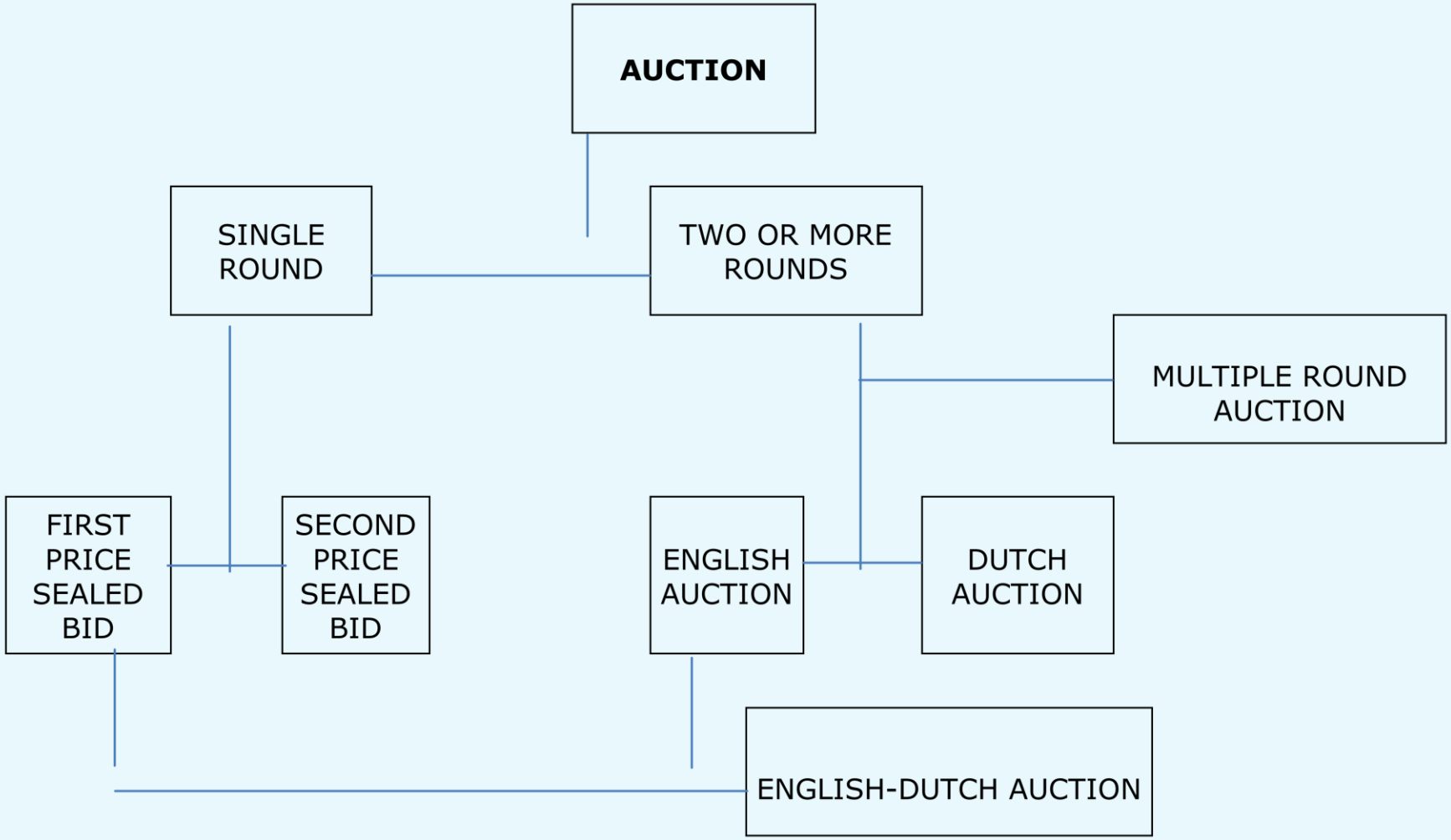
Most widely-used Auctions; Reference ITU-D D Res 9[1]



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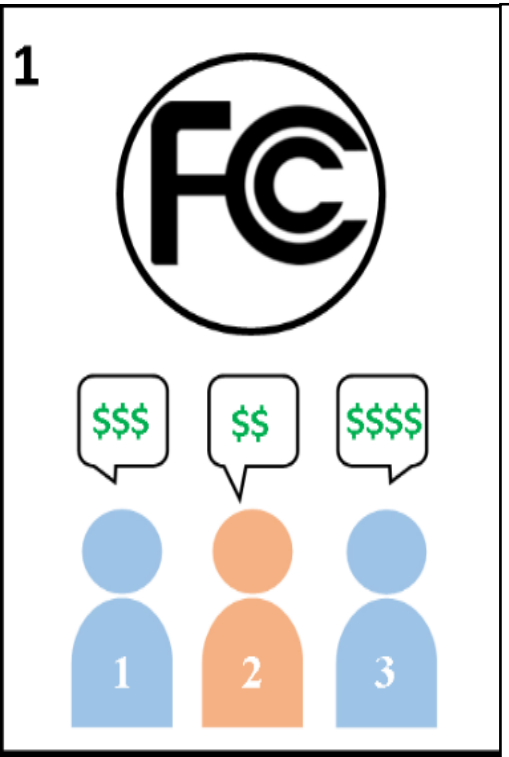
Reverse auctions; USA Doc ITU-D SG1RGQ/209 Sep. 2019

1. Promote last mile connectivity for its Rural Digital Opportunity Fund in the future
2. Last mile, the final stretch of connectivity between broadband providers & individual consumers i.e., the physical links directly to homes and businesses. Geographic barriers pose an added challenge to connectivity, especially for low-income and rural consumers
3. FCC used a reverse auction to efficiently & effectively allocate limited government funds to providers for last mile broadband (BB) deployment & connectivity in hard to reach places. Reverse auction serves as one example that aims to promote affordable access to broadband for all
4. Providers compete to build out BB to a specific number of locations in an unserved area for the smallest government subsidy. Bids represent amount of government support that a BB provider would accept in order to commit to providing BB coverage, while still making a profit
5. The BB provider that bids the lowest, after adjusting for quality, is awarded the funding and is required to cover 100% of the locations identified by the FCC in the areas it won within a specified number of years

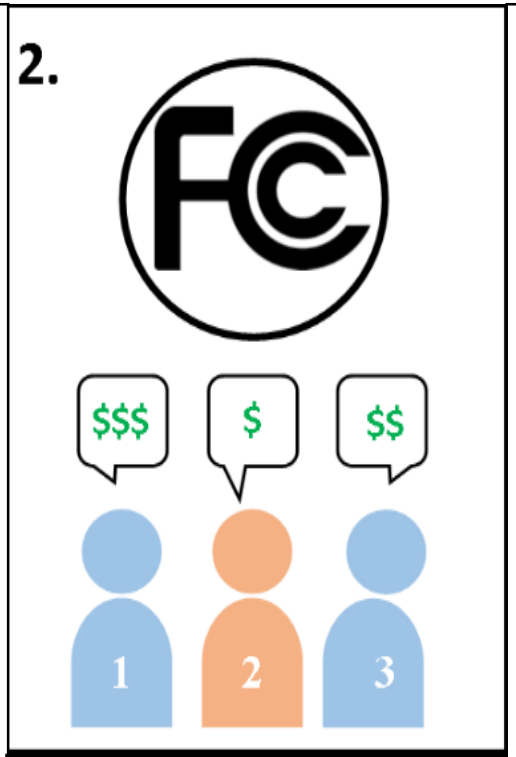
Reverse auctions; USA Doc ITU-D SG1RGQ/209 Sep. 2019

1. FCC promotes last mile connectivity by using rural broadband "reverse auctions."
2. FCC has successfully used multiple approaches/techniques to fund broadband infrastructure projects in order to enhance nationwide broadband connectivity and close the digital divide.
3. FCC) used a reverse auction to efficiently and effectively allocate limited government funds to broadband providers for last mile broadband **deployment** and connectivity in hard to reach places.
4. The Auction encouraged fixed broadband deployment in high cost and rural areas by giving broadband providers subsidies to offset infrastructure and service costs.
5. Winning bidders must cover **40% of the locations** for which they were awarded funding within **three years** of the auction at the performance tier and latency they agreed to during bidding. The broadband providers must then increase broadband coverage by **20% each following year**, meeting full coverage by the **sixth year**

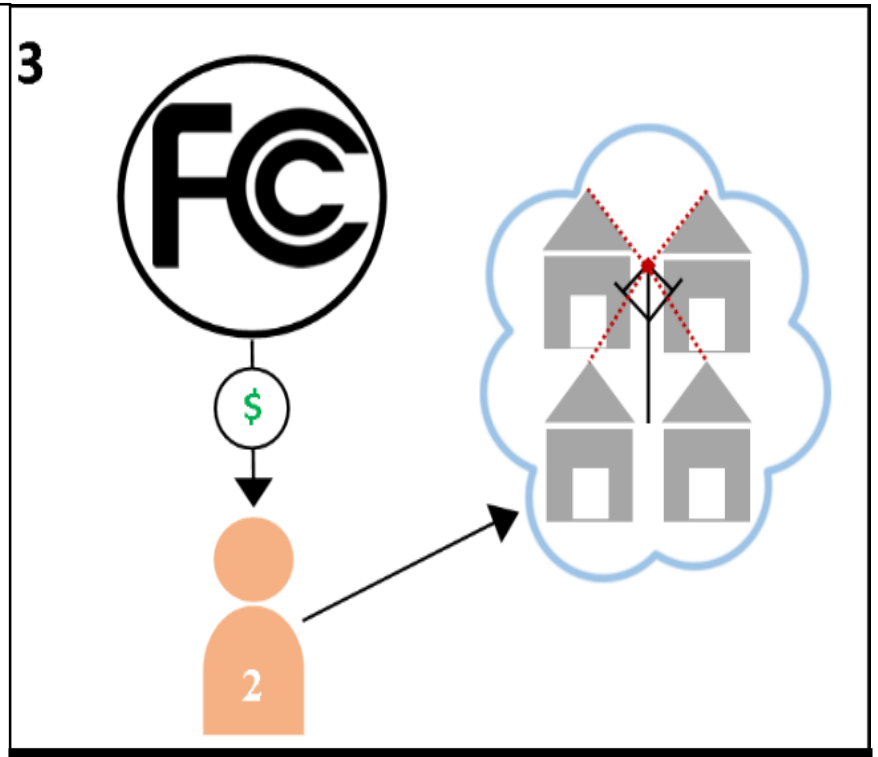
Reverse auctions; USA Doc ITU-D SG1RGQ/209



Broadband providers present initial bids for government funding to provide coverage in an area



Broadband providers compete by lowering their bids (the subsidy required to provide coverage)



The broadband provider offering the lowest bid will receive FCC funding to build infrastructure and provide coverage in the area

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Reverse Auction ; USA Doc ITU-D SG1RGQ/209

Performance Tier	Speed	Usage Allowance	Weight
Minimum	≥ 10/1 Mbps	≥ 150 GB	65
Baseline	≥ 25/3 Mbps	≥ 150 GB or U.S. median (whichever is higher)	45
Above Baseline	≥ 100/20 Mbps	2 TB	15
Gigabit	≥ 1 Gbps/500 Mbps	2 TB	0

High Latency ≤ 750 ms & MOS of ≥ 4 **Weight** 25

1. MOS refers to Mean Opinion Score, which quantifies the quality of voice services. The quality of a voice call can be affected by the latency. FCC requires high latency bidders to meet a MOS of four or higher to guarantee quality voice services are deployed to consumers alongside broadband

Reverse auctions advantages; USA Doc ITU-D SG1RGQ/209

1. Adjusting bids based on the QoS (speed, usage allowance, latency, etc.), a reverse auction can encompass many types of services at the same time (satellite, fixed wireless, fiber, etc.) and find the service that is the best fit for each area
2. Considering many unserved and hard to serve areas at once, a reverse auction can efficiently distribute government funds to those areas where government support will make the greatest impact.
3. The FCC's Connect America Fund Phase II Auction (CAF II Auction) successfully used a reverse auction solution to help bridge the digital divide between urban and rural FCC Staff Paper, *Maximum Impact for Minimum Subsidy: Reverse Auctions for Universal Access in Chile and India*, (2010)

The Author doesn't find that reverse-auction is advantageous to the German way, obligating Bidders to firstly cover rural and remote areas

Increasing mobile broadband coverage through spectrum awards; Coleago Consulting Ltd; Ref [18]; Sep. 2019

1. Germany has used “reverse roll-out requirements”. In the 2010 German 800 MHz auction, four classes of locations were identified with each assigned a different level of priority. The first priority class involved providing coverage to the smallest towns, the second priority class involved slightly larger towns and so on
2. Roll-out could not commence in a lower priority class until the previous priority class has been covered by 90%
3. The obligation could be met through jointly providing coverage with another operator based on “economic cooperation”
4. Five years later the obligation had to be met entirely by the individual operator

Auctions Principles:
Legal, Economic & Engineering

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Legal principles; Reference SM.2012 [4]

1. Radio Frequency (RF) spectrum is the property of the State. Thus, any spectrum occupancy relating to non-governmental activities is considered to be private occupancy
2. Belonging to the State's public domain, spectrum is managed in the interests of the national community
3. As the owner of the spectrum, the State has the right to require private occupants thereof to pay *spectrum fees* (known also as *spectrum occupancy fees*, *frequency availability fees* or *spectrum usage fees*, annual licensing fees or simply as *fees* where there is no ambiguity)
4. Planning, management &monitoring of the spectrum are carried out by the State or by entities to which the State has delegated such responsibilities
5. Lawful to require, that private spectrum occupants also pay *administrative fees* (known also as *frequency management fees* or *service fees*, as well as *administrative charges* to cover all of the costs arising out of spectrum planning, management & monitoring activities
6. Spectrum & administrative fees should respect the rules of **transparency**, objectivity, proportionality and non-discrimination. Where transparency is concerned, it is particularly important that the rules governing the establishment of fees be **simple** and readily understandable by all concerned
7. The rules governing the establishment of fees must be relatively stable over time in order to provide spectrum occupants with the necessary visibility and legal security
8. In return for the fees they pay, users enjoy **protection** under the relevant provisions of the regulations in force.
9. By contrast, users of freely accessible frequencies (Short Range Devices used, for example, for Wi-Fi, Bluetooth, amateur radio and radio-controlled models) are **not protected** & should therefore **not be required to pay fees**. A reality principle unites with this legal principle to dictate that fees should not be applied to freely accessible frequencies

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Ofcom A2. Draft statutory instrument – General trading regulations Ref. [2]

Official changes derived from Auctions

1. 2019 No. 950 Electronic Communications The Wireless Telegraphy (Spectrum Trading) (Amendment) Regulations 2019
2. 2019 No. 951 Electronic Communications The Wireless Telegraphy (Mobile Spectrum Trading) (Amendment) Regulations 2019

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Economic principles; Reference [4]

1. RF is a limited &, in some cases, scarce resource. The main objectives of the manager are to secure both optimum spectrum occupancy and effective
2. frequency utilization
3. The reasons & aims for spectrum & administrative fees are different. That difference should thus be reflected in two distinct approaches for establishing each kind of fee
4. Purpose of administrative fees is to pay for the service rendered by authorities
5. Purpose of spectrum fees is:
   I. enable achievement of the budgetary objective set by the authorities
   II. not clash with the economic objectives of the authorities in regard to national development and the development of new services
   III. take account of all the benefits that occupants derive from the spectrum
6. Constitute a tool for spectrum management
7. Fees constitute financial resources for the State & for the spectrum manager. The level at which they are set reflect inflation & the evolving status of the spectrum manager's budget

Advancing Auctions

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Design of a Competitive Auction or Tender; Source Common Wealth, 2016 Mazar

1. Draft rules for use of the spectrum: licence parameters; coverage and QoS obligations, bilateral and multilateral agreements; obligations relating to the mutual interference caused to/by other services in the band or in adjacent bands; **technology neutrality**
2. Technology neutrality allows for license holders to evolve their technology and the services delivered as markets develop
3. Clarification of the international situation: interference that may be caused to the notified licensed network in border areas, what are the commitments taken by the government to protect the services of other countries and those taken by other governments to protect the licensed network
4. Obligations to protect the public human hazards, against electromagnetic waves
5. Setting licence terms and conditions (e.g. fees, term limits, renewal criteria)
6. Setting auction rules
7. Publication: transparency, openness and responsiveness
8. Check for potential bidders' qualifications in terms of financing, operational experience in other countries, and management capabilities

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Auctions' mechanisms: Reference [2] p. 3

1. ***Administratve*** mechanisms include administratve incentve pricing (AIP) and spectrum fee formulas that recover regulator costs of spectrum management
2. ***Market-based*** mechanisms for setting spectrum prices typically involve a market exchange such as spectrum auctions and (in the secondary market) spectrum trading

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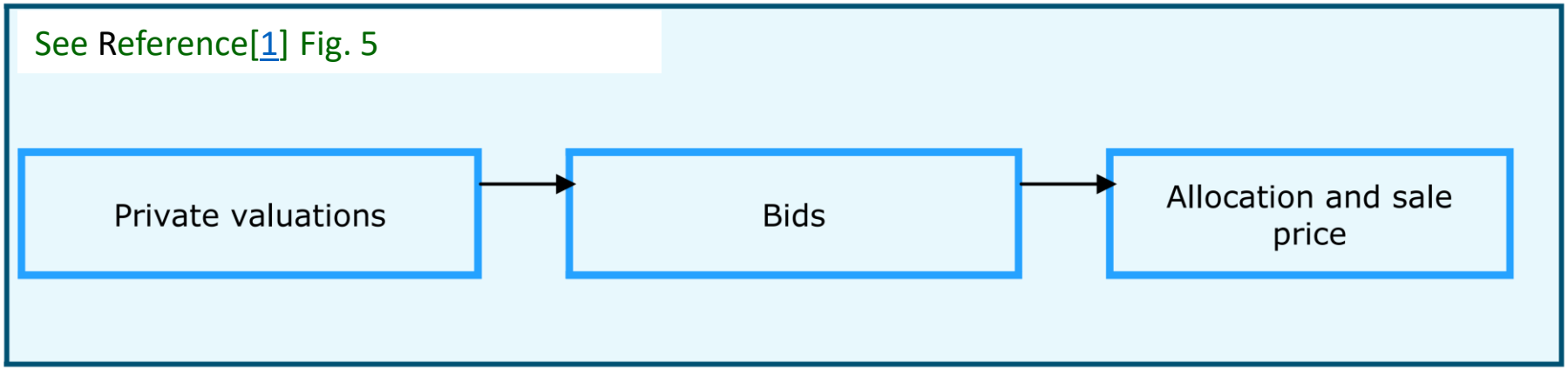
Operating principle of an Auction; Reference[1]

