ECONOMIC AND FINANCIAL ASPECTS OF SPECTRUM ALLOCATION

A presentation to the ITU Regional Economic and Financial Forum of Telecommunications/ICT for Africa

Telecom Advisory Services, LLC

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- Economic, technical and social principles governing assignment and use of the radio spectrum
- Economic and market-related aspects to consider when assigning and using radio spectrum
- Guidelines on assigning and using radio spectrum

THE RADIO-FREQUENCY SPECTRUM IS THE PORTION OF THE ELECTROMAGNETIC SPECTRUM THAT IS USED FOR TELECOMMUNICATIONS

USES AND PROPERTIES OF BANDS IN THE RADIO-FREQUENCY SPECTRUM

Band	Frequency range	Range	Common use	Bandwidth
VLF (myriametric waves)	3-30 kHz	1 000 km	Long-range radionavigation	Very narrow
LF (kilometric waves)	30-300 kHz	1 000 km	Long-range radionavigation	Very narrow
MF (hectometric waves)	300-3 000 kHz	2-3 000 km	Long-range radionavigation	Moderate
HF (decametric waves)	3-30 MHz	Up to 1 000 km	Fixed point-to-point, Global broadcasting	Wide
VHF (metric waves)	30-300 MHz	2-300 km	Broadcasting, Mobile, WAN	Very wide
UHF (decimetric waves)	300-3 000 MHz	< 100 km	Broadcasting, Mobile, Satellite	Very wide
SHF (centimetric waves)	3-30 GHz	30-2 000 km	Fixed, Broadcasting, Mobile, WAN, Satellite communications	Very wide up to 1 GHz
EHF (millimetric waves)	30-300 GHz	20-2 000 km	Broadcasting, Fixed point-to-point, Mobile, Satellite communications	Very wide up to 10 GHz

Source: ITU 2011 ICT Regulation Toolkit. Radio Spectrum Management. Module 5, p. 12

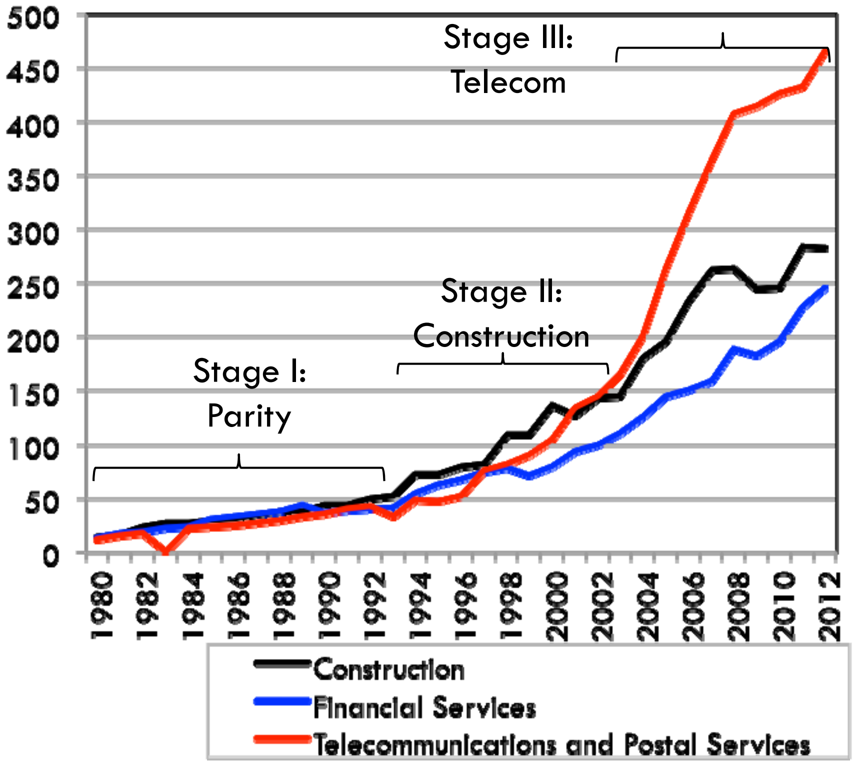
THE SPECTRUM AS AN ECONOMIC RESOURCE

	Spectrum	Land	Oil reserves	Water
Is the resource varied?	Yes	Yes	Not very	Not very
Is it scarce?	Yes	Yes	Yes	Yes
Can it be made more productive?	Yes	Yes	Yes	No
Is it renewable?	Yes	Partially	No	Yes
Can it be stored for later use?	No	No	Yes	Yes
Can it be exported?	No	No	Yes	Yes
Can it be traded?	Yes	Yes	Yes	Yes

Source: ITU 2011 ICT Regulation Toolkit. Radio Spectrum Management. Module 5, p. 8.