1. In a world of perfect information, the higher the number of participants, the higher the sales price
2. Sale price is equal to the expectation of the highest private valuation
3. During the auction, participants indicate the amount they commit to pay to acquire the object for which the auction is organized. The amount may be indicated in a sealed envelope, orally in public, by Internet, etc.
4. In cases where spectrum is auctioned, its value is revealed in the market clearing prices

See Reference[1] Fig. 5



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Best Practices; Reference Mazar Yahounde [15]

1. Fees for RF licenses are set according to the costs associated with the management and administration of all related processes.
   Administration handles:
2. RF allocations to radio services
3. Assignment of licence and RF to Tx Stations
4. Fee collection: RF License & annual fees
5. Equipment Type approval
6. Coordination with neighbour countries (no borders to the RF waves)
7. Notifying ITU to the Master International Frequency Register (MIFR) e.g. http://www.itu.int/ITU-R/eBCD/ePub.aspx ???
8. External relations: toward ITU, International and Regional orgs see http://eprints.mdx.ac.uk/133/2/MazarAug08.pdf p. 179
9. Use cartography to ease sharing

Economic Impact & Spectrum Price

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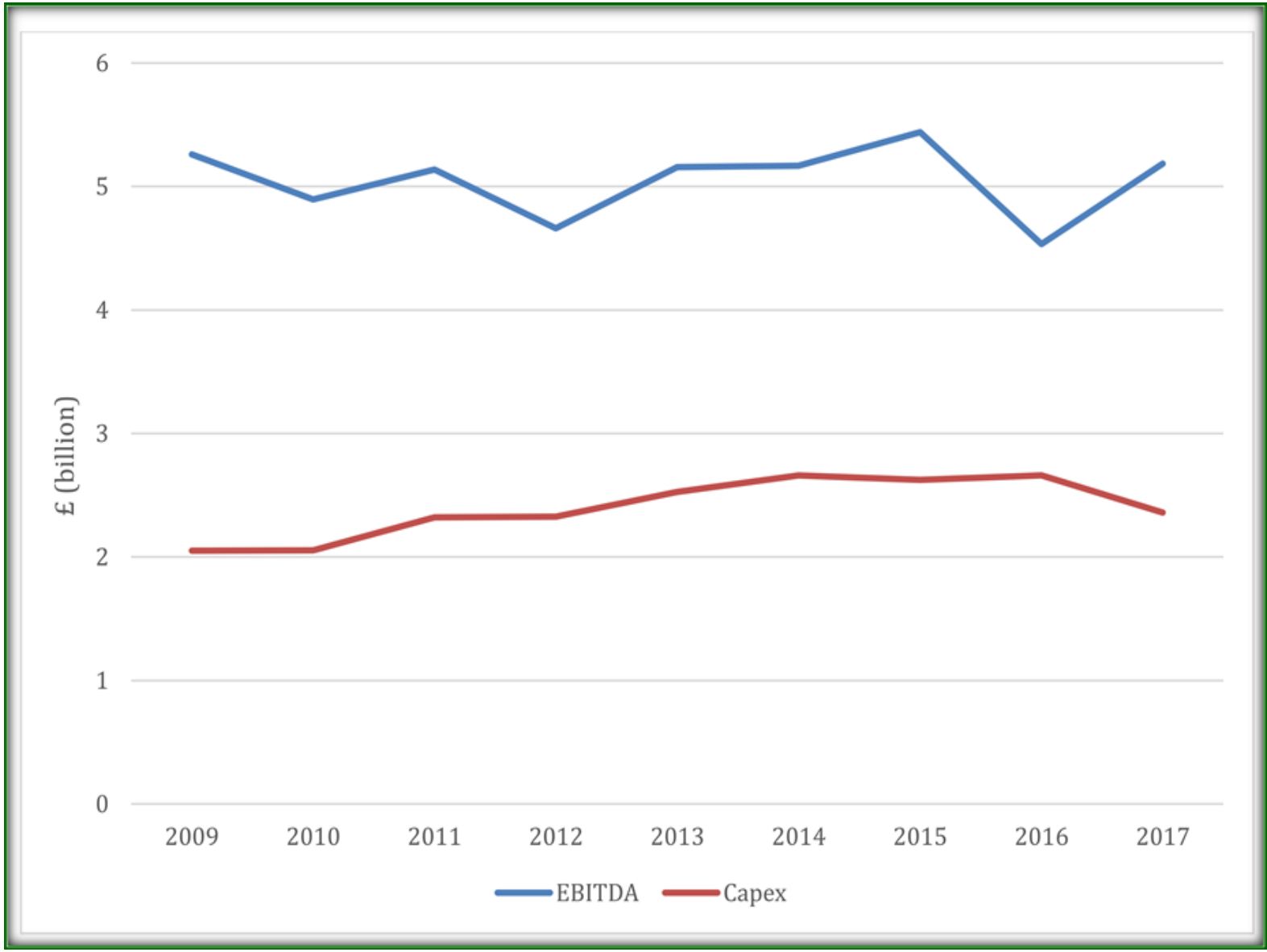
Aggregate capex & EBIDTA for the 4 UK MNOs, 2009 to 2017 (April 2018 prices) Ofcom Ref. [8] p. 54

CAPEX (capital expenditures) & EBITDA (earnings before interest, taxes, depreciation, and amortization) accumulated 2009 to 2017 (price April 2018)



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Regulators may distinguish fees, among: Reference [10]

1. RF services: broadcasting (audio and video), mobile, fixed links, satellites…
2. Categories of terminal equipment & radio transmitters, licences examinations, inspection certificates & certifications (conformity assessment), human-hazards measurements,
3. Issue of type approvals, not for European Directive 1999/5/EC (R&TTE) signatories

Economic Valuation of Spectrum; Ref. ITU-D BB [7]

1. *Spectrum assignment* – Valuation is often instrumental in determining threshold or reserve prices in spectrum auctions or tender processes, and bidders can be expected to estimate spectrum value in designing their bidding strategies
2. *Spectrum trading* – Secondary markets involve both suppliers and customers, and both seek to determine valuation in order to arrive at an optimal price point for their businesses
3. *Spectrum fees* – Regulators need to estimate spectrum value in order to set recurring fees (or even up-front fees) that go beyond their regulatory costs (i.e., fees set based on *administered incentive pricing* (AIP)
4. Unlicensed equipment- importer doesn't pay

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Factors affecting the RF value; Ref. [7]

1. Factors are detailed at Table 2 ITU-D 2012, Alden J., *Exploring the Value and Economic Valuation of Spectrum*.
2. Intrinsic factors are propagation characteristics, sharing capacity, profusion of uses, global and regional harmonization and international constraints. All other factors are extrinsic.
3. Physical factors are geography and climate
4. Socioeconomic factors are demographics, population density, income distribution, economic level and growth rate, political stability, absence of corruption and rule of law
5. Policy & regulation factors include the existence of an independent regulatory agency, favourable investment & customs laws, competition policy, infrastructure sharing, rules of protection of the public against electromagnetic waves, open access rules, technology neutrality, protection against interference, coverage obligations, spectrum caps, auction rules and bidding credits/set-asides, transparency, licensing framework and dispute-resolution mechanisms

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Tariff has two components: Reference [10]

1. **One-off licence charge** is the authorization to execute the telecommunication service. It reflects the **costs** that occur once in connection with issuing the licence (e.g. for frequency planning & management, international co-ordination, administrative costs & investment in equipment); the indirect costs of staff departments such as the communications department and legal department are also part of that tariff. Often, these indirect costs are covered by the general budget. The one-off licence-fee is cost-oriented and is not to be confused with the amount to be paid in case of an auction. The licence-fee can reflect the benefits of exploitation of the licence, such as a percentage of turnover or the profits, as a result of implementing the licence; this component is useful for cellular communications and digital TV; and
2. **Annual costs** are paid every year by licence holder for enforcement and monitoring costs. These are activities which contribute to safeguard the use of the frequencies, ensuring compliance with the rules, relating to the use of the airwaves and of equipment. The Minister or the Parliament approves the tariffs. Tariffs should be published.

Principles for Licence fees; Reference 2012 [4]

1. Decisions & changes related to fee collection should be undertaken transparently thru consultation with users & industry
2. Fees should consider the value of the spectrum
3. Fee mechanisms should be easy to understand & implement
4. Fees should not be an impediment to innovation & use of new radio technologies, or to competition.
5. Fees should support the attainment of the spectrum manager's national goals and objectives

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Fees based on spectrum management costs; Reference R SM.2012 [4]

1. Direct & indirect spectrum management costs
2. Fees based on user's gross income
3. Incentive fees
4. Opportunity cost fees

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Factors to compare or transpose fee levels Reference [4]

Socio-economic	**Operator's propensity to pay fees**
GDP or GDP/inhabitant	increases in line with GDP since the potential turnover increases with GDP
Total population; population density	increases with population size: potential turnover increases with population size
Geographic distribution of the population (concentrated in a few areas, dispersed, ...)	increases with concentration: cost of network deployment decreases with concentration
Country size, relief and degree of insularity	decreases in line with the country's size & relief: cost of network deployment increases with those parameters.
	Characteristics of authorizations or licences
Period of validity of authorizations	Operator's propensity to pay fees increases with the period of validity since equipment amortization is better assured and the final years of operation are generally far more profitable than the initial years
Stability of operating conditions	Operator's propensity to pay fees increases with the level of stability since instability leads operators to cover themselves against the inherent risks
Renewability of authorizations	Influence of this factor is similar to that of the period of validity
	Content of authorized operator terms of reference
Coverage of the territory in question Quality of Service (QoS) Participation in universal service Participation in research and development efforts Other obligations (free calls to certain numbers, number portability, spectrum monitoring, ...)	Such obligations increase the operating costs with the degree to which they are mandatory and has a corresponding negative effect on operator's propensity to pay It is necessary to analyse the degree to which each such obligation is mandatory, taking particular account of the following: – conditions governing international access may influence QoS – existence of local practices/customs such as cost-free service for certain categories of user, the effect of which is to reduce the operating result

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Paradigm Shift

See Reference ITU-D Res 9 [1] Fig. 3

Administrative paradigm	Technical paradigm	Economic and financial paradigms
– Unused spectrum: wasted	– Spectrum: scarce resource	– Spectrum: resource of (in)estimable value
– Provide basic services	– Accommodate more services in less spectrum	– Accommodate new services with minimum interference and at the correct value (cost)
– Who?	– Who? – Where? – What? – When? – How?	– Who? – Where? – What? – When? – How? – How much?
Administrative parameters	**Technical parameters**	**Economic and financial parameters**

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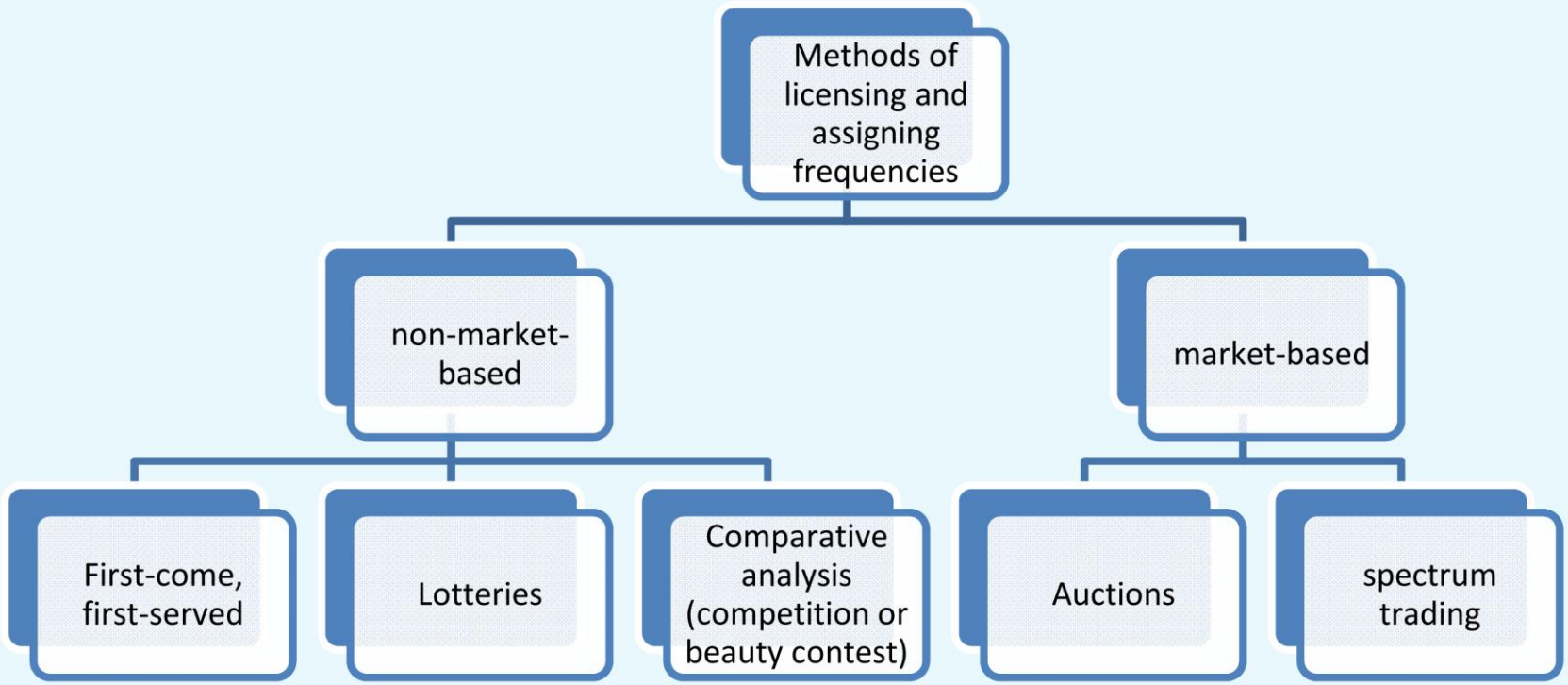
Methods of licensing & assigning frequencies

See Reference[1] Fig. 4



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Auctions Advantages & Disadvantages; Reference[1]

Advantages	Disadvantages
• Relative maximization of revenue for the government • Optimization of spectrum (economic efficiency) • Opening up to competition • Relative speed of process • Transparency	• Limited technical requirements • Does not necessarily achieve the highest social value • A poorly qualified candidate may win the license • Successful candidate may overbid ("Winner's curse"): uncertainty regarding the demand, tariffs, etc. • Possible collusion during the bidding

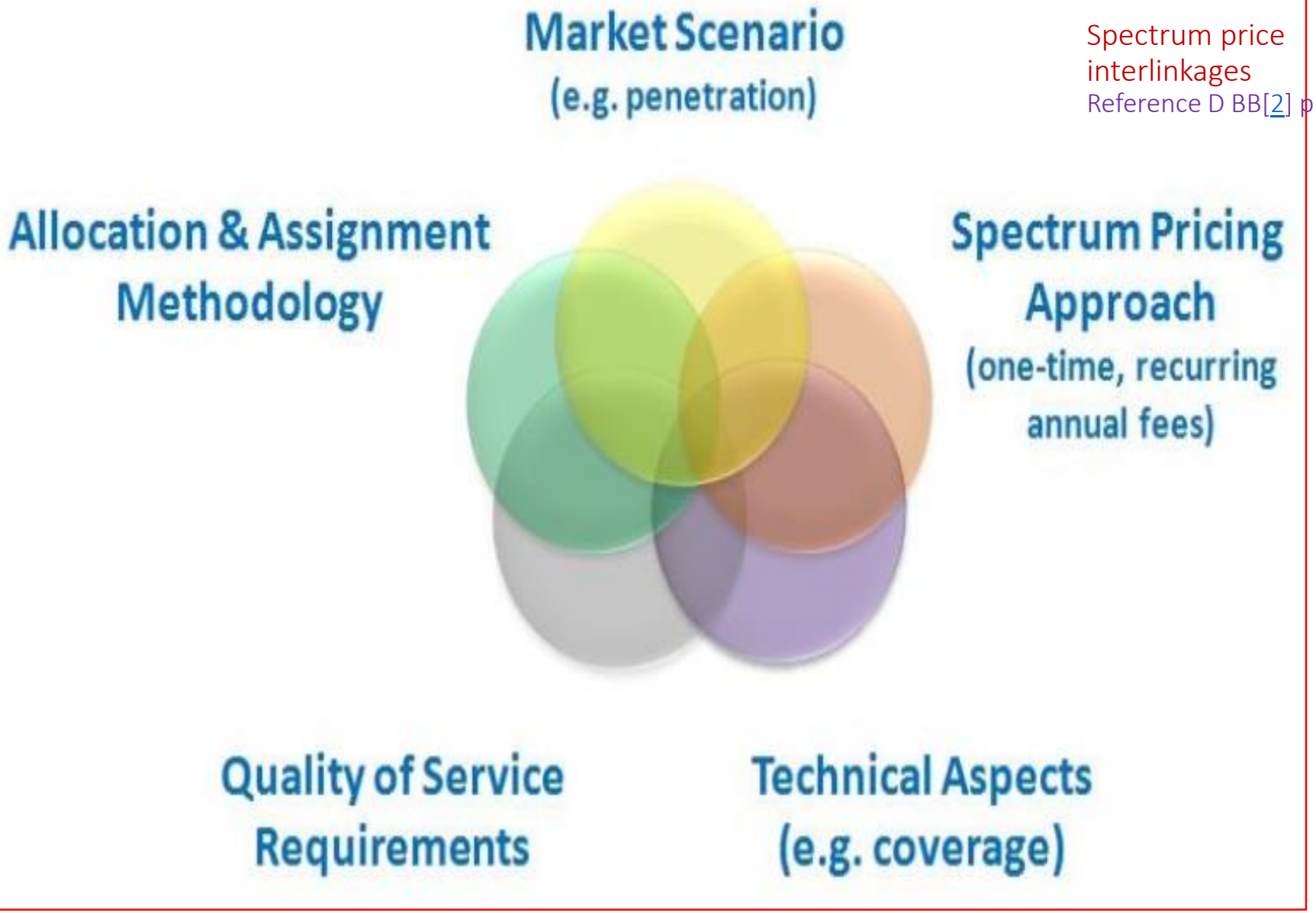
1. … bands serve for meteorological services, space research or radio astronomy. The value of these RF bands is inestimable, as they cannot serve any other wireless application
2. In general, fees are paid for terrestrial & earth stations (Earth-to-space); those stations are located in a specific country; this is not the case of satellites. Coverage area is significant for terrestrial cellular, broadcasting and point to multipoint (P-MP) fixed wireless. For point to point links, the range of the application is more meaningful than the surface
3. EC **Directive** 1997/13/EC **(Licensing) Article 11 (**fees and charges for individual licences) **permits** the collection of fees for the use of frequencies, to enhance efficient use of the frequencies:

Different methods to evaluate the Licence-Fee; Ref. [10]

1. Advantages of auctions are more efficient use of frequencies through revelation of the private valuation of its price, optimization of spectrum access, competition, transparency, accountability, speed and offering the public with the highest value for use of the public resource. However, incompetent bidders may win, and auctions facilitate anti-competitive outcomes; for example: large operators acquiring a disproportionally large part of the available RF spectrum. So, safeguards are needed, such as restrictions on the amount of spectrum a bidder may win and by obliging the winning bidder to use the frequency awarded. The sale price is equal to the expectation of the highest private valuation. Higher levels of communication infrastructure, fewer barriers to shareholdings and greater demand for RF spectrum access will boost the state's revenue. There are additional methods to evaluate the licence-fee. In some cases extra market-based fees apply in case of beauty contests (possibility of a voluntary bid), and occasionally ‘usage fees’.
2. Combined with complementary policies (such as administrative incentive pricing) spectrum trading and liberalisation play an important part, in securing the optimal use of the radio spectrum. They can help to promote innovation, investment and competition in the supply of wireless services, economic growth; they can open up new opportunities for businesses to innovate and grow, giving consumers faster access to new services and lower prices (see Ofcom website and chapter 8, the UK case study 8.3.3).

Spectrum price interlinkages

Reference D BB[2] p. 4



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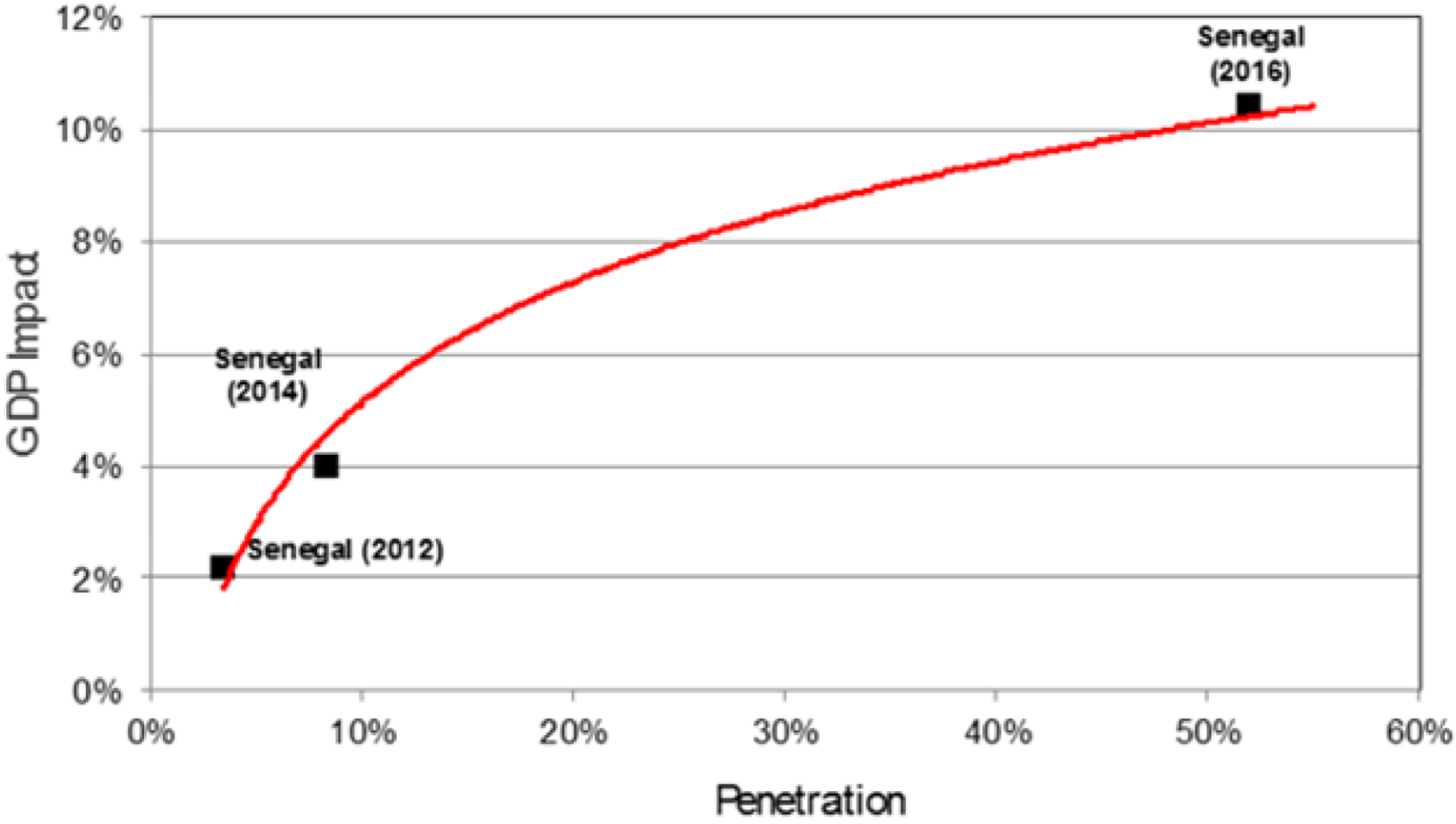
Senegal: Mobile broadband economic impact Reference [5] fig. 1



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Determining economic value of spectrum;

Reference ITU-D BB [2] p. 3

In an auction, the economic value is reflected in the price paid by the successful bidder, which will meet or exceed the reserve price established for the auction. It will be composed of bidding deposits paid at the outset and the applicable winning price

Setting the price of spectrum; Reference[1] Annex 6

Methods	Subjects
Simple fees	Simple fee to have the right to use the spectrum
Fees based on costs	Based on all the kinds of cost systems
Incitative prices of spectrum (Spectrum « Value »)	– "Economical Variables" to calculate the fees (Formulae) – Bandwidth – exclusivity – geographic location – coverage… – Fees based on brut income – Fees on cost opportunity
Auctions	– Sealed bid (first price) auction – Single round sealed (second price) auction – English or ascending auction – Dutch (descending) auction – English/Dutch auction – Clock auction – Simultaneous multiple-round auction – Sequential/simultaneous open auction
Secondary Market	"Rights to Frequencies Uses"

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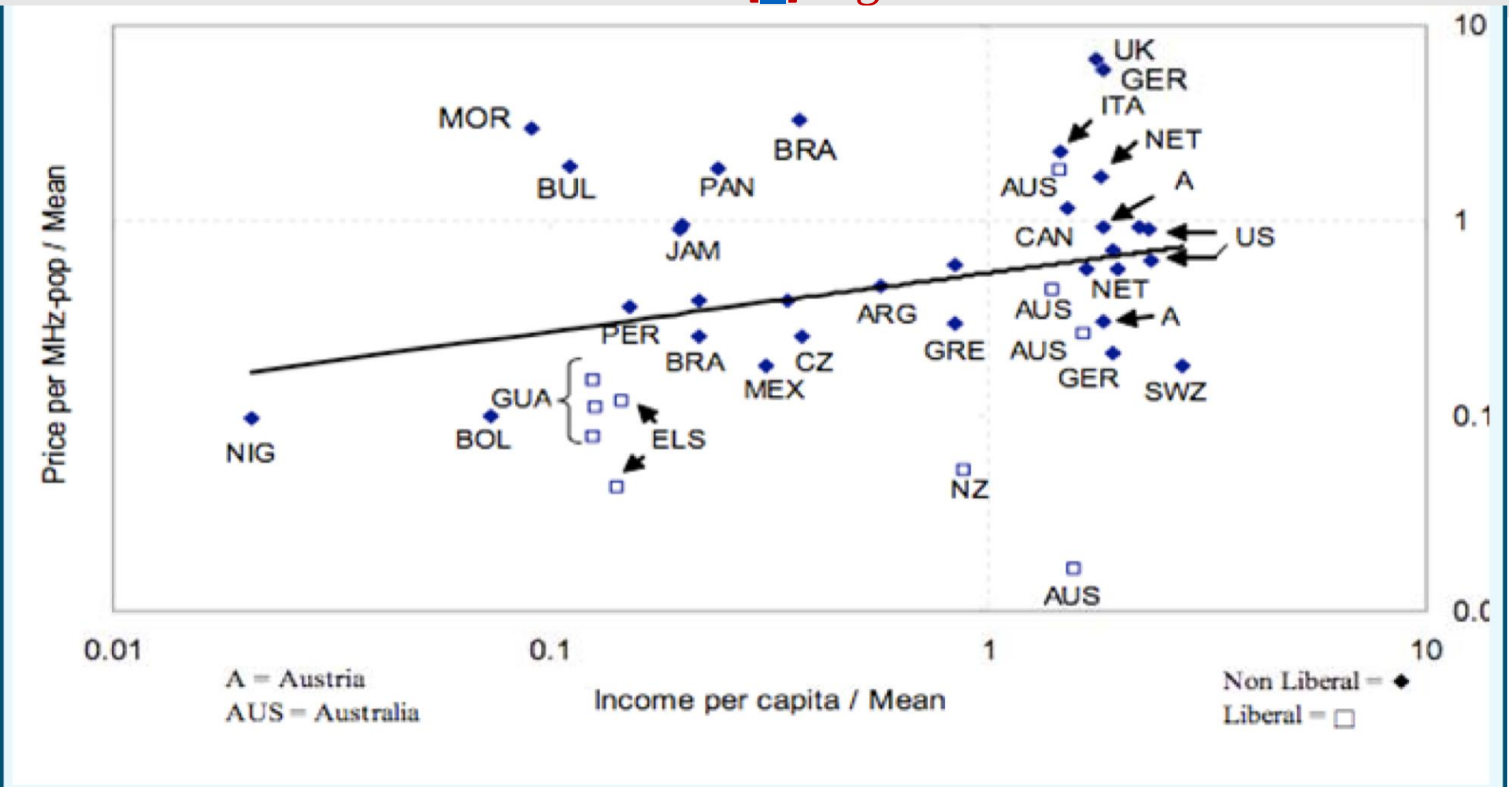
Correlation between sale price and income per capita

Reference[1] Fig. 10



Source: *Thomas Hazlett, Property Rights and Wireless License Values, 2004*

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Spectrum auctions in Africa. see SRG Spectrum HB 2018 Fig 23-1

No.	Country	Spectrum Sold	Amount
1	Nigeria	30 MHz of 2.3 GHz &80MHz of 2.6GHz	$119 million USD
2	Ghana	20MHz of 800MHz	$67.5 million USD
3	Kenya	60MHz of 800MHz	$75 million USD
4	Senegal	20MHz of 800MHz & 20MHz of 1800MHz	$53 million USD
5	Egypt	40MHz of 900/1800 MHz	$1.9 billion USD
6	Rwanda	10MHz of 800MZ	PPP to cover 95% of the pop. with LTE in three years
Mozambique attempted to auction off spectrum 800MHz band			
South Africa attempted to auction spectrum but is currently in a standstill			

Source: Public data sources and Summit Ridge Group, LLC analysis

Summary of spectrum auction in Africa. see SRG Spectrum HB 2018 Figure 23-1

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Explanatory variables of dependent spectrum value Ref. [11]

1. **Dependent vari**able is spectrum value; usually the value realised at a spectrum auction, on a per MHz basis
2. **Explanatory variables** include economic and geographic factors and spectrum characteristics
3. **Econometric model** estimates the relationships between spectrum value and the explanatory factors, and these relationships can be used to predict spectrum value in future auctions
4. Econometrics more useful than **benchmarking**

Bidder deposits; Ref. [11]

1. In an auction, the economic value is reflected in the price paid by the successful bidder, which will meet or exceed the **reserve price** established for the auction.
2. It will be composed of bidding deposits paid at the outset and the applicable winning price

3. Concludes agreements on deposits before Auction

Opportunity Cost & Administrative Incentive Pricing (AIP)

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Methodology: Incentive Pricing Reference [15]

1. Fee is an indirect approximation of the market value
2. Fee formulas consist of relatively few and measurable elements, such as: allocated **bandwidth**, **RF** carrier
3. Objectives of incentive fees:
    1) Rent arising from the public or private use of a scarce common good
    2) Fostering and ensuring efficient use of spectrum by preventing operators from stockpiling spectrum that they don't really need
    3) Incentives to re-farm to less congested frequency bands, and use more spectrally efficient equipment

Simple, functional & linear equations; proposed by author Apr 2019 Reference [4]

1. For all services, fee formula, only transmitters: **Cost /MHz: α x *F* x ρ x σ x *I* x *Mpub***
2. Except Cost unit in the national currency (cur) k α, (cur/MHz) and *B* (MHz), all parameters serve as modifiers (relative indexes).
3. Model determines the fees only for transmitters; i.e. VSAT earth stations operators pay only for their transmitters' bandwidth; FM and TV receivers don't pay Spectrum Utilization Fee (SUF). Unlicensed Short Range Devices don't pay license or annual fees; maybe type-approval
4. Modifier to the fee reflects the particular circumstances of the spectrum being priced

α (fee /MHz): basic price unit. Based on the market dynamics, the country's vision of the ICT sector and international best practice. α = value of 1 MHz for cellular service below 6 000 MHz

F: depends solely on centre frequency; *F* equals 1 below 6 000 MHz and 6 000/*f* for higher frequencies. *F* is uncorrelated to the service

ρ: regional factor; equals 1 for national license, & proportional (less than 1) to the number of administrative areas (regions, provinces) covered by non-national license

σ: regional factor; equals 1 for national license, & proportional (less than 1) to the number of administrative areas (regions, provinces) covered by non-national license

I: site location: urban or rural (site outside the urban area) areas. Defines the socio-economic development within different districts and classifies different fees. *I* may get two values, e.g. full price in urban; 25% full price in rural areas. Administrations may decide other value, or provide additional classes like remote, etc.

M_{pub}: public moderator to differentiate among services. M_{pub} actually defines the fees. M_{pub} equals 1 for the cellular service. For other services, M_{pub} numbers are arbitrary & predetermine the annual cost of the service. For example, for free-to-air television M_{pub} may be significantly lower than 1. M_{pub} serves as framework for holding the values of different services

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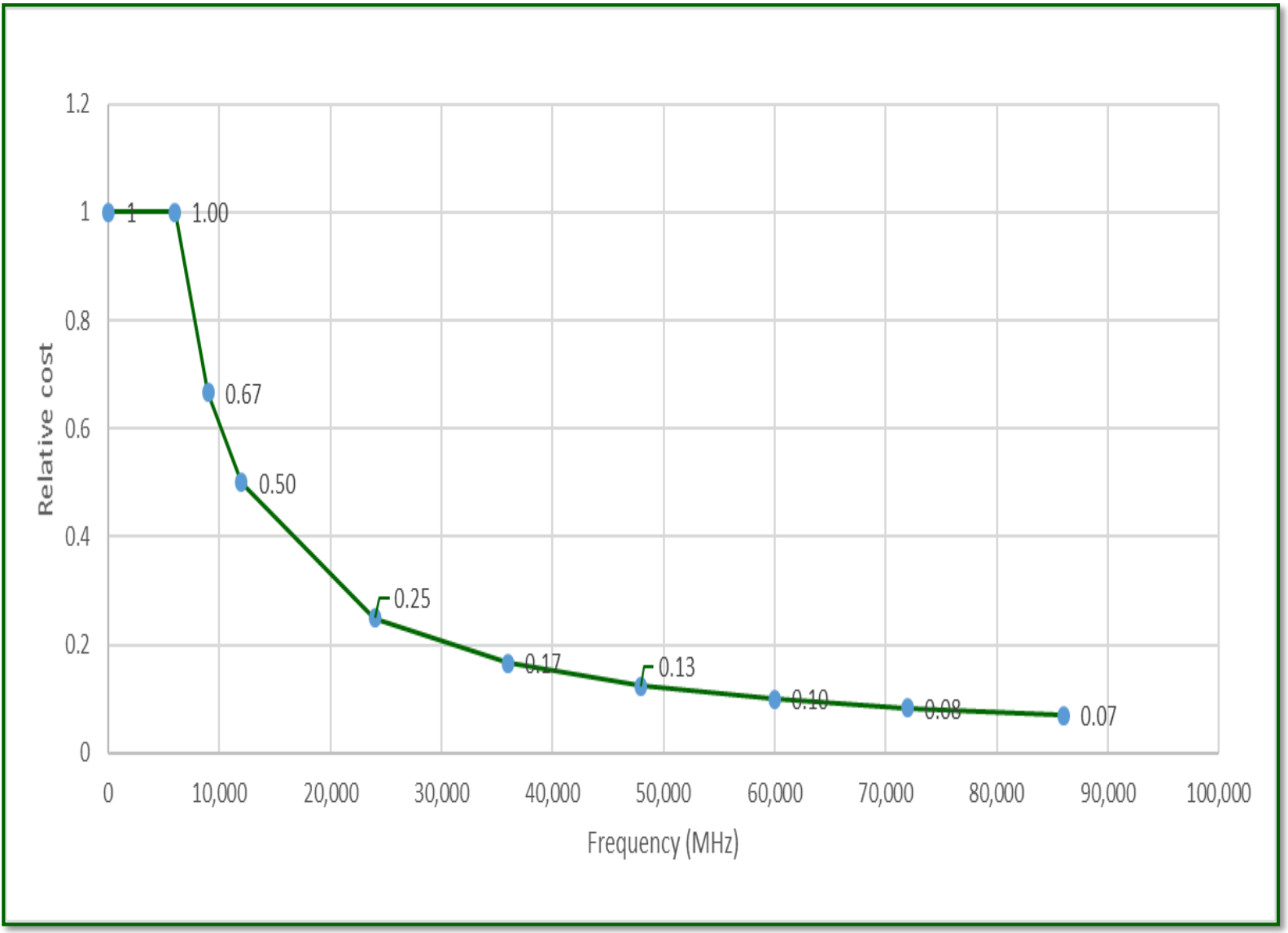
Higher RF – lower fees Reference [4] section 4.8