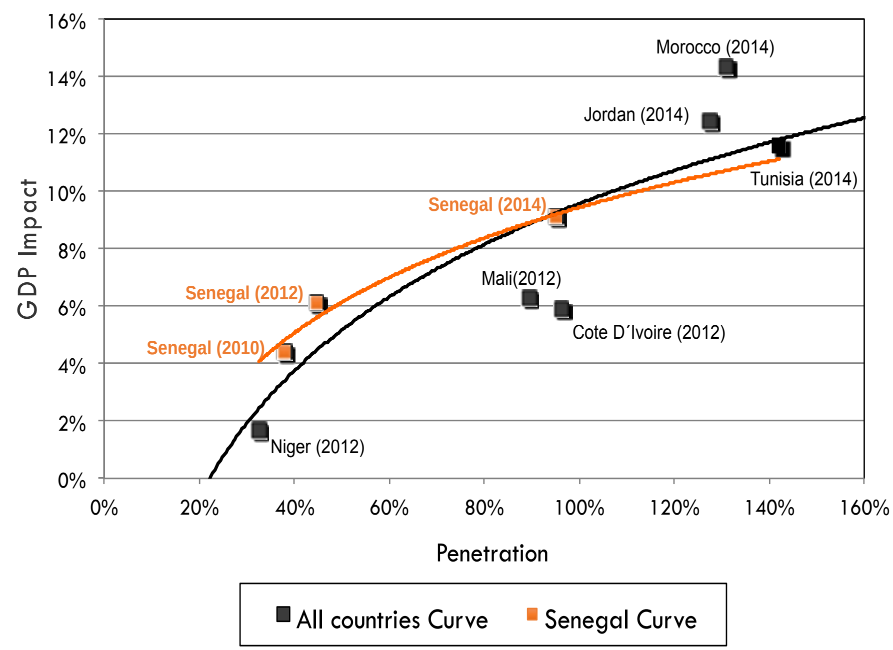
RADIO SPECTRUM MANAGEMENT DECISIONS ARE A CRITICAL ECONOMIC POLICY DECISION BECAUSE OF THE IMPORTANCE OF TELECOMMUNICATIONS

SENEGAL: GDP BY INDUSTRY (1980-2012) (in CFA '000'000'000)



Source: Senegal National Accounts

AFRICA: MOBILE TELECOMMUNICATIONS ECONOMIC IMPACT VS. WIRELESS PENETRATION



Source: Telecom Advisory Services analysis

THE LIMITED ALLOCATION OF SPECTRUM TO MOBILE TELECOMMUNICATIONS IN AFRICA COULD BECOME A FUTURE INDUSTRY – AND ECONOMIC -- BOTTLENECK

AFRICA: MOBILE TELECOMMUNICATIONS INSTALLED BASE (in '000'000)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Connections	543	638	739	815	901	987	1,068	1,136	1,196	1,249	1,287
Unique Subscribers	290	335	379	424	467	509	545	577	607	633	658
Mobile broadband(*)	17	32	52	78	108	141	181	224	271	318	364

(*) 3G / 4G Source: GSMA

SPECTRUM ASSIGNED TO IMT MOBILE SERVICES (in MHz)

	United States	European Union	Ghana	Kenya	Nigeria	Senegal	South Africa	Tanzania
Assigned Spectrum	547	590	330	220	363	232	340	360
Un-assigned spectrum	- - -	- - -	30	130	- - -	128	20	- - -
Future blocks	500	500	250	250	250	250	250	250
Total	1,047	1,090	610	600	613	610	610	610

Sources: Plum Consulting; NRAs; operators

SPECTRUM MANAGEMENT COMPRISES THREE AREAS OF REGULATORY RESPONSIBILITY RESULTING IN THREE DECISIONS TO BE IMPLEMENTED IN A SEQUENTIAL MANNER

AREAS OF RESPONSIBILITY OF SPECTRUM MANAGEMENT

Area of responsibility	Regulatory Policy Initiatives
Allocation	• Entry in the national table of frequency allocations of a given frequency band for the purpose of its use by one or more specific services • Spectrum can be allocated on an exclusive basis (allocated to a single service) or a shared basis (shared by more than one service), and on a primary or secondary basis
Allotment	• Entry of a designated frequency or channel in a plan for use by a specific service under specific conditions • The allocation is made by a competent conference, such as the World Radiocommunication Conference convened by the International Telecommunication Union
Assignment	• Authorization given by a national regulatory authority for a given entity (e.g. a mobile telecommunication service operator or provider) to use a designated frequency or channel under specified conditions

SPECTRUM MANAGEMENT AIMS AT MAXIMIZING THREE OBJECTIVES: ECONOMIC EFFICIENCY, TECHNICAL EFFICIENCY, AND SOCIAL BENEFIT

OBJECTIVES TO BE MAXIMIZED IN THROUGH SPECTRUM MANAGEMENT

Administrative Paradigm

- Unused spectrum: wasted
- Provide basic services
- Who?

Administrative Parameters

Technical Paradigm

- Spectrum: scarce resource
- Accommodate more services in less spectrum
- Who?
- Where?
- What?
- When?
- How?