1. Rec. ITU-R P.2040 – Effects of building materials and structures on radiowave propagation above about 100 MHz, Rec. ITU-R P.2109 – Prediction of building entry loss, and Report ITU-R P.2346 – Compilation of measurement data relating to building entry loss, explain why above 6 000 MHz the building materials attenuate the signal and may obligate a line of sight between the transmitter & receiver. Reference [10], section 5.6.8 specifies that practically before fifth generation, cellular networks operate below 6 000 MHz
2. < 6 000 MHz, propagation properties provide better coverage & penetration
3. < 6 000 MHz, there are less frequencies available, relative to higher frequencies. These bands are considered subject to excess demand
4. Model does not distinguishamong different cellular bands< 6 000 MHz: the advantage at lower RF is compensated by the provision of more bandwidth (& capacity) & availability of terminal equipment (e.g. 1800 vs 900 MHz)
5. Encourage efficient choices about frequency requirements. Lower frequency bands may serve greater distances and 'bypass' topographical obstacles. Relatively short distances can be facilitated in higher RF. To ensure the availability of lower frequency bands, operators are encouraged, through the factor *F* in the fee formula, to select the highest RF available, relative to the physical distance to cover
6. Factor *F* provides incentives for potential users to use higher RF, when contemplating new licenses, to optimize the use of spectrum

Relative fees (coefficient *F*) depend on frequency: F=1 for f <6 000 MHz F=1/f for f ≥ 6 000 MHz Reference [4] Fig. 11



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Example to calculate fees per MHz Reference [4]

- PtP annual fees per 1 MHz, operating nationwide, at 15 GHz, sharing with 3 other operators (σ = 1/4), given for PtP (M_{Pub}= 0.1)
- Cost /MHz: $\alpha \times F \times \rho \times \sigma \times l \times Mpub$ =
  $\alpha \times 6/15 \times \rho \times \sigma \times l \times Mpub$=
  α x 6/15 x 1 x 1/4 x 0.1= 0.01 α

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Current & new fees per 1MHz for national coverage

RF band	Current Fees	Proposed M_{pub}	Proposed national Fees FxM_{pub}
National Cellular			
GSM 880–960 (MHz)	Per 200KHz: K46,666.80 Per 1 MHz: K5x46,666.80= K233,334		K1x400,000
3G 1,710–1,880 (MHz)			K120,000=0.3x400,000
2,100 (MHz)			K68,000=0.17x400,000
Broad Wireless Access (BWA)			
2.3GHz 2300–2400 (MHz)	Per 1MHz per province: K4,166.70. Per 1 MHz national K4,166.70x10= K41,667		K80,000=1.00xK80,000
2.5GHz 2500–2690 (MHz)			K77,440=0.88xK80,000
3.5GHz 3400–3600 (MHz)			K52,800=0.66xK80,000
5.4GHz 5470–5720 (MHz)			K34,400=0.43xK80,000
10.5GHz 10.15–10.3 10.5–10.65 (GHz)			K17,600=0.22xK80,000
		K80,000	
Fixed Links			
1.350 – 1.400GHz	Per transmitter K833.40 h.mazar@atdi-group.com		K400,000=4.00xK100,000
5.925 – 8.500GHz			K86,000=0.86xK100,000
10.70 – 12.50GHz			K50,000=0.50xK100,000
12.75 – 13.25GHz			K46,000=0.46xK100,000
14.50 – 15.35GHz			K40,000=0.40xK100,000
17.30 – 19.70GHz			K33,000=0.33xK100,000
22.00 – 24.00GHz			K26,000=0.26xK100,000
		K100,000	

Proposed max basic price unit M_{pub} (K./MHz) as function of Service

M_{pub}	Service	RF (MHz)	Max Annual Fee (Kwacha/MHz)
M_{pub_TV}	V/UHF TV	174–862	No change of annual fees
M_{pub_TV}	UHF TV	694–862	K40,000
M_{pub_cel}	Cellular	450–2,300	K400,000
M_{pub_BWA}	BWA	2,300–10,650	K80,000
M_{pub_PtP}	PtP	1,350–24,000	K100,000

Current and new fees per 1 MHz for national coverage

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Factors **non-included** in the formulae Reference [4]

1. Equation Cost /MHz: $\alpha \times F \times \rho \times \sigma \times I \times Mpub$ includes straightforward parameters that are directly connected to the use of the RF, & the 'shadow price', of denying other operators to use the same RF spectrum
2. Equation disregards others parameters, such as
    1. Number of base stations, to promote installation of more stations to improve QoS, & to achieve better coverage & capacity
    2. Surface of coverage or radius cell, as it is difficult to define; moreover, public & regulators may prefer higher coverage (surfaces and radii). Surface of coverage has no meaning for µ wave links. The surface is included in the moderator ρ, representing the number of districts
    3. Power, as it is difficult to monitor power or e.i.r.p.; total e.i.r.p. of cellular stations change continuously (due to power control)
    4. Effective altitude, as it complicates the method, and there is a need of digital terrain map (DTM)
    5. Temporal scope and duty cycle, as most emissions (cellular and µwave links) are all day long. To remind that a **non-used frequency is a waste to the economy**

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Sub-Sahara 800/700 MHz Case Study

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Comparison among some African countries: population, GDP, cellular penetration; Source using ITU indicators

Countries	Population (millions)	GDP per habitant (USD)	cellulars/100 habitants		
			2012	2017	2017/2012
Rwanda	12,2	773,0	52,7	72,2	1,4
Sénégal	15,8	1,033.07	83,7	99,4	3,5
Zambie	17,1	1539,9	71,6	78,6	1,1
Cameroun	24,1	1526,9	62,2	83,7	1,3
Côte d'Ivoire	24,3	1,662.44	84,5	130,68	9,1
Kenya	49,7	1710,5	70,4	86,1	1,2
Afrique Sud	56,7	6339,6	129,0	156,0	1,2
France	65,0	41463,6	97,8	106,2	1,1

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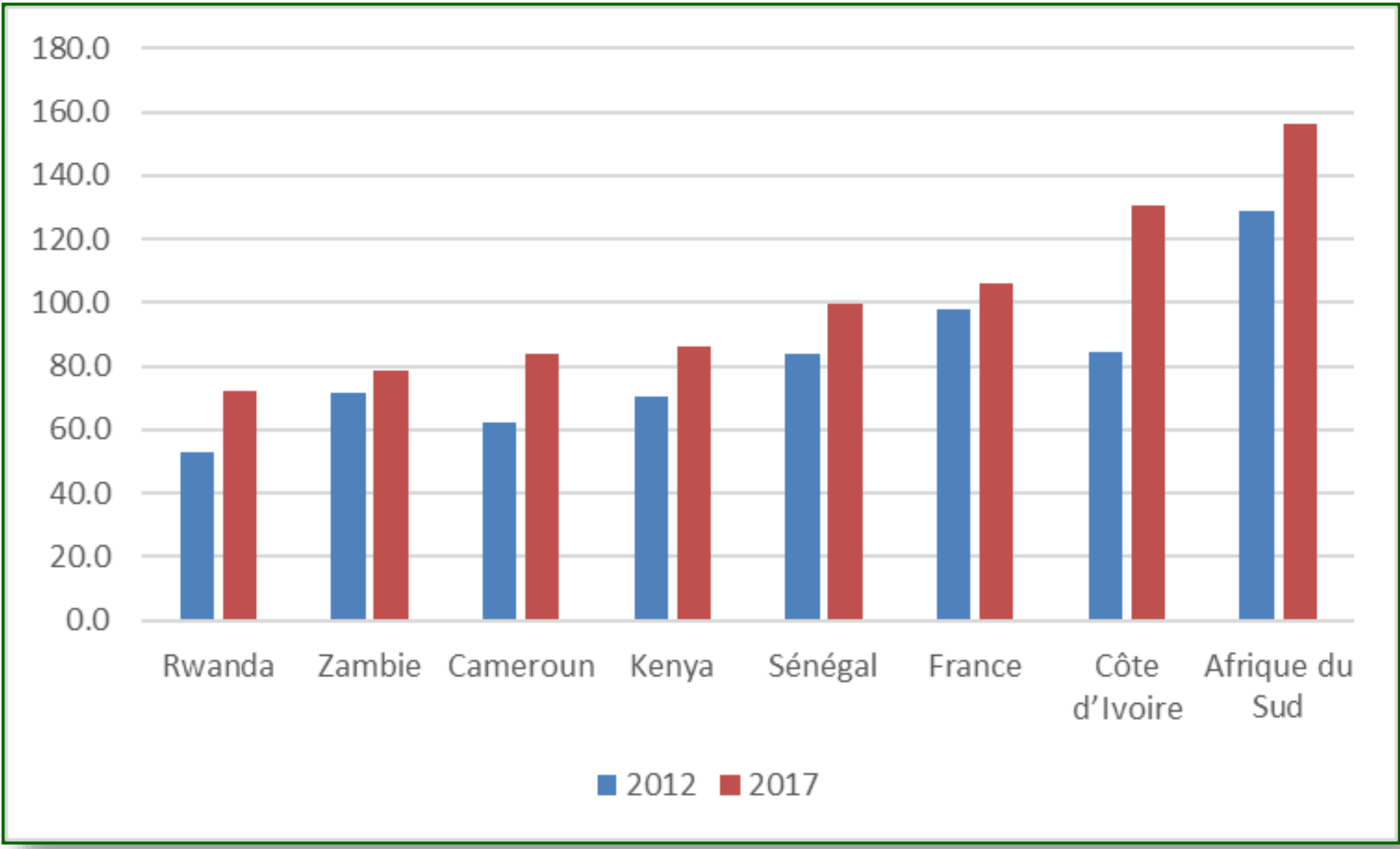
Comparison among some African countries: cellular penetration; Source:



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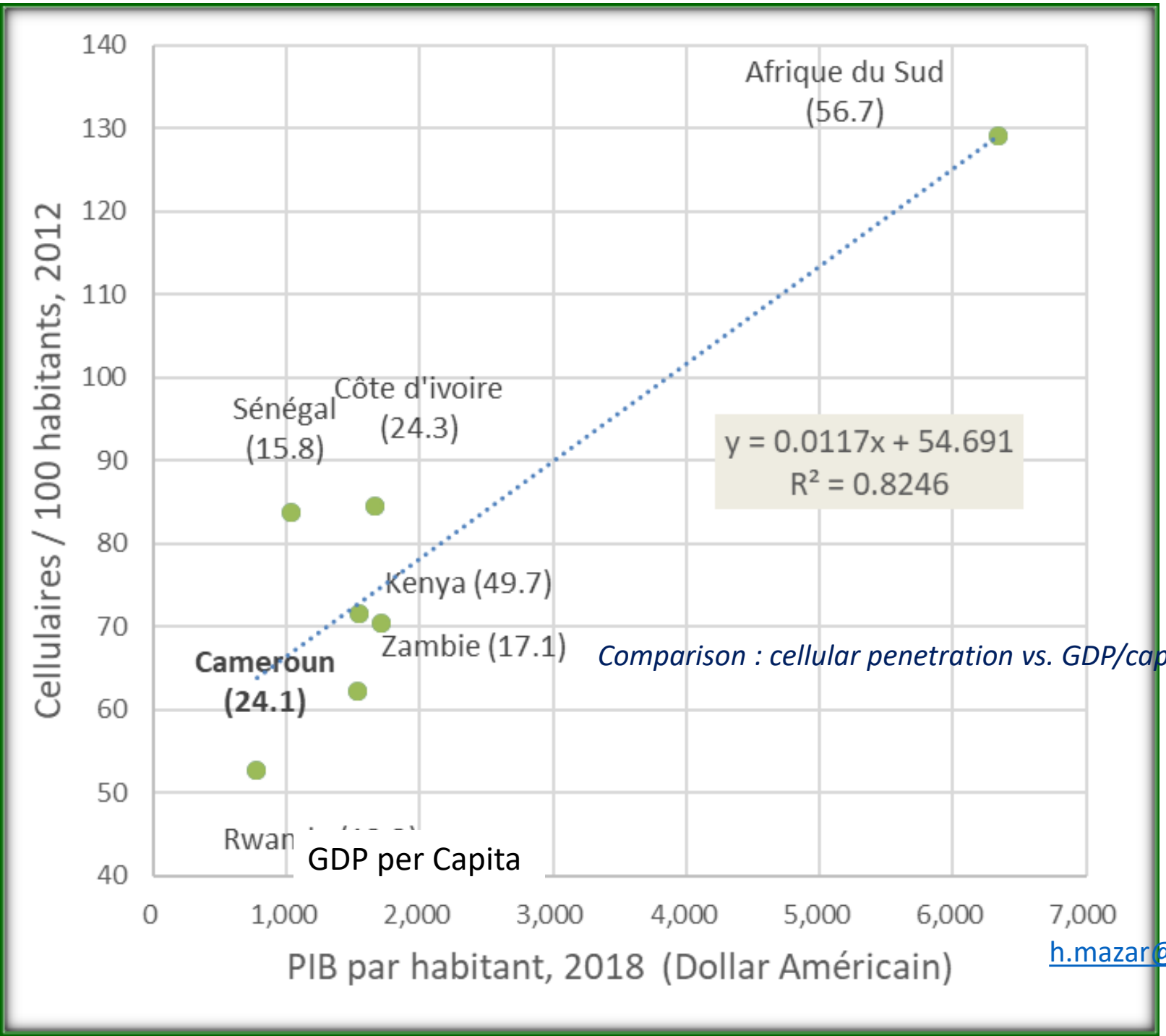

Comparison : cellular penetration vs. GDP/capita ; R^2= *0.8246*

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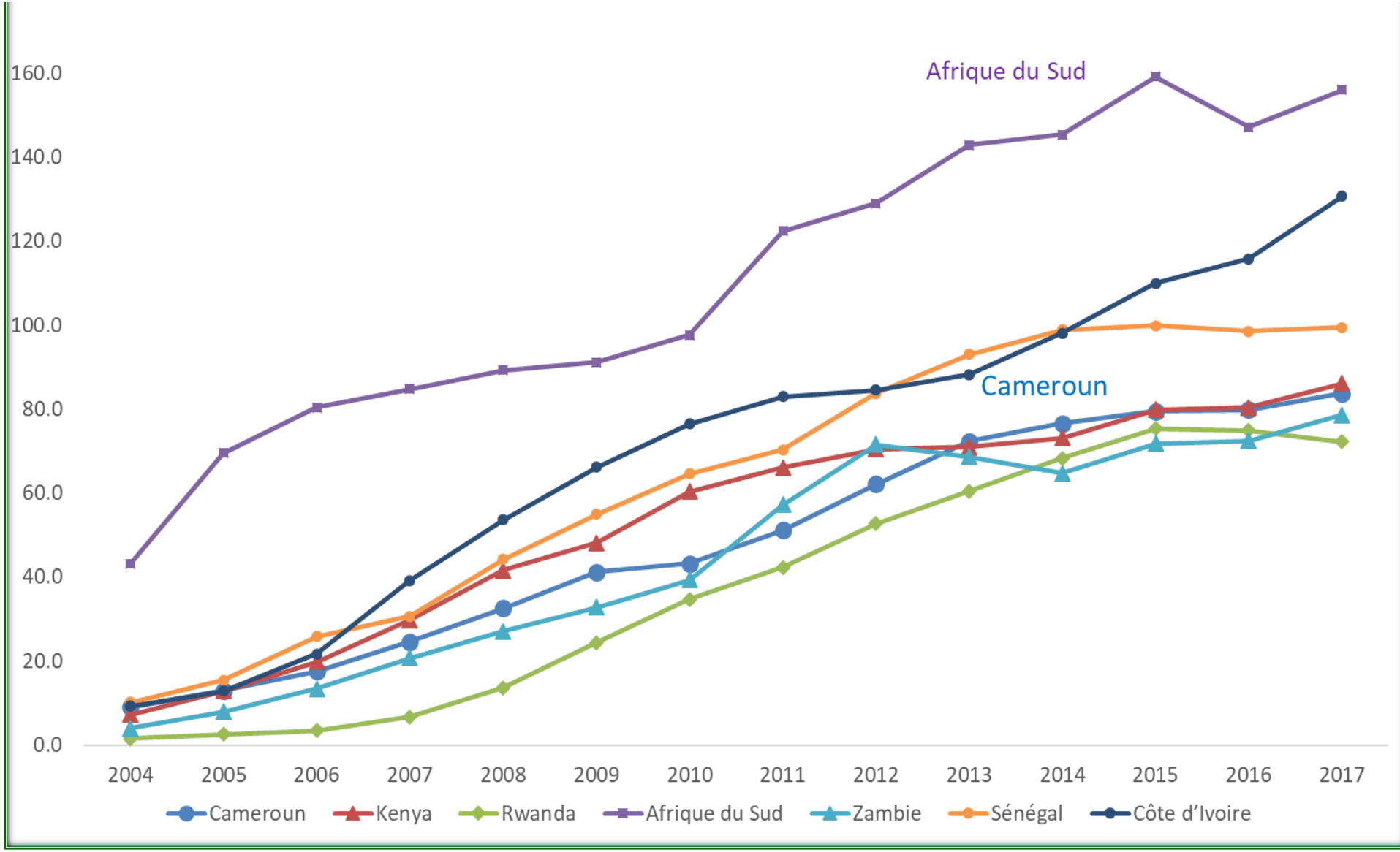
Comparison: Cellular Penetration 2004-2017; Ref. [3]