Technical Parameters

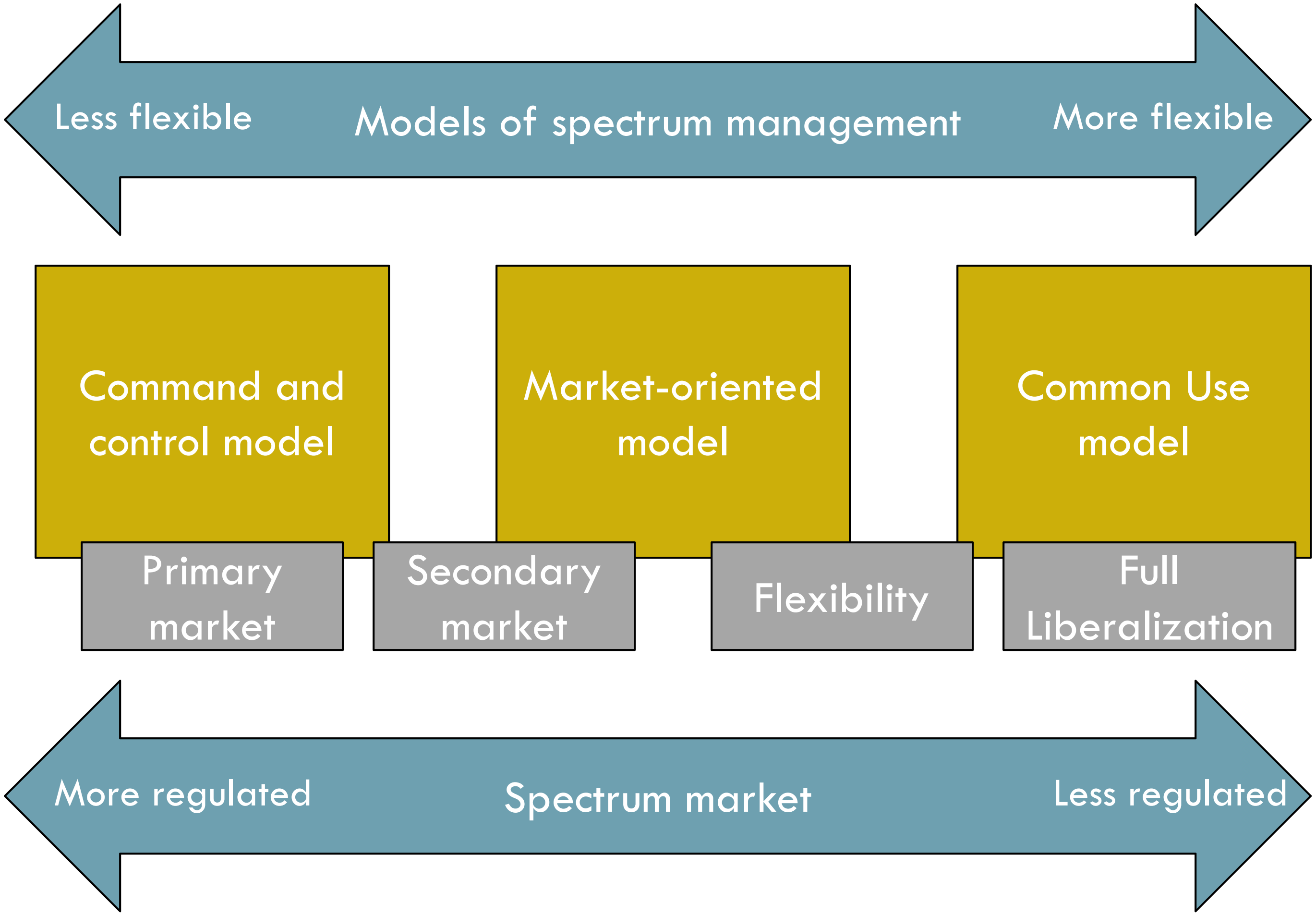
Economic and Financial Paradigm

- Spectrum: resource of estimable value
- Accommodate new services with minimum interference and at the correct value (cost)
- Who?
- Where?
- What?
- When?
- How?
- How much?

Economic and Financial Parameters

THERE ARE THREE ADMINISTRATIVE MODELS FOR ASSIGNING SPECTRUM: COMMAND AND CONTROL, MARKET-ORIENTED, AND COMMON USE OR UNLICENSED

MODELS FOR ASSIGNING SPECTRUM



Source: Author

THE COMMAND AND CONTROL MODEL INVOLVES GRANTING USAGE LICENCES WITHIN A PRIMARY MARKET, ORGANIZED ON THE BASIS OF ADMINISTRATIVE ASSIGNMENTS

- In the early days of wireless communications (primarily maritime), as there were so few spectrum users, the risk of interference was minimal, with the result that use of the spectrum was completely free and unlicensed
- The proliferation of radio stations in the 1920s prompted the US Congress to set up a telecommunication regulator empowered to grant licences for the exclusive use of bands of spectrum
- This model was criticized by Ronald Coase in 1959, when he asserted that the the command and control model was not the economically most efficient way of assigning a scarce resource
  - When a resource is scarce, the best way of distributing it is through a price-setting mechanism in order to ensure that the recipient of the frequency band will generate the greatest economic value
  - Consequently, Coase established that, in the same way as land is protected by clear property rights, the spectrum should be, too
  - The protection of spectrum property rights is irrevocable, guaranteeing the right to utilize the spectrum for a specified period and under specified conditions, so that it can be assigned as efficiently as possible
  - Thus, setting the price of spectrum by means of an auction will guarantee more effective assignment of its use than the command and control model. In a frequency band auction, the highest bidder is granted a licence to transmit and receive signals in the band acquired
- On the basis of Coase's recommendation, in 1993 the US Congress empowered the telecommunication regulator to organize licence auctions
- This method has since spread to most countries of the world, partly because it gives governments the possibility to generate significant revenues

TYPES OF AUCTION

Modelo	Observaciones
Sealed-bid first-price	• Bidders tender simultaneous sealed bids in a single round, and the winner pays the price corresponding to the highest offer • The process begins with a presentation of interested parties and their prequalification, followed by the submission of bids • In some cases, the prequalification and tendering phases are combined in order to avoid candidates having prior knowledge of the identity of the bidders
Sealed bid second-price	• Sealed bids are also tendered simultaneously, but the license is awarded at the value of the second-highest bid • In a second-price auction, the winner only pays the price offered by the second highest bidder
Multiple round (ascending or English)	• Bids are progressively raised in each round • At the end of each round, participants obtain feedback on their position in the state of play • The winner pays the highest price bid
Multiple round (descending or Dutch)	• The seller publicly announces progressively lower prices. The winner pays the price bid