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Mozambique Auction; press release of *Nacional de Comunicacoes de Mocambique* (INCM)

1. **800 MHz**
    1. 5 slots of 5 MHz bandwidth
    2. Reserve-price 15 M. USD
2. 1800 MHz
    1. 6 slots of 5 MHz bandwidth
    2. Reserve-price 30 M. USD
3. 2600 MHz
    1. 9 slots of 5 MHz bandwidth
    2. Reserve-price is 15 M. USD

- At 1800MHz & 2.6GHz no bids. The only lot auctioned was 800MHz
- Revenue equals the sum of 3 highest bid amounts
- Revenues about 83.4 million USD dollars
- 34% paid upon the assignment of RF. 33% in 2019 & 33% in 2020

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Mozambique Auction; press release of Vodacom

1. In the 800MHz range, five lots of 2×5MHz were on offer
2. Reserve-price of USD15 million per lot
3. All available spectrum in the 800MHz band had been acquired
4. HM: 5 lots of 2×5MHz are equivalent to 2.5 lots of 2×10 MHz
5. HM: Therefore, 83.4 M. USD are equivalent to 33 M. USD of 2×10 MHz

Mozambique Case

Table 1: Operator revenue (USD '000 000)

	2011	2012	2013	2014	2015	2016	2017
Vodacom	192	237	217	305	214	171	247
mCel	339	300	282	212	149	71	62
Movitel	–	68	106	172	129	88	99
TDM	246	116	116	109	82	41	50
Total	775	721	721	798	574	370	458

Source: Ministry of Transport and Communications/Instituto Nacional das Comunicações de Moçambique (INCM), 2017

Ghana Case

NCA Announces Winner for One Lot of 2x5MHz Spectrum in the **800MHZ Band**

- The National Communications Authority (NCA) announces that Ghana Telecommunications Company Limited (Vodafone Ghana) has won one (1) lot of 2x5MHz
- Process started Sept 2018 when the NCA published a Request for Applications (RFA) & made available 3 lots of **2x5** MHz & **800 MHz**
- Two companies submitted applications, with Vodafone emerged the only successful applicant
- **30 M.USD** for 3 lots of 2x5 MHz equivalent to **20 M.USD** for 2 lots
- September this year, the Authority's public-call for a 'Request for Applications' resulted in the submission of 2 applications
- The sale of the Spectrum is in line with Section 58 of Electronic Communications Act 2008, Act 775 on Spectrum Management which highlights the NCA's mandate and the options for Frequency Assignment

Sub-Sahara African GE06 Frequency Coordination Meetings; ITU-R website

1. The aim of this activity was to assist the 48 Sub-Sahara African ITU Member States in coordinating the necessary modifications to the GE-06 (RRC-06) TV plan, to ensure the availability for each country of the RF required to support at least four TV multiplexes with national coverage, in addition to the frequency assignments or allotments already recorded in the GE-06 l plan, in the band 470-694 MHz
2. Activity to enable to apply the relevant procedures of the GE-06 agreement and the Radio Regulations, to modify the GE-06 plan and bring in service their frequency assignments to the broadcasting and mobile services in the UHF band without harmful interference

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Deploy digital television in 47 Sub-Saharan African countries; digital switchover in 2015 ; ITU-R website

1. RF coordination negotiations have succeeded in setting up the mechanism to deploy digital television in 47 Sub-Saharan African countries
2. Consolidation of national plans to implement the digital switchover in the African region is in conformity with the deadlines of June 2015 (for UHF) and June 2020 (for VHF in 33 countries) set in 2006 by ITU's Regional Radiocommunication Conference (RRC-06), which adopted the GE-06 TV Plan
3. Landmark also makes Africa the first region to be in a position in 2015 to allocate bandwidth freed up by the transition to digital television – the so-called 'digital dividend' – to the mobile service for both the 700 MHz & 800 MHz bands. Decisions of the World Radiocommunication Conference 2012 (WRC-12) to facilitate availability of the digital dividend (DD) to the mobile service will be effective with some technical refinements immediately after the next World Radiocommunication Conference in 2015 (WRC-15)
4. High level of cooperation extended to the process by African Telecommunications Union (ATU)
5. Sub-Saharan African countries submitted official modifications to the GE-06 Plan following the final frequency coordination meeting held in Nairobi, 17-19 July 2013 and the deadline of 31 August set for notifications
6. Enable African countries to allocate the DD to mobile services in the band 694-862 MHz, as a regionally harmonized implementation of the decisions taken at the WRC- 2012. Objective reached by re-planning the spectrum requirements of television broadcasting in the 470-694 MHz frequency band
7. The meeting in Nairobi organized jointly by ITU and the ATU) attracted 124 participants from 35 Member States. It was the third and last overall coordination meeting of African countries, after similar meetings in Bamako (March 2011) and Kampala (April 2011) and a number of other bilateral and multilateral meetings held in 2011 and 2012.

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Sub-Sahara African Countries
ITU-R website

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Frequency arrangements	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)
A1	824-849	20	869-894	45
A2	**880-915**	**10**	**925-960**	**45**
A3	**832-862**	**11**	**791-821**	**41**
A4	698-716 776-793	12 13	728-746 746-763	30 30

NOTE 1 – Due to different usage in bands 698-960 MHz between Regions, there is **no common solution possible at this time** NOTE 2 – In A3, IMT systems are operating in FDD mode and use a **reversed duplex direction**, with mobile terminal transmit within the upper band & base station transmit within the lower band. Such an arrangement provides better conditions for coexistence with the lower adjacent broadcasting service

A5	**703-748**	**10**	**758-803**	**55**
A7	**703-733**	**25**	**758-788**	**55**
A8	698-703	50	753-758	55
A9	733-736	52	788-791	55

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700/800 MHz; 3GPP bandplans Band 20 & 28 ETSI TS 136 101 V14.7.0 (2018-04)Table 5.5-1

Operating Band	Uplink (UL) Base station (BS) receive User Equipment (UE) transmit	Downlink (DL) BS transmit UE receive	Duplex Mode
20	832 MHz – 862 MHz	791 MHz – 821 MHz	FDD
28	703 MHz – 748 MHz	758 MHz – 803 MHz	FDD

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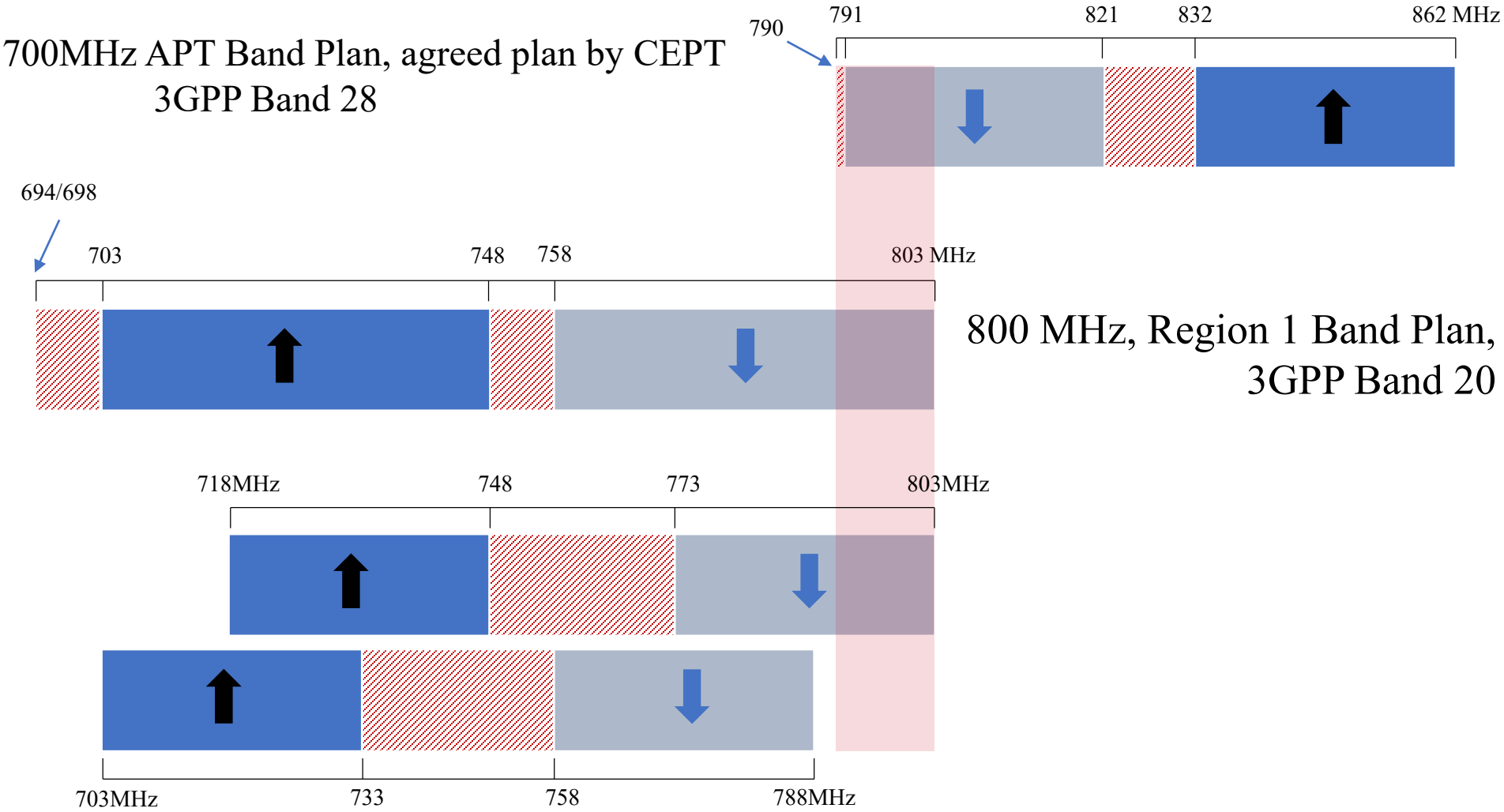
Digital Dividends: 700/800MHz band plan (source GSMA)

700MHz APT Band Plan, agreed plan by CEPT
3GPP Band 28



800 MHz, Region 1 Band Plan,
3GPP Band 20

harmonised plan: 2x30MHz

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Tanzania 700 MHz Auction
see TCRA website

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Tanzania 700 MHz Auction; Results of the 700 MHz spectrum auction Auction carried out on 8th June 2018, Tanzania Communications Regulatory Authority (TCRA) announces successful conclusion of 2 x 20 MHz auction at 700 MHz

Objectives, promoting

1. efficient use of spectrum (where efficiency implies assigning spectrum to those that will generate the greatest socio-economic benefit from its use)
2. competition, i.e. an outcome which supports or does not undermine effective competition;
3. benefits for consumers, though the sustainable provision of widespread, high quality services
4. investment and innovation

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Benefits to the nation

1. Advancement of the country's mobile broadband **infrastructure and capability** which will serve as a catalyst for the nation's economic development
2. Facilitation of social economic benefits as mobile broadband will be key for promoting efficient provision of services such as education, health,agriculture, commerce, financial services through ICTs
3. Lowering mobile communications costs due to cost savings as a result deploying **fewer base stations** for wider coverage and therefore potential lower consumer prices
4. Extending the provision of mobile broadband services to a wider Tanzania n population especially those in **rural areas**
5. Promotion, enhancement and facilitation of innovation for new ICT services & technologies to be deployed in the band;
6. Source of national revenue by obtaining optimal return for the spectrum band as a scarce resource

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Tanzania 700 MHz Auction; Results of the 700 MHz spectrum auction

Auction carried out on 8th June 2018, TCRA announces successful conclusion of 2 x 20 MHz auction at 700 MHz

All spectrum available were assigned; results are

1. Vodacom Tanzania PLC acquired 2 x 10 MHz for a total price of US$ **10,005,000**
2. Azam Telecom (T) Limited acquired 2 x 10 MHz for a total price of US$ **10,000,000**
3. Total Auction proceeds is US$ **20,005,000**

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Tanzania 700 MHz Auction; Results of the 700 MHz spectrum auction Auction carried out on 8th June 2018, TCRA announces successful conclusion of 2 x 20 MHz auction at 700 MHz

Auction results in Tanzania can be normalized to other African economies

c	GDP (billion USD)	GDP per capita (USD)	ARPU (USD)	Price (Million USD)
	Reference year 2017 of GDPs			for 2 x 10 MHz
Tanzania	52.09	936.33	31.29	**10**
Zambia	25.81	1,509.80	36.38	
Normalised factor	2	0.62	0.86	
Normalised per GDP				**5**
	Normalised per GDP/capita			**16.13**
		Normalised per ARPU		**11.63**

Important to refer to the number of potential bidders in Tanzania and other countries

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Tanzania 700 MHz Auction; Results of the 700 MHz spectrum auction Auction carried out on 8th June 2018, TCRA announces successful conclusion of 2 x 20 MHz auction at 700 MHz

Coverage obligations in the license to be issued

1. By end of year 2021, population coverage for broadband services meeting the specified quality of service level should be equal to 60%
2. By end of year 2024, population coverage should be equal to 90%

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Tanzania 700 MHz Auction; Award of 700 MHz Spectrum, Information Memorandum

1. Key features were a market & technical assessment phase which included a detailed, bottom-up spectrum valuation exercise performed for each of the incumbents in Tanzania to ensure that Reserve Prices were set at appropriate levels
2. Spectrum restraints
3. Industry stakeholder consultation
4. Electronic Auction System to ensure security, transparency & efficiency & time was allowed for bidder training and the testing of connections
5. Back-up procedure was also in place in the event of catastrophic IT failure
6. *Regulators should allow min. 12 months for a successful assignment process*
7. Post auction competitiveness when designing the auction process
8. *Coverage obligations to attain policy objectives*
9. Many examples of partial or total auction failure in Africa. Neither no or only some of the spectrum was successfully assigned. In nearly all cases an excessively high auction reserve-price was the main cause of auction failure
10. Understanding the value of spectrum to bidders is critical to the success of the Auction
11. Simultaneous Multi-Round Ascending Clock Auction was implemented which provided the simplest auction format to meet the goals of the project. As there were some questions around potential levels of demand the design also included an Alternative Auction Procedure in the event of limited demand
12. Strive for maximum clarity & minimise confusion & ambiguity
13. Process agreed with the TCRA also allowed for consultation on the draft Information Memorandum as well as a Question & Answer process following publication of the final version

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Results & Regrets Gaborone, personal perspective Graham Friend

A large, populous country with reasonable income; Population: 56 million; Area: 945,087 km²; GDP / Capita: 2,700 USD

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Tanzania 700 MHz Auction; Learning from best-practice; Dec 18

1. Focus on long term policy objectives
2. Follow a robust process
3. Allow sufficient time
4. Consider the consequences for future competition
5. Use a bespoke modelling exercise to understand the value of spectrum
6. Set appropriate reserve-prices
7. Keep the process as simple as possible: Adopt the simplest possible auction design
8. Strive for clarity and minimise confusion

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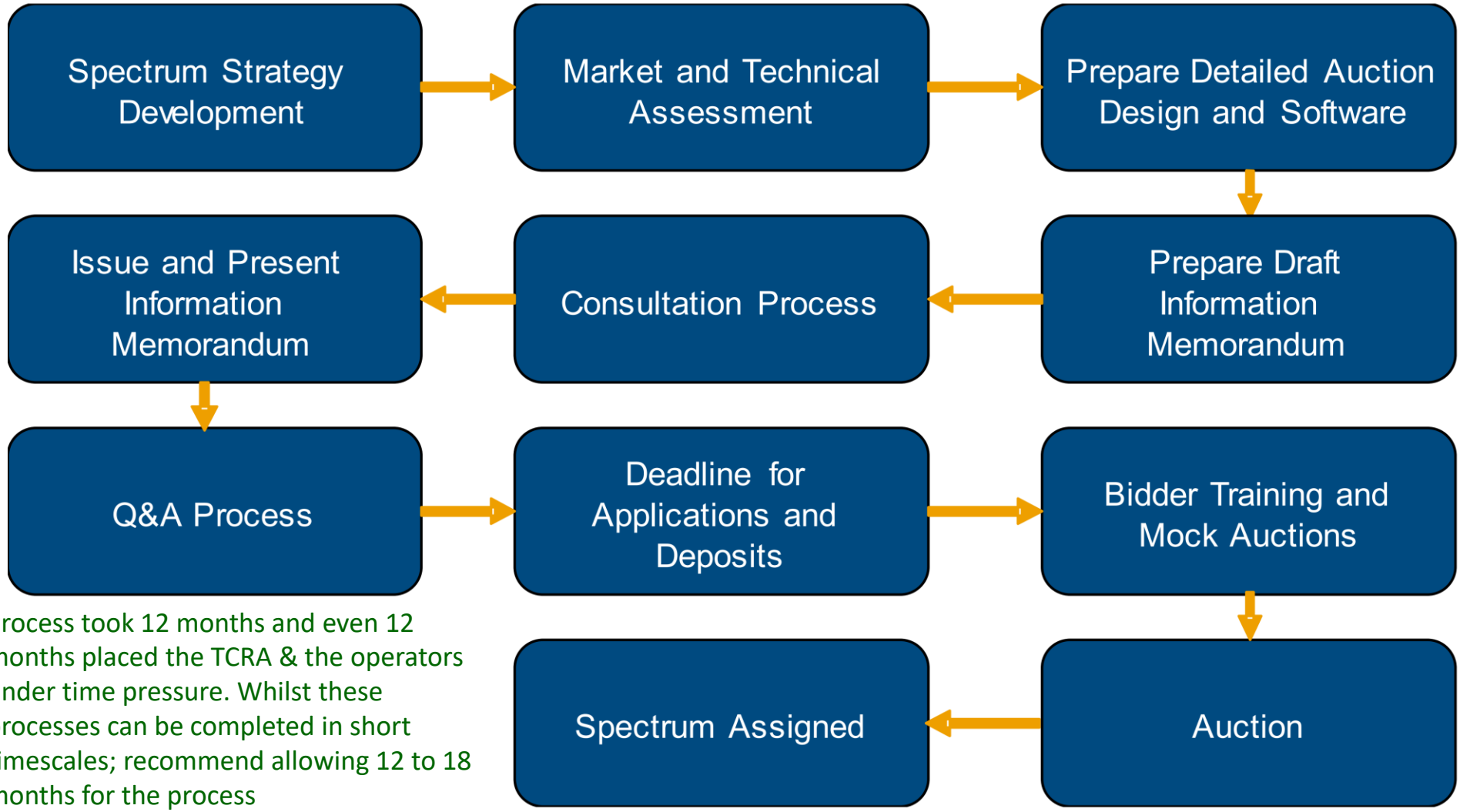
Assignment Process (Coleago Consulting); Exhibit 1



Process took 12 months and even 12 months placed the TCRA & the operators under time pressure. Whilst these processes can be completed in short timescales; recommend allowing 12 to 18 months for the process

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Detailed bottom-up valuation exercise

1. Tanzania Spectrum Values; US$ Millions for 2 x 10 MHz
2. Average auction benchmark value for spectrum, much deviation
3. if the reserve price based on the benchmark , partial auction failure
4. benchmarks do not capture the differences in value between operators
5. A market specific modelling exercise is more reliable for setting reserve prices

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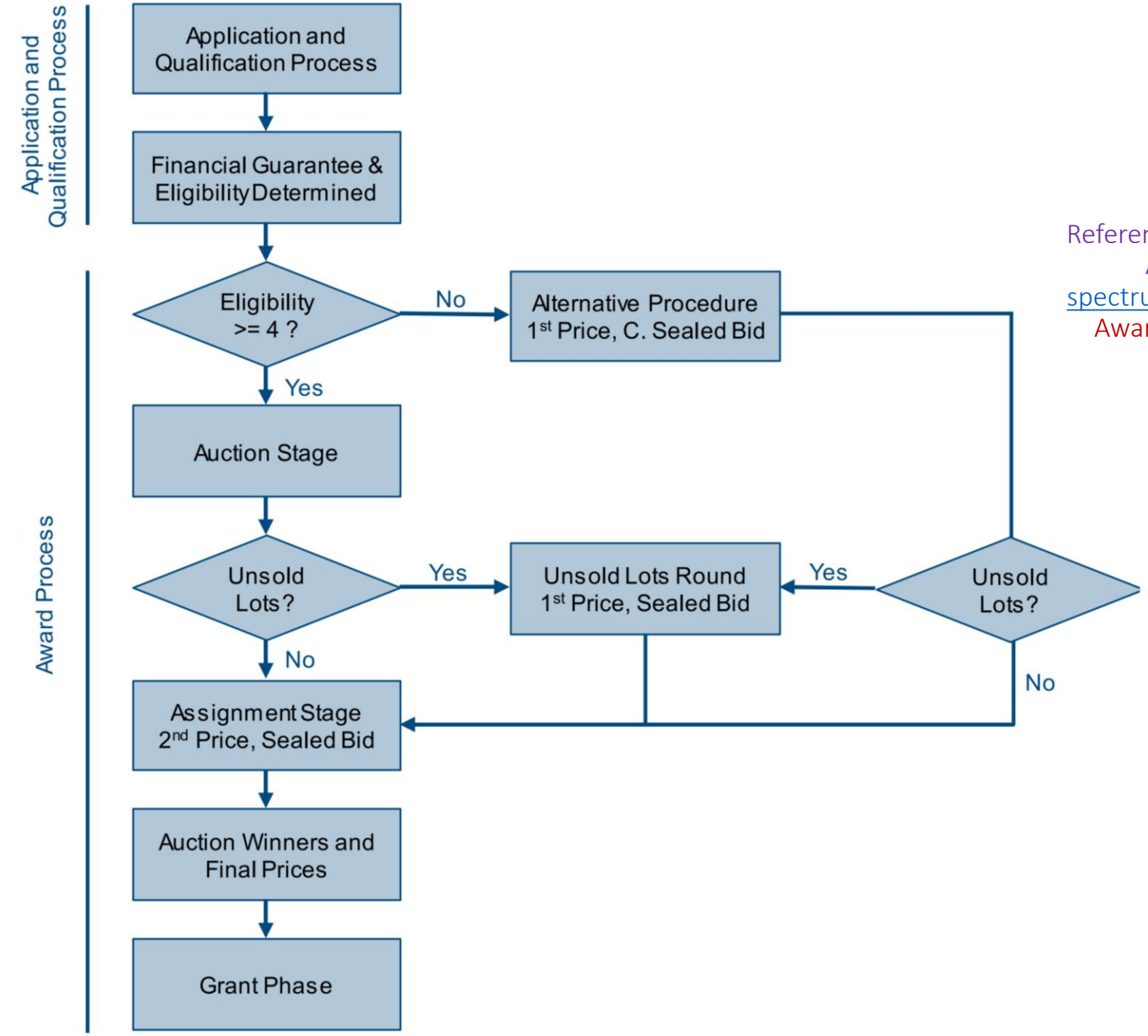
Reserve price

- A high reserve price would result in complete auction failure but this is a “good” failure as the regulator can always start the process again
- “bad” failure: only one operator would acquire the spectrum which would be damaging to competitive dynamics and regulator would find it difficult to assign the unsold spectrum
- High risk of failure as whilst the Reserve Price is below the value to three operators, operators may not be able to raise the finance to pay such a high reserve
- Low but material reserve price to maximise auction participation & to recognise the burden the coverage obligations would place on the operators

Results

1. During the final stages of the project the Ministers decided to reserve 2 x 10 MHz of spectrum for future use. No explanation for the decision to reserve the spectrum
2. Key Auction Results: All the spectrum was sold; US$ 20 million raised; Competition increased with a new entrant Azam Telecom Increased coverage



Source: The Authority

Reference Final Draft Date 11 Apr 2018 TRCA;
spectrum.auction@tcra.go.tz
Award Process Overview

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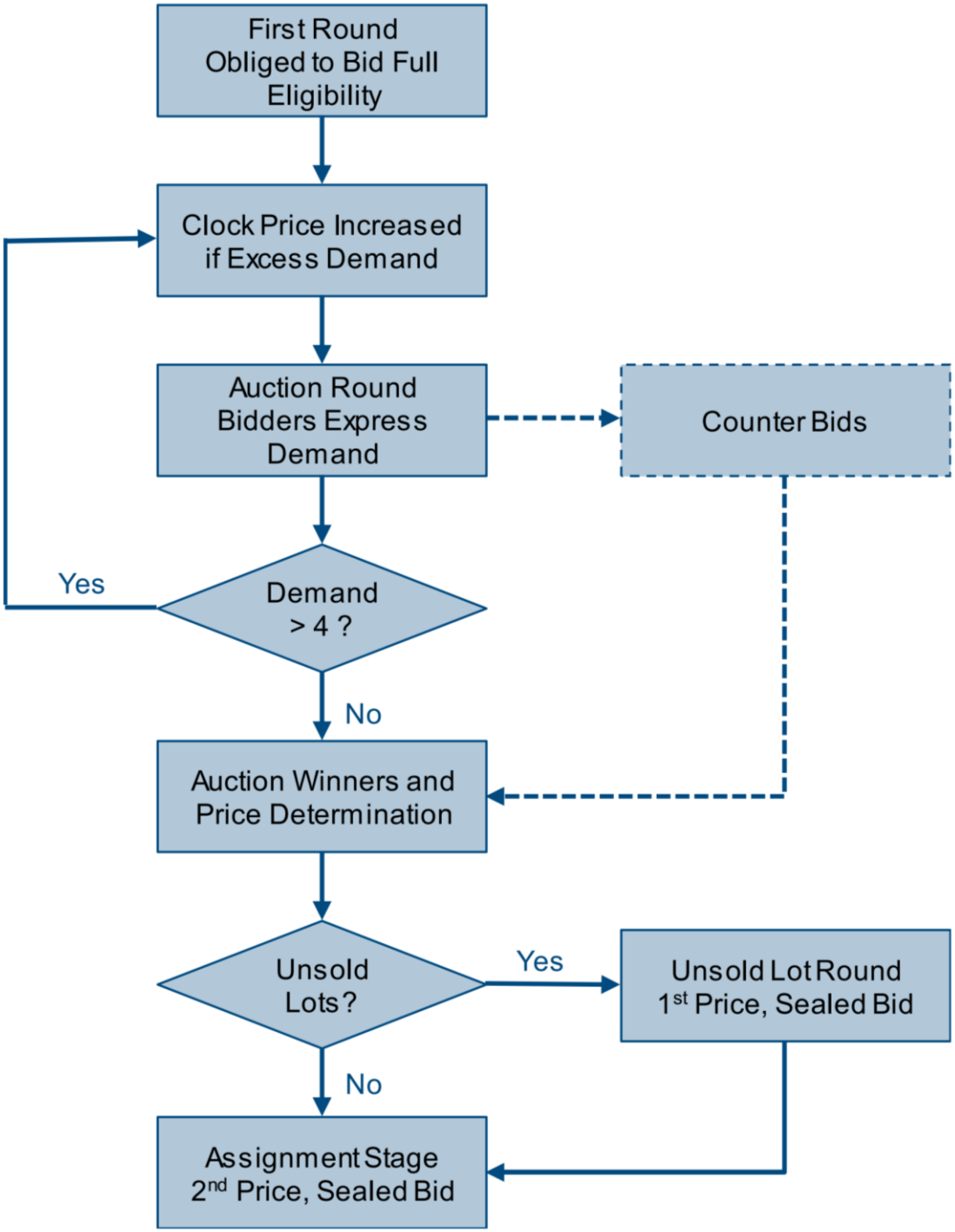

Reference Final Draft Date 11 Apr 2018

TRCA; spectrum.auction@tcra.go.tz;

Two Stage Auction Process

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Application, Qualification and Award Process Timetable

Process Step	Indicative Timings (subject to change)
Publication of Information Memorandum and start of the Application Window	[11/04/18]
Deadline for Questions	[18/04/18]
Provision of Answers	[25/04/18]
Application Deadline	[23/05/18]
Confirmation of Bidders	[04/06/18]
Bidder Training	[w/c 04/06/18]
Award Process Start Date	[08/06/18]
Publication of Results	[Expected w/c 18/06/18]
Payment Deadline	[Expected w/c 02/07/18]
Grant of Licences	[Expected w/c 18/07/18]

ITU ICT Indicators

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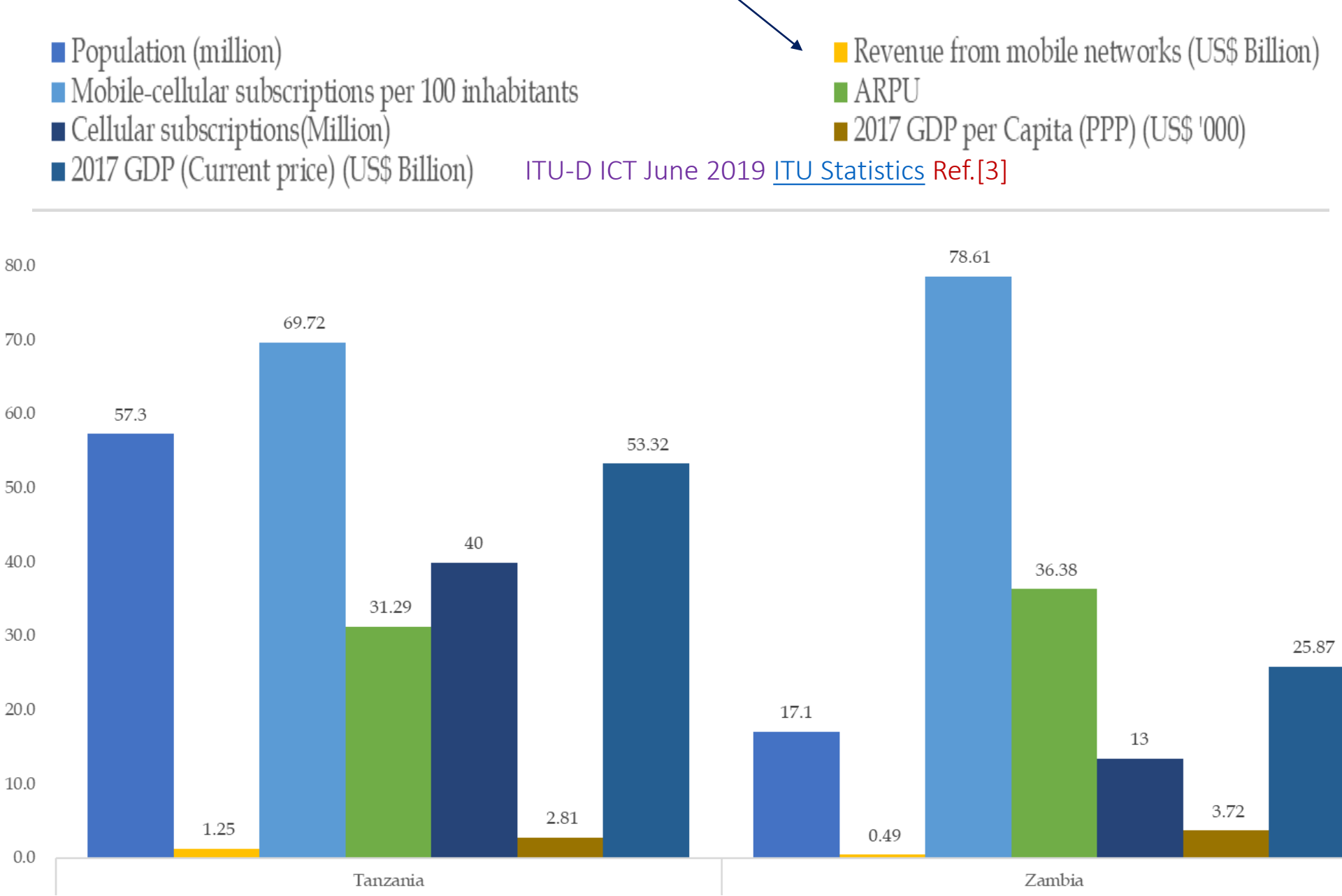

ITU-D ICT June 2019 ITU Statistics Ref.[3]

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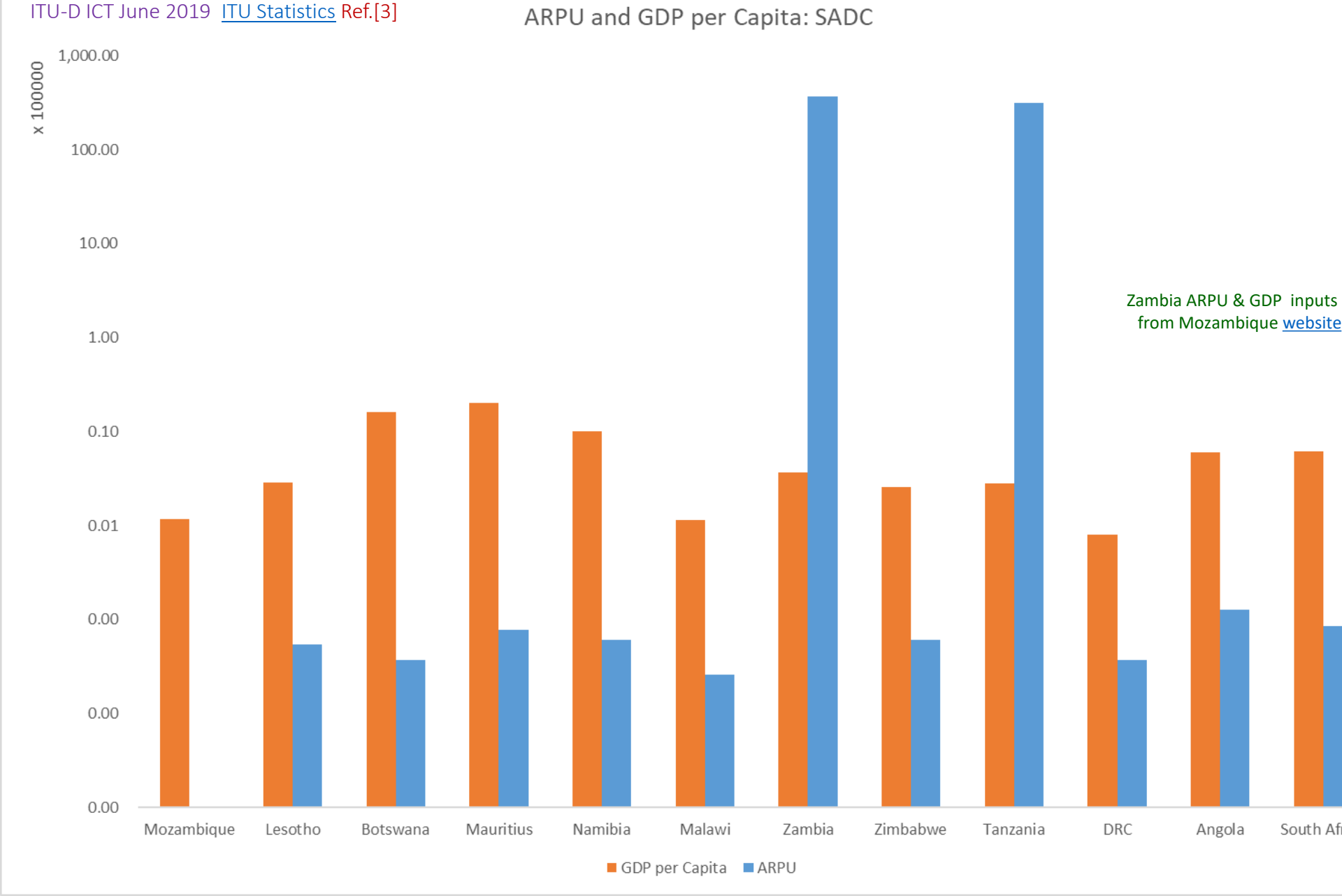
ITU-D ICT June 2019 ITU Statistics Ref.[3]