FROM A REGULATOR'S PERSPECTIVE, VARIOUS FACTORS HAVE TO BE TAKEN INTO ACCOUNT IN DESIGNING AN AUCTION AND SELECTING THE MOST SUITABLE MODEL

- Type of band(s) to be auctioned
- Current and future status of those bands
- Type of valuation of the band (private or common value)
- Participants' behavior (neutrality or risk aversion)
- Desired characteristics for the new market
- Type and amount of information to be disclosed on the conduct of the auction
- Spectrum caps (multi-band, multi-auction)
- Medium- and long-term auction plans
- Coverage obligations
- Inherent tax liabilities
- Infrastructure sharing/secondary markets

IN DESIGNING AN AUCTION, THE REGULATOR HAS TO CONSIDER A SERIES OF OBJECTIVES TO BE ACHIEVED

- Promoting efficient assignment of spectrum
- Stimulating competition in the industry
- Encouraging participation in the auction
- Generating revenues for the government
- Increasing geographic coverage of networks

> - There is no single or “best” model
> - This means that there is no clear correlation between the auction model and the outcomes
> - Each model has specific features, each having a different appeal for governments and bidders
> - Ultimately, the auction model depends on the market structure (and the government’s objectives in terms of developing an appropriate competition model)

AUCTIONS CAN GENERATE DISTORTIVE BEHAVIORS, WHICH NEED TO BE CONTROLLED

TYPES OF AUCTION DISTORTION

Distorsion	Definition	Remedies
Signaling strategies	• Multiple round auctions is more exposed to signaling strategies among bidders	• Conduct a single round auction with pre-qualification
Risk avoidance	• Risk aversion could lead to lower valuation of licences • Furthermore, any uncertainty with regard to the duration of the licence to be auctioned creates confusion and could result in lower bids	• Specify in the most precise manner the characteristics of the right that is being auctioned (coverage, available bandwidth, licence right, etc.), as well as the license conditions, service restrictions, equipment standards, etc..
Colusion	• Several bidders share information or agree to behave in a certain manner (cooperative strategy) to earn the auctioned good (or share the licences)	• Consider single round auctions in a sealed bid instead of multiple ascending rounds • Consider hyprid auctions shifting from ascending rounds to saled bid when the number of bidders diminishes
Winner's curse	• The winner of the spectrum auction pays an amount for the license that exceeds the amount of its economic value • If the "winner's curse" is extremely severe, it may give rise to friction costs which are liable to affect investment in the future deployment of networks	• In a multiple-round auction, bidders can have access to information on how much each of their opponents estimates the spectrum to be worth, thereby reducing uncertainty

ANOTHER MARKET-ORIENTED SPECTRUM ASSIGNMENT MODEL IS THAT OF A SECONDARY MARKET

- In some countries licenses can be transferred through a private transaction without any significant restrictions, subject to some degree of power of veto on the part of the regulator for technical or exceptional reasons
- Contracts could entail sale, sale with repurchase, short term or long-term lease, or mortgage
- In markets which have matured to a greater level of flexibility and the implementation of secondary markets, regulatory mechanisms have been introduced with the aim of cutting down on the administrative restrictions on licensing, allowing licenses to be subdivided and recombined in new configurations
- The option of temporarily surrendering spectrum usage rights for a period of time could come to be more important than the option of selling spectrum, as a way of channeling into a secondary market the supply of spectrum which is being underused in the short term. Since we are typically dealing with long-term licenses that have been granted through competitive mechanisms, the license-holder is unlikely to want to relinquish the license, or even part of it, but with the incentive of a rent may be willing to surrender temporary or shared use

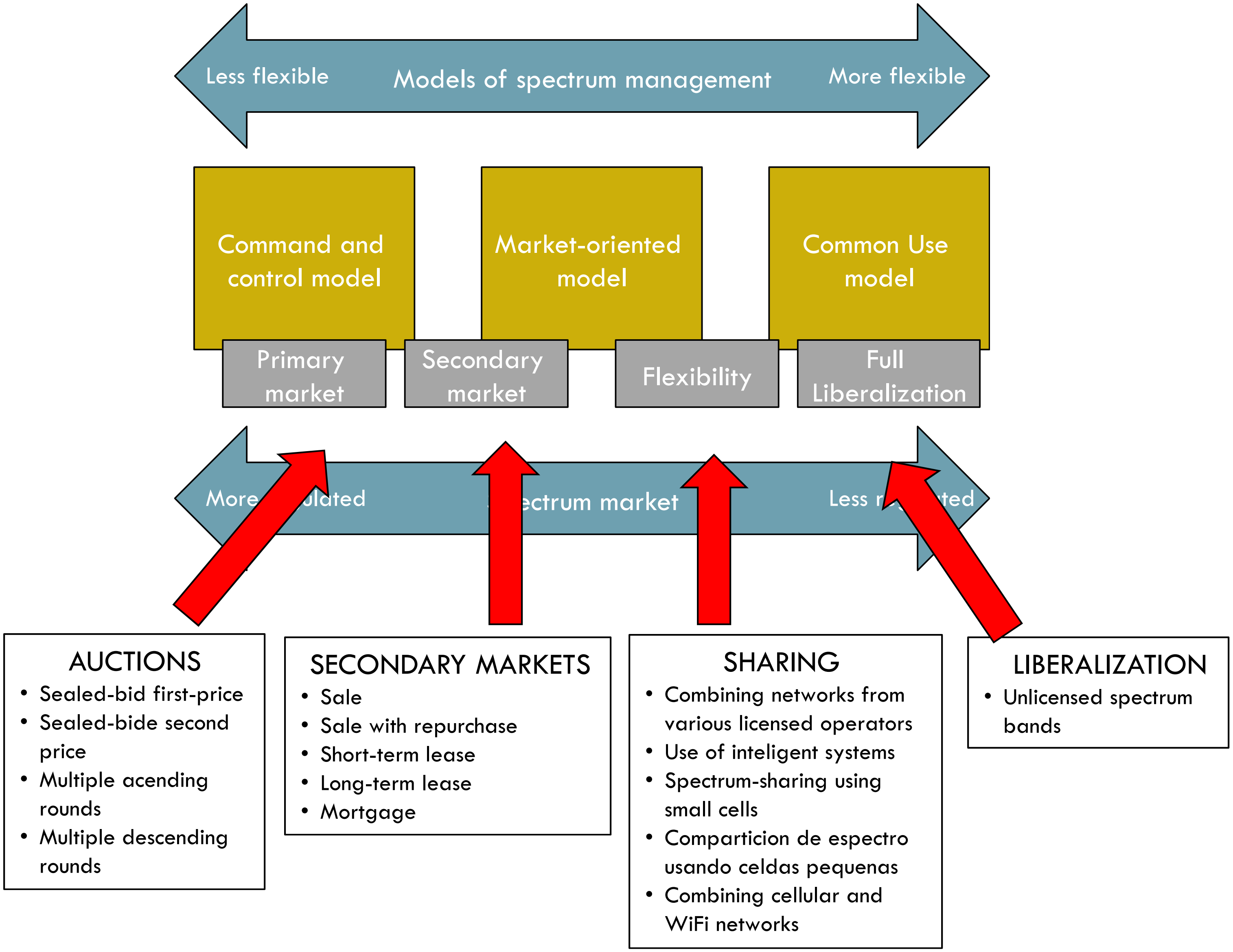
SPECTRUM SHARING IS AN APPROACH OF A COMMON-USE MODEL TO IMPROVE ASSIGNMENT EFFICIENCY – IT ENTAILS DIFFERENT OPTIONS

SHARING MODELS

Model	Characteristics
Unlicensed spectrum (common-use bands)	• The use of the bands is free and is regulated solely on the basis of technical restrictions and type-approval of equipment in order to limit interference to other services • Currently, the application of common bands is becoming more widespread in many industrialized countries (United States, United Kingdom, Canada)
Combination of spectrum from various licensed operators	• This sharing model assigns given frequency bands for cooperative use in restricted geographic areas • The concept has been developed by New Zealand in what it calls "licensed spectrum parks"
Use of software defined radio (SDR) and cognitive radio system (CRS)	• Software-defined radio systems allow the operational parameters of radio frequencies, including band selection, type of modulation and output power, to be set or changed by means of software • Cognitive radio systems allow transmitters and receivers to adapt dynamically and independently to operational parameters and protocols based on information taken from the operating and geographic environment
Sharing of spectrum using small cells	• When the primary licensee uses spectrum in remote areas, this spectrum can be reused by small cells in high-demand urban areas that are far away from the remote location • For example, the United States telecommunications regulator allows shared-spectrum use and the deployment of small cells in the 3.5 GHz band, where maritime radar is the primary user
Combinations of wireless networks (e.g. Routing cellular traffic through Wi-Fi sites, off-load)	• Combining Wi-Fi and cellular technologies that operate in different spectrum bands means that a large amount of the increase in wireless traffic can be accommodated • Analysts estimate that 40 per cent of wireless traffic (mainly Internet access) is routed via public and private Wi-Fi locations

IN SUM, WE HAVE REVIEWED THREE SPECTRUM ASSIGNMENT MODELS, IMPLEMENTED THROUGH FOUR DISTINCT APPROACHES

MODELS OF SPECTRUM ASSIGNMENT



AGENDA

- Economic, technical and social principles governing assignment and use of the spectrum
- Economic and market-related aspects to consider when assigning and using radio spectrum
- Guidelines on assigning and using radio spectrum

SPECTRUM VALUATION METHODOLOGIES

Objective	Methodology	General Description
Estimation of a reserve price in an auction	Avoided cost estimation	Calculation of the potential cost reduction (based on additional capacity or coverage) that would result from making additional spectrum available to operators
Estimation of revenues to be generated in an auction	Use of comparable results (*benchmarking*)	• Collate and normalize auction prices obtained in cases similar to the country for which the results will be used (for example, neighboring countries); • Through econometric analysis, which allows different cases to be included taking account of socio-economic or topographic differences
Determination of optimum license price in secondary market transaction	Business case estimation	Estimate the expected profitability in terms of discounted cash flows derived from acquisition of the spectrum
Estimation of spectrum economic value based on alternative allocation scenarios (digital dividend)	Estimation of social and economic benefits	Assessment of economic and social impact of alternative allocation scenarios

ESTIMATION OF AVOIDED COSTS IS BASED ON A CALCULATION OF THE POTENTIAL COST REDUCTION RESULTING FROM MAKING ADDITIONAL SPECTRUM AVAILABLE TO OPERATORS

- This model assumes that the operator must respond to demands for greater capacity in its network due to growth in the number of users and use of devices. Demand for increased network capacity may be met through:
- Improved technological efficiency (more Mbps/MHz)
- Better reuse of frequencies
- Enhancement of radio base infrastructure
- Combination of networks (for example, routing of cellular traffic via Wi-Fi sites)
- As a final option, acquisition of more spectrum
- The additional capital investment required for the first four options, without the possibility of acquiring more spectrum, is what is referred to as *avoided costs*
- The advantage of the avoided costs model lies in the fact that, by being based directly on the specific characteristics of the market for which the spectrum price is being determined, the estimate is based on the immediate environment and specific context and does not depend on any extrapolation of spectrum price resulting from auctions in other countries
- On the other hand, development of the model requires access to information on infrastructure and specific network operating costs for operators in the market for which the spectrum price is being determined

AS AN EXAMPLE, THE USE OF 700 MHZ AND 470-698 MHZ BANDS ALLOW A REDUCTION OF THE NUMBER OF BASE STATIONS WHILE ACHIEVING BETTER SIGNAL PROPAGATION

METHODOLOGY FOR CALCULATION OF A REDUCTION OF BASE STATIONS

Base stations required under 470-698 MHz allocation to IMT = Base stations required under 700 MHz allocation to IMT − Urban base stations required under 470-698 MHz allocation to IMT + Rural base stations required under 470-698 MHz allocation to IMT

Country	Current number of base stations	Reduction in the number of base stations under 470-698 MHz
Argentina	15,731	881
Brazil	73,111	3,977
Chile	4,892	271
Colombia	14,019	749
Mexico	37,943	1,998
Peru	9,335	513
Rest Latam	41,931	2,269
TOTAL	196,962	10,659

- Reduction in base stations: 5%
- NPV of CAPEX: US$897 million

Source: Telecom Advisory Services analysis

USE OF COMPARABLE RESULTS (COMMONLY REFERRED TO AS *BENCHMARKING*) IS THE MOST COMMONLY USED SPECTRUM VALUATION METHODOLOGY

- Comparable results can be analyzed through two methodologies
  - Compiling and normalizing auction prices obtained in cases similar to the country for which the results will be used (for example, neighboring countries)
  - Econometric analysis, which allows different cases to be included taking account of socio-economic or topographic differences
- The main advantages of this methodology lie in the simplicity of compilation and communication and in the fact that prices can easily be verified
- The drawback is that comparable data may not necessarily reflect the specific conditions of the country for which the results of the analysis are used
  - The value generated by a spectrum auction varies according to the market in which the spectrum is used
  - In addition, the selection of data may have a significant impact on the results of the spectrum price to be estimated
- The conditions that affect the price include the national financial and fiscal framework, parafiscal obligations incumbent on the regulator (universal fund, and so on), coverage obligations, spectrum caps, short- and medium-term availability of bands, license period, and renewal options

HOWEVER, THIS METHODOLOGY REQUIRES NORMALIZATION OF THE DATA USED TO BE IMPLEMENTED

- Time at which the auction is conducted in terms of market development: older auction data might not be appropriate since commercial, industrial and technological factors could have changed relative to the current situation
- Characteristics of the frequencies to be auctioned: these include the frequency range, the technologies and services that might be used in the frequencies concerned, and the amount of spectrum available. The data used must correspond to similar frequencies; differences in frequency allocation plans must be considered, and the information compiled should preferably relate to countries with similar plans
- License characteristics: these must include the terms of sale of the license, including the period of validity and coverage obligations if any
- Economic and structural factors: size of the economy, projected growth, income level
- Population density and urbanization rate
- Specific characteristics of auction participants: those depend of the intended use for the spectrum (increase revenues, reduce cost) and market expectations. Variables to be compiled should include the licenses that participants hold at time of auction, their network deployment, their strategic objectives and market expectations
- Auction specific characteristics: reserve price, spectrum caps, etc.

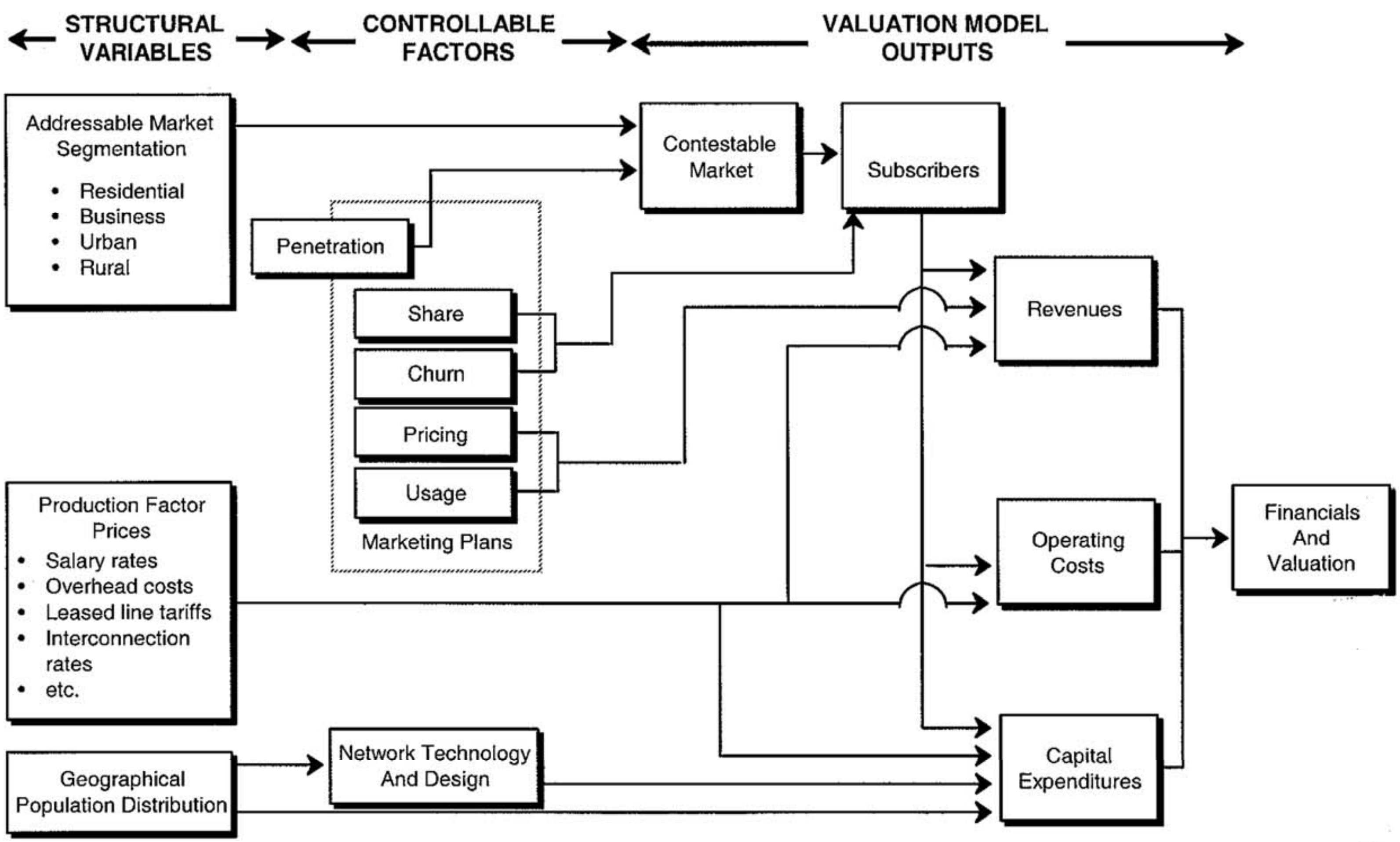
ONCE CASES HAVE BEEN SELECTED WITH RESULTS THAT ARE VALID IN TERMS OF COMPARABILITY, THE NORMALIZED VALUES MUST BE CALCULATED

- The three indicators that should be used are:
  - Value per MHz per head of population in real terms
  - Value per MHz by per capita GDP
  - Value per MHz per head of population, adjusted by purchasing power parity
  - All the above by year (taking account of differences in license periods)
- In addition to normalization by MHz, population and per capita GDP, compilation of price data in each comparable auction must be calibrated in terms of total value collected and license period
- At the same time the prices must also be converted into a single currency, using types of exchange adjusted to purchasing power parity and inflation
- Once data on prices obtained by auctions in each country have been collected and normalized, it is important to consider prices in comparable frequency bands in order to calculate averages with a view to estimating the potential value of the spectrum to be auctioned
- In the event that some of the cases to be considered in the average include countries with particular characteristics such as limits on the amount of spectrum that can be acquired by an operator, such cases must be excluded or assigned a normalizing weight
- If there are not sufficient examples in specific frequency bands, cases will need to be aggregated in groups of bands with similar signal propagation characteristics (for example, aggregating the 800 MHz band in Europe and the 700 MHz band in the Americas for 4G, or the AWS band in the Americas with the 2.1 GHz band in Europe and Asia)

THE OBJECTIVE OF DEVELOPING A BUSINESS CASE IS TO CALCULATE THE PROFITABILITY TO BE GENERATED BY ACQUIRING THE SPECTRUM LICENSE

- The basic assumption of this methodology is that an operator acquiring a license in order to offer a telecommunication service would never pay more than the net present value (NPV) of the discounted cash flows generated by exploiting the license
- This model is particularly suited to the case of new entrants in the mobile market
- Calculation of the discounted cash flow value requires an estimate of revenues based on the number of expected new subscribers, revenue per subscriber, and business operating costs.
- This calculation is based on two assumptions
  - First, that the spectrum is a cost-free input in the mobile operator's production operation. The price to be paid for spectrum thus cannot exceed the net value of the discounted cash flows generated by the acquisition of that spectrum
  - Secondly, the model assumes that all profitability is the result of acquiring the spectrum, when in reality a proportion of the profitability should be attributed to other factors such as the brand power associated with the purchaser

THE BUSINESS CASE ENTAILS DEVELOPING A MODEL BASED ON STRUCTURAL VARIABLES AND ASSUMPTION REGARDING KEY FACTORS



Source: Telecom Advisory Services

THESE METHODOLOGIES CAN USED IN A COMBINED FASHION TO DETERMINE THE SPECTRUM PRICE IN AN AUCTION

- The starting point for determining spectrum value is a determination of the auction reserve price
  - This is the minimum price for which the seller is disposed to sell a commodity or service
  - Calculation of the reserve price, also regarded as the indifference point, is based on the avoided costs methodology
  - This assumes that an operator considering acquisition of a license should not pay less that the cost involved in other ways of meeting the demand created by an increase in network traffic
- Having fixed the reserve price based on the avoided costs model, estimates of the maximum price should not exceed the net present value of the cash flows to be generated through access to the new spectrum
- Having determined the two extremes of the price range, the value to be generated by an auction would be situated between those two extreme points
- Nevertheless analysis of comparable results could generate a result outside the extremes of the price range, depending on the specific conditions in the country where the auction takes place (or the "winner's curse" effect)

VALUATION OF UNLICENSED SPECTRUM CALLS FOR METHODOLOGIES BASED ON SOCIAL AND ECONOMIC BENEFIT ASSESSMENT

- For this, it is necessary to ascertain the potential economic contribution of general licenses in four areas
  - Complementary value: the value contributed by the general license as a complement to other exclusive technologies.
  - Value of alternative technologies: common licenses can provide the platform required to develop new technologies to replace existing ones, increasing the range of options available to consumers
  - Value of alternative business models: as introducing new business models operating under common licenses does not require prior authorization for operators holding an exclusive license, development can be more dynamic. There is no need for rent- or subsidy- sharing mechanisms, or modes of using frequencies beyond the requirement that the new business model comply with pre-established rules for common-use licenses
  - Value of expanding communication systems: Wi-Fi technology allows the establishment of local telecommunication operators in isolated communities, thereby addressing a potential market failure
- The combination of these four aspects of value creation enables us to calculate the contribution to GDP (in terms of new business) and create a consumer surplus (through lower prices for access to communications) and producer surplus (derived from the reduction in capital investment in networks resulting from traffic routing measures)

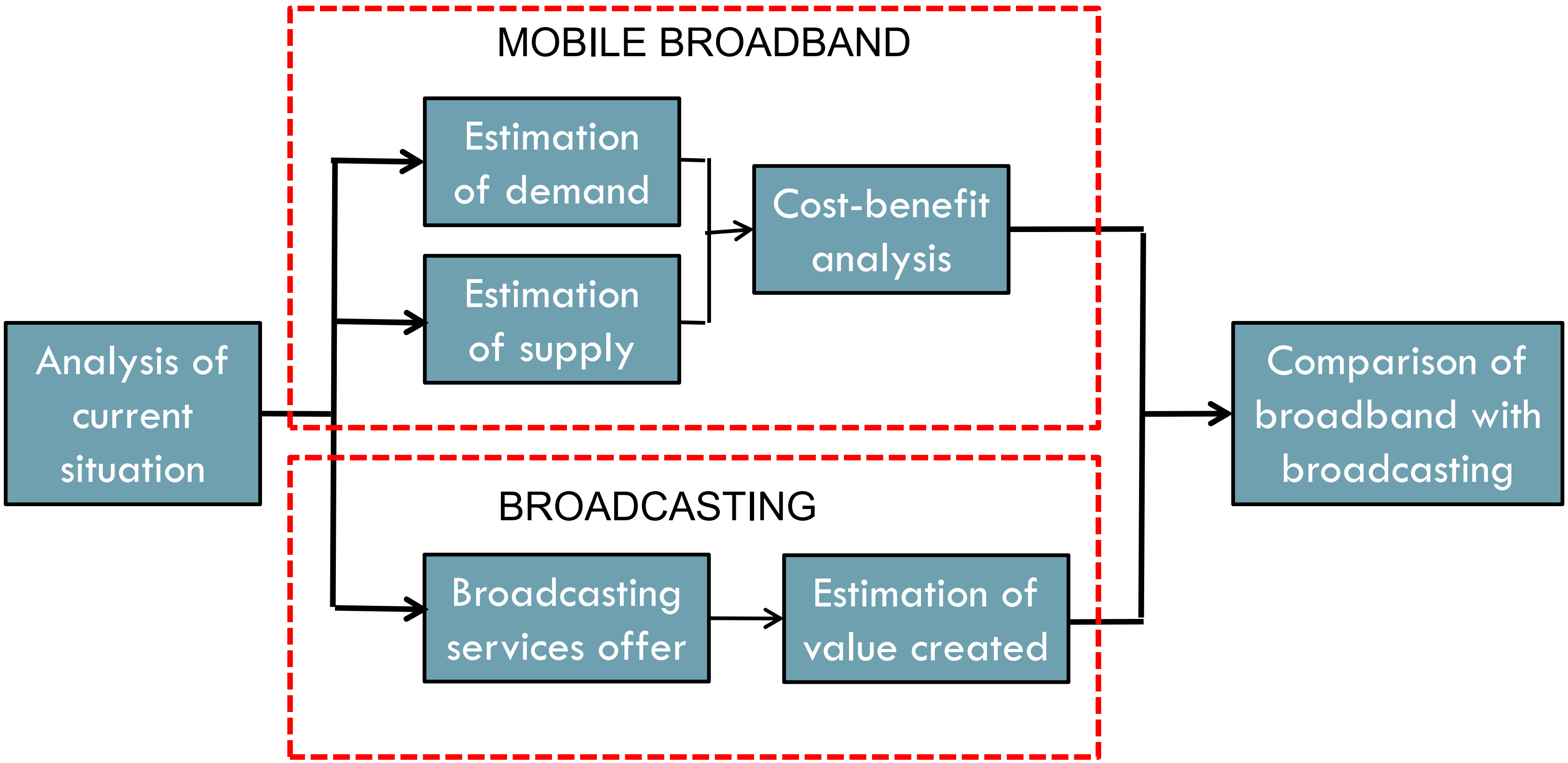
UNITED STATES: ECONOMIC VALUE OF UNLICENSED SPECTRUM

	Effect	Economic Value			GDP
		Consumer Surplus	Producer Surplus	Total Surplus	
Wi-Fi Cellular Off-Loading	Value of Free Wi-Fi traffic offered in public sites	$ 1.902	N.A.	$ 1.902	N.A.
	Benefit of Total Cost of Ownership required to support future capacity requirement with Wi-Fi complementing cellular networks	N.A.	$ 10.700	$ 10.700	N.A.
	Contribution to GDP of increase of average mobile speed resulting from Wi-Fi off-loading	N.A.	N.A.	N.A.	$ 2.831
	Sum of revenues of service providers offering paid Wi-Fi access in public places	N.A.	N.A.	N.A.	$ 0.271
	Subtotal