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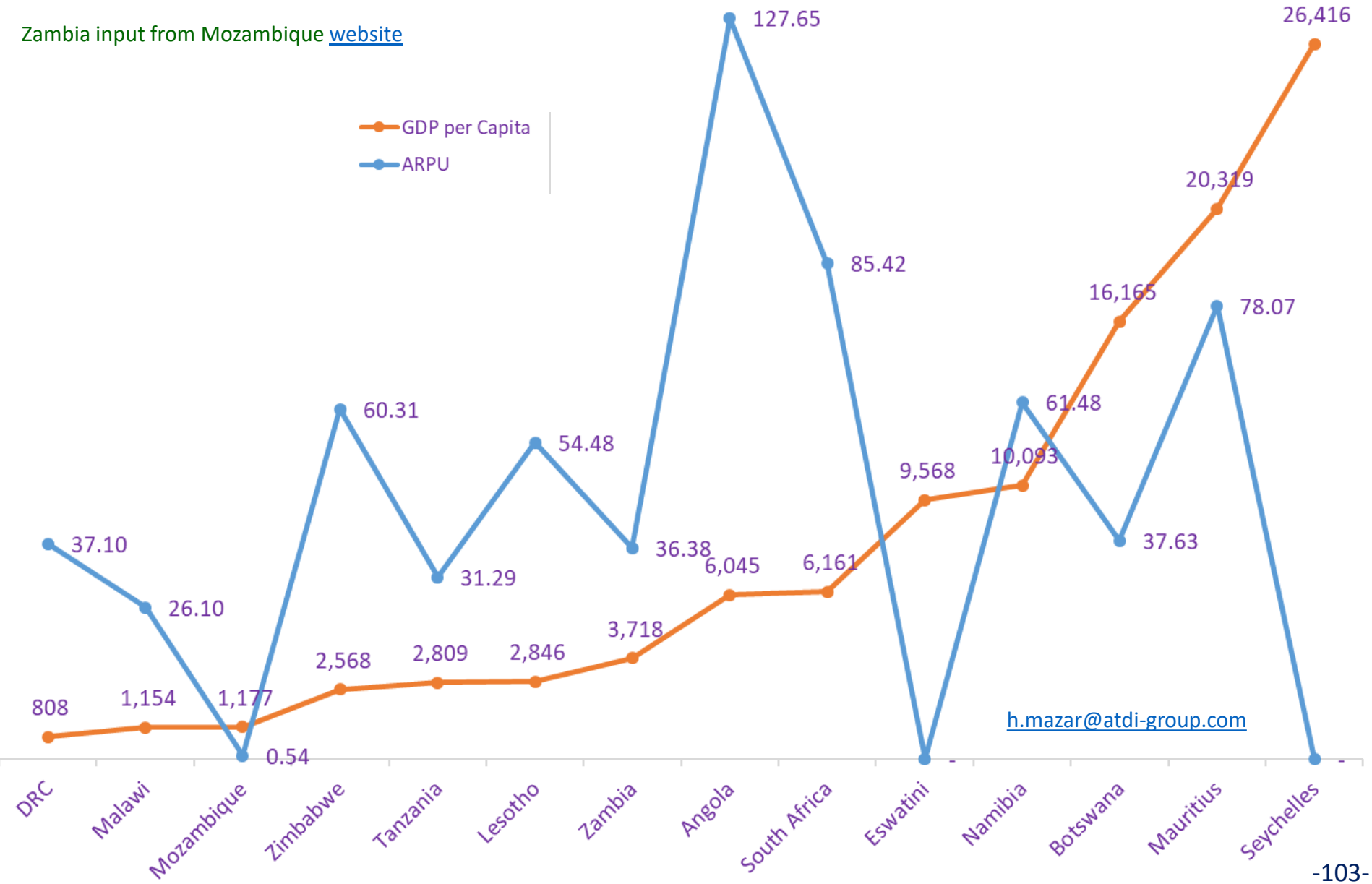
ARPU vs. GDP per Capita; USD, 2019 data, from 2017; SADC

ITU-D ICT June 2019 ITU Statistics Ref.[3]

Zambia input from Mozambique website



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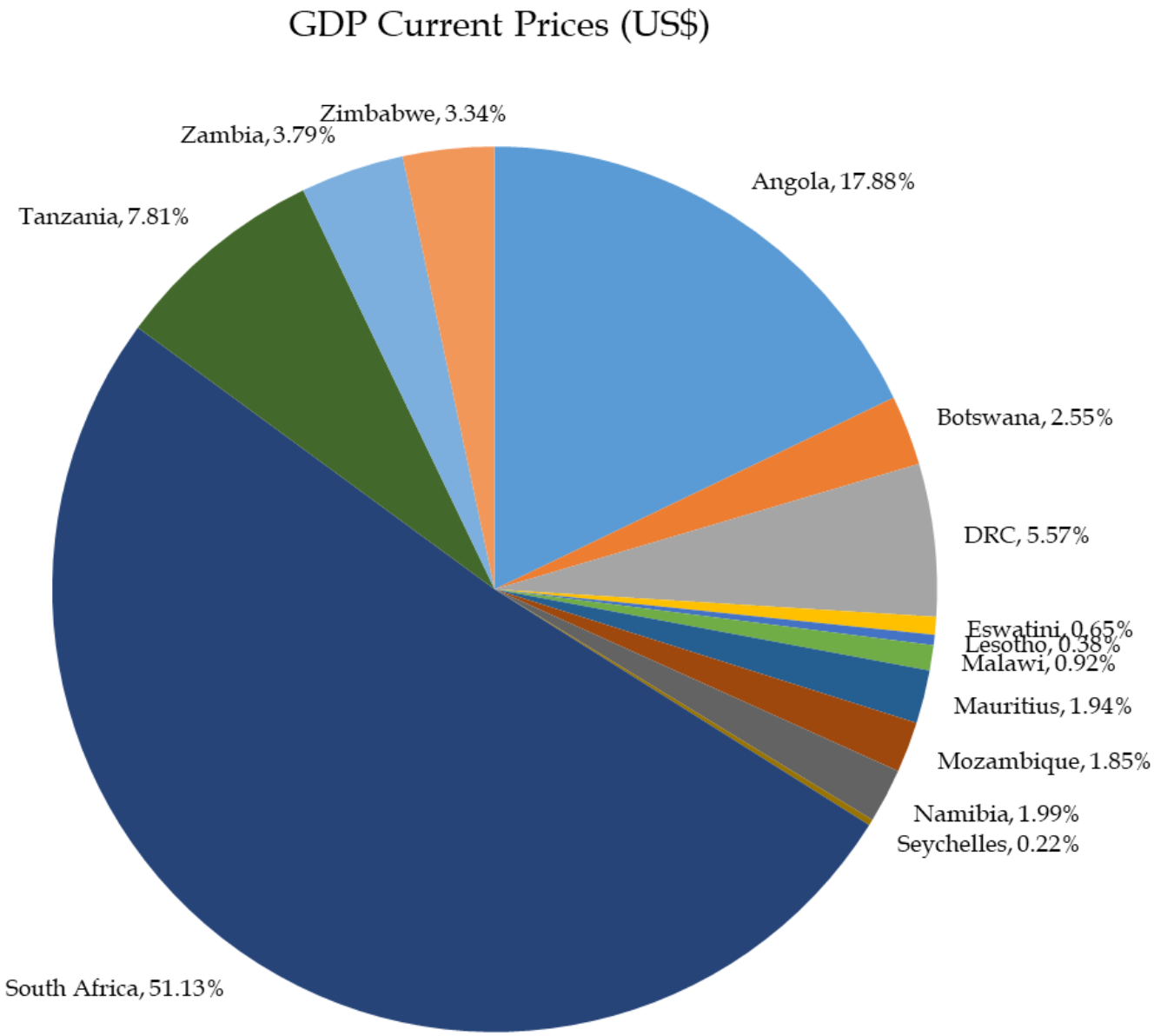
ITU-D ICT June 2019 ITU Statistics Ref.[3]

SADC



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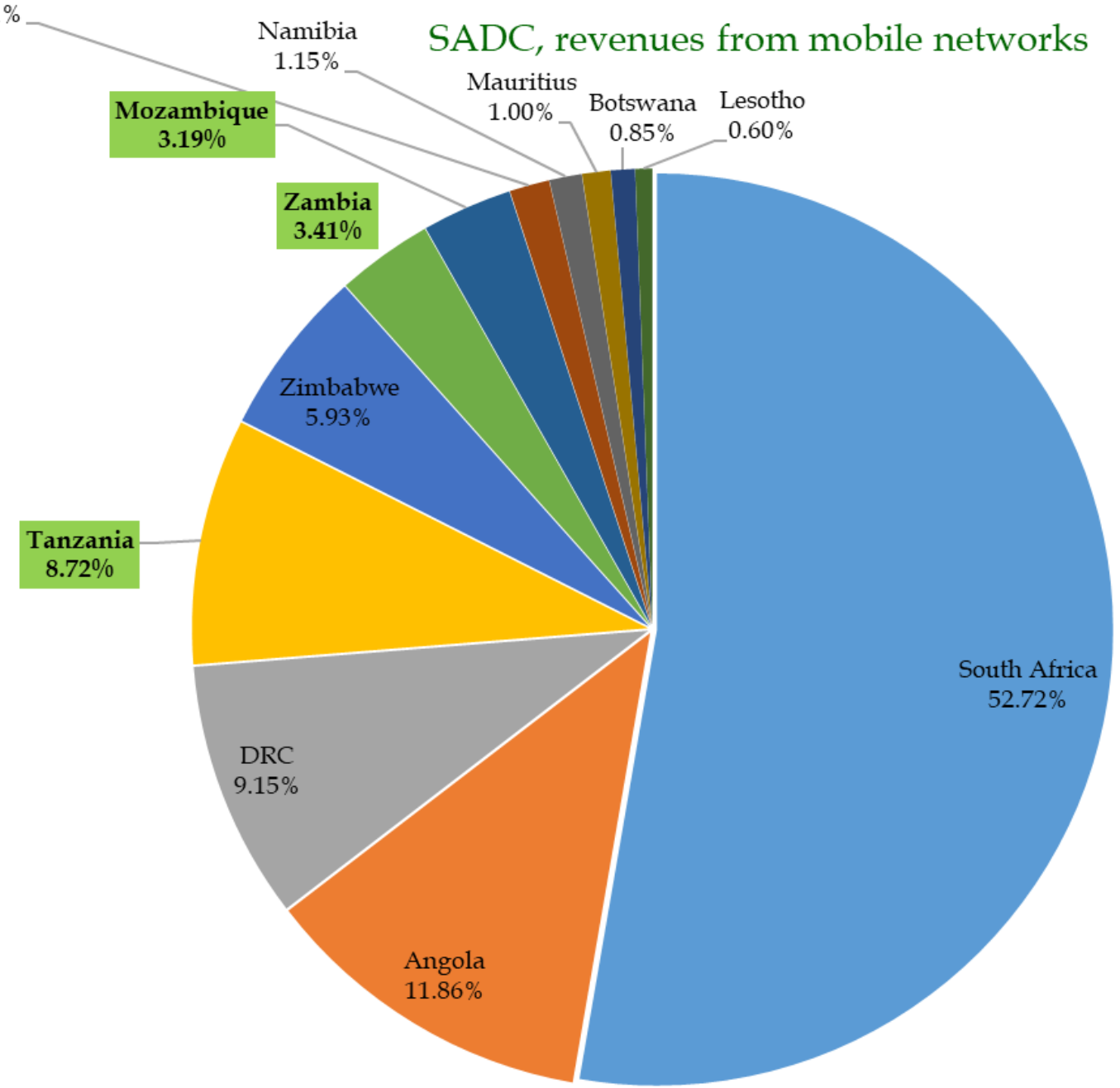
ITU-D ICT June 2019 ITU Statistics Ref.[3]



Tanzania input from GSMA 2018 about 2017

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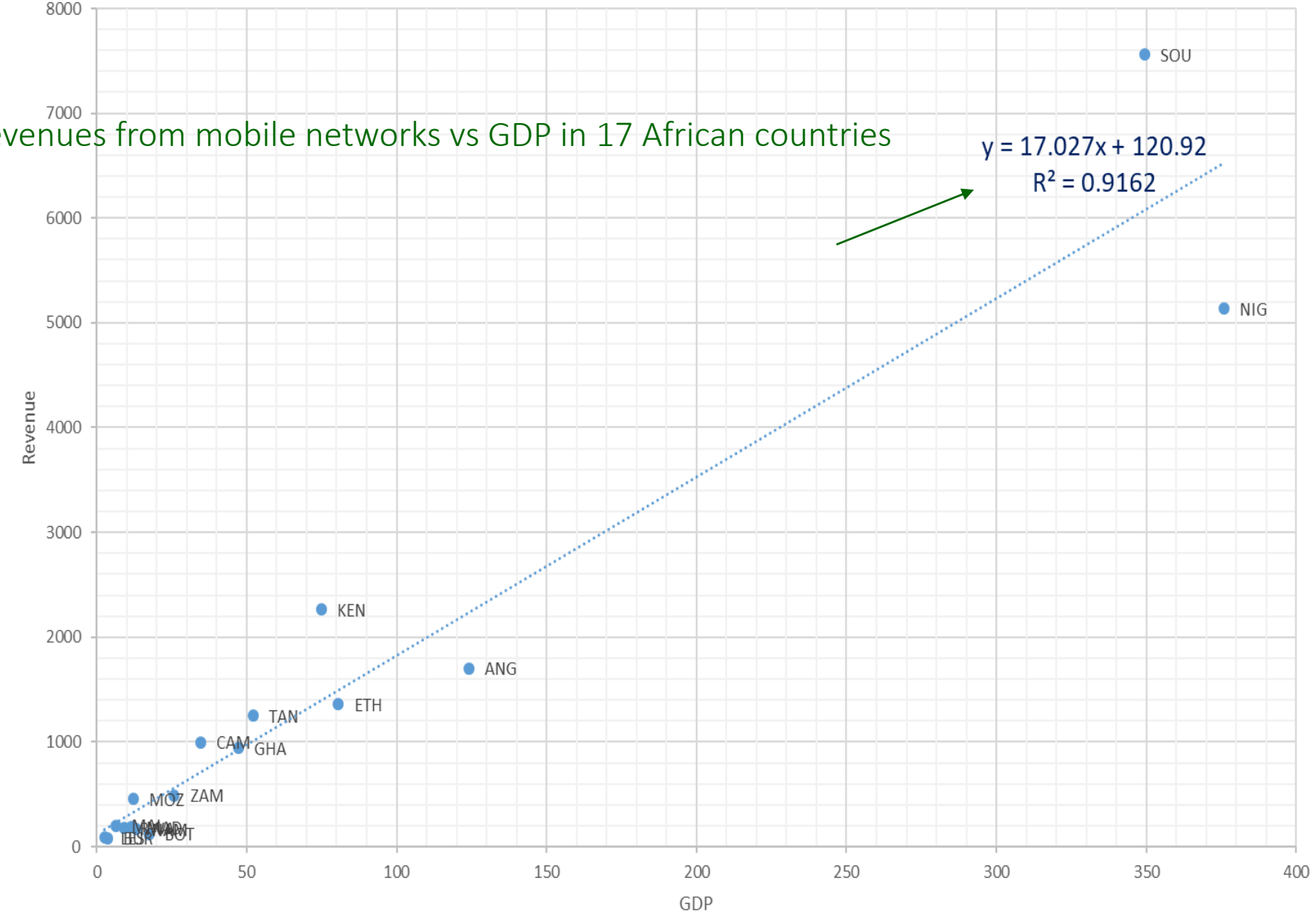
Compare GDPs among countries to define the minimum price

Revenues from mobile networks vs GDP in 17 African countries



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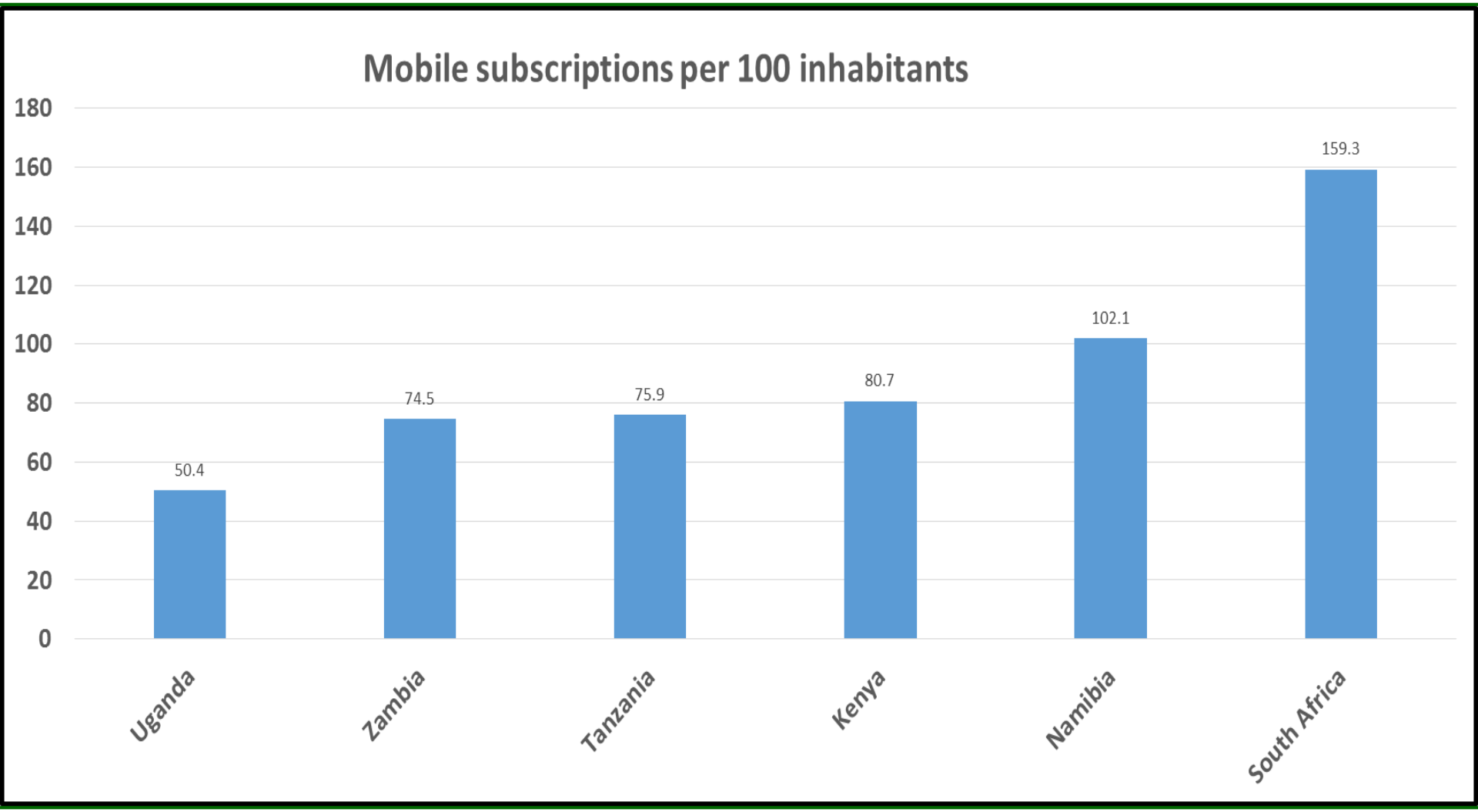

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Possible Benefits from Auctions

1. Advancement of the country's mobile broadband **infrastructure and capability** which will serve as a catalyst for the nation's economic development
2. Facilitation of social **provision of services** economic benefits to consumer as mobile broadband will widespread high quality services, and will be key to promote education, health and PPDR
3. Lowering mobile communications costs as a result deploying **fewer base stations** for wider coverage and therefore potential lower consumer prices
4. Extending mobile broadband services to a wider population especially those in **rural areas**
5. Promotion, enhancement and facilitation of **innovation for new ICT services & technologies**
6. Source of **national revenue** by obtaining optimal return for a scarce resource

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Objectives of Assigning 800/700 MHz

1. Increase QoS: data and voice services
2. Increase mobile broadband coverage & capacity for both urban & rural areas
3. Maintain & enhance competition

Normalized results in Ghana & Tanzania can define reserve-price

Normalised revenues from mobile networks (RMN) & GDP

Reference year 2017 for **2 x 10 MHz**

Reference for Revenues is ITU statistical database, while GDP is based on world-bank statistical database; but, ITU Indicator Revenues of Mozambique are 6,412,559.753 M and not 458 M!

	RMN (US$ MN)	GDP (US$ BN)	Price (US$ MN)
Ghana	945.00	47.33	**20.00**
Mozambique	458.00	12.33	**33.00**
Tanzania	1,250.00	52.11	**10.00**
Zambia	490.00	25.81	
Any other Country Normalised 2 x 10 MHz	GHA: **10.4**	GHA: **10.9**	
	MOZ: **35**	MOZ: **69.1**	
	TZA: **3.9**	TZA: **5.0**	

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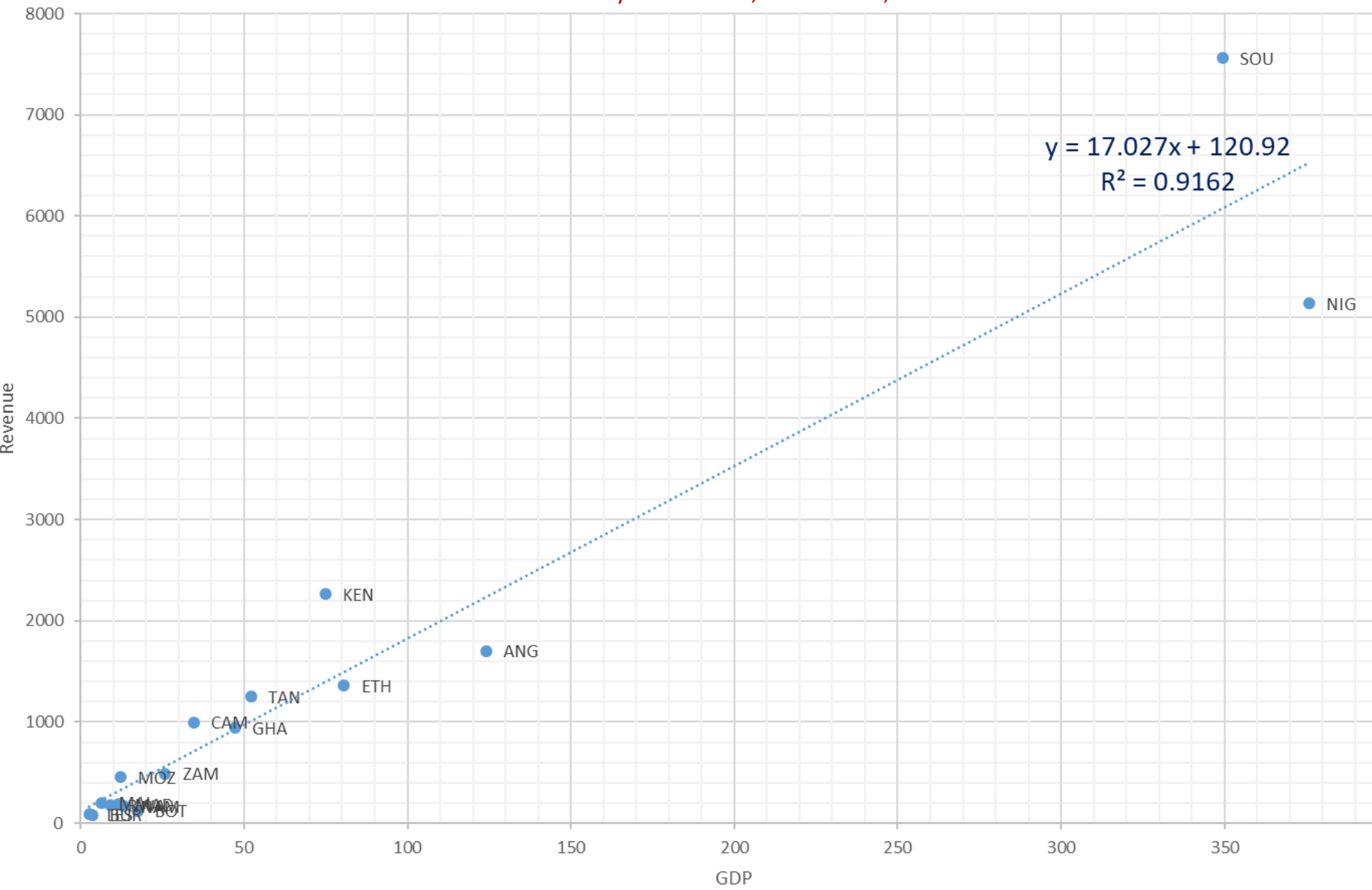
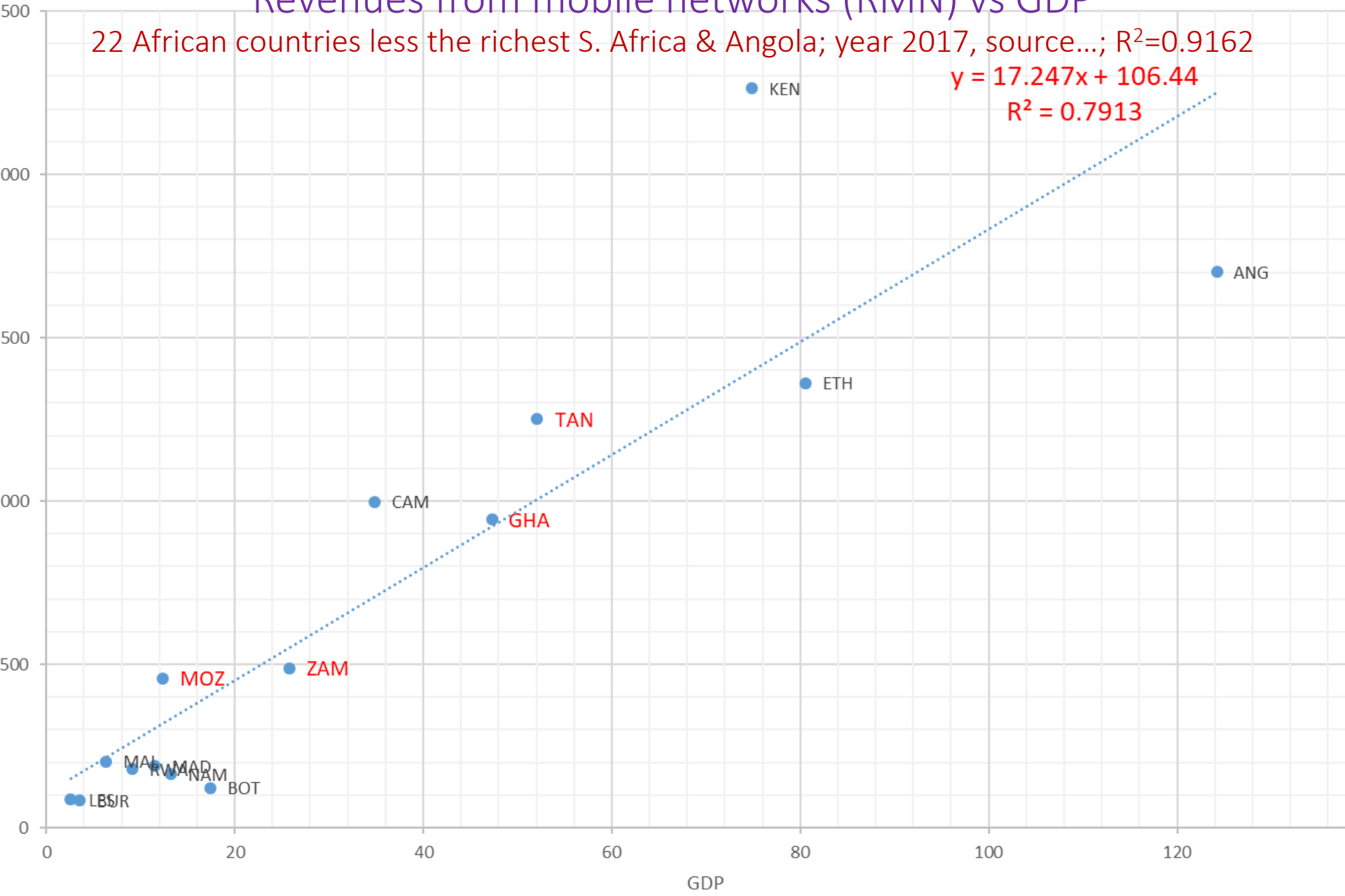
Revenue from Mobile Networks (RMN) vs GDP, Million US$

22 African countries year 2017, source…; R^2=0.9162



Revenues from mobile networks (RMN) vs GDP

22 African countries less the richest S. Africa & Angola; year 2017, source…; R^2=0.9162



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Recommendations

1. Restrictive granting procedure of assignment of scarce- resource 800/700 MHz in high-demand
2. Set appropriate initial reserve-prices & save time & money
3. Draft Information Memorandum
4. Start Consultation Process
5. RF validity will be similar to business-license
6. Assign 800/700 MHz, only for existing MNOs or ISPs
   (Fixed applications only in 800 MHz)
7. Follow RR Allocations
8. Assignment based on technology-neutrality
9. Follow ITU Rec. M.1036/ 3GPP channel-arrangements, European standards
10. Where the assignment shall be thru a competitive process, the bid should include a clause *Caveat Emptor*- check & monitor before participating in a bid
11. In case of competitive bidding, make reference to similar countries in Africa, that have successfully conducted a bidding process

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FDD 700/800 MHz bands frequency-arrangements; see Rec ITU-R M.1036 band-plan A3 (3GPP band-plan 20) at 800 MHz and M.1036 band-plan A7 (3GPP band-plan 28) at 700 MHz; ETSI TS 136 101 V14.7.0 (2018-04) Table 5.5-1：

ITU/GPP	UpLink, Base station receives	DownLink, Base Station transmits
A3/20	832 MHz–862 MHz	791 MHz–821 MHz
A7/28	703 MHz–748 MHz	758 MHz–803 MHz

Auctions- Administrative Uncertainties

1. Administrative Auction: only initial price without Auction?
2. Auctions? Beauty Contest?
3. More or less competitors than lots?
4. Auctions to some Operators?
5. Low or high reserve-price?
6. Type of market auction?
7. Open/ Close?
8. How to perform the industry stakeholder consultation?
9. Slots of 2x5 MHz or 2x10 MHz
10. 2x5 MHz at least for Public Protection and Disaster Relief (PPDR)?
11. Spectrum-caps and set-asides?
12. Spectrum hoarding and collusion prevention?
13. Auction design, format and methodology, rules?
14. Licensing mechanisms?
15. Auction software tools?
16. Bidder training & mock auctions?

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Decisions are needed: mainly technical uncertainties

1. Proper technical planning to achieve optimal assignments
2. Allocations only at 800 or also at 700 MHz?
3. Is there enough RF to all RF users?
4. Spectrum packaging (size and number of lots)?
5. Lots of 2x5 MHz or 2 x10 MHz?
6. 5 x2 MHz or even 10x2 to PPDR?
7. Aggregate, adjacent RF?
8. Oblige active RF sharing?
9. Rollout time? 18 months for existing Operators?

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Relevant Material from Dr. Haim Mazar presentations (1); see http://mazar.atwebpages.com/Downloads

1. Academic_Course_Advanced_Wireless_Communications_Mazar1_Engineering_2020.pdf
2. Academic_Course_Advanced_wireless_communications_Mazar2_Services_2020.pdf
3. Academic_Course_Advanced_Wireless_Communications_Mazar3_Regulation_EMC_HumanHazards_2020.pdf
4. Cameroon_EconomicModels_African_RF_Spectrum23Aug19French.pdf
5. Cameroon_Yaounde_Commonwealth_SM Forum_Mazar_Nov16_Spectrum re-farming.pdf
6. CamerounCellulaires_affectation_bande_470 694_21Dec18_French.pdf
7. CamerounSolutions_techniquesDTTV_MPT_UHF_21Dec2018_French.pdf
8. China_Beijing_SRMC 9July15_National Spectrum Control.pdf
9. China_Beijing_SRMC 9July15_SRD.pdf
10. China_Chengdu_National Spectrum Control Xihua University.pdf
11. Delft_Univ_Cultural_Factors_Shaping_RF_Spectrum_Governance_24Sept2010_Mazar.pdf
12. European vs North American Wireless Regulations_Mazar_ITU world telecom 2011_2633.pdf
13. Geneva_ITU-RSG1SG5-IoT-Workshop_Mazar_22Nov16.pdf
14. Heron5G_RF_regulations_6June19_Mazar.pdf
15. How_Geography_and_Culture_influence_RF_regulation_NZL_case_Wellington_4Feb2010_Mazar.pdf
16. IMT_5G_frequencies_HERON_ATDI_Mazar.pdf
17. ITUD_Gambia_Optimised_Ways_to_Transmit_the_Video_Signals_16July2010_Mazar.pdf
18. ITUD_Gambia_Policies_and_Strategies_to_Optimise_RF_Spectrum_Use_14July2010_Mazar.pdf
19. ITU_regional_SM_conference_connecting_Yerevan13Dec2017.pdf

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Relevant Material from Dr. Haim Mazar presentations (2); see http://mazar.atwebpages.com/Downloads

20. ITU_regional_SM_workshop_parameters_Yerevan14Dec2017.pdf
21. ITU_workshop_international_regional_and_national_regulation_of_SRDs_Mazar.pdf
22. International_Regional_National_RF_Regulation_Standardisation_Ruppin_Mazar.pdf
23. International_Regional_National_RF_Spectrum_Management_13Dec2011_Afeka_Tel_Aviv_Academic_College_of_Engineering_Mazar.pdf
24. January 2016_National Spectrum Control_China@SRTC&XHU.pdf
25. January 2016_SRD_Mazar_SNG&SRTC&XHY&GDRTC.pdf
26. Lusaka_ZICTA_Auctioning_Training_30Sept-4Oct19_Mazar.pdf
27. Paper WT11 Technical Symposium TS11 Haim Mazar_A Comparison between European and North American Wireless Regulations.pdf
28. Presentation WT11 Technical Symposium TS11 Haim Mazar_A Comparison between European and North American Wireless Regulations.pdf
29. Regulating_SRD_Israel_MoC_28Jan2019_Mazar.pdf
30. Regulation of SRDs_Mazar_TCBC_Baltimore_15April2015.pdf
31. Regulation_and_Standardization_of_Wireless_Communications_Israel_Europe_America_22Dec09_Ort_Braude_College_Mazar.pdf
32. WarsawEMF2019_Mazar_WRC19_5G_IMT2020_ITU4Dec19.pdf
33. Webinar_International_GoGlobal_Haim_Mazar_UHF_RFID_global_and_regional_ruling_19Feb13.pdf
34. Wireless_Communications_Coexistence_between_Israel_and_Neighbors_Ashdod_17May2010_Mazar.pdf
35. Wireless_Telecommunications_training_program_Nepal_Kathmandu_24_28Nov08_Mazar.pdf
36. ZICTA_CEPT&UK_9Jan17_Mazar.pdf
37. ZambiaZICTA_PricingModel19April2017Mazar.pdf
38. ZambiaZICTA_RF_Audit19Apr2017Mazar.pdf

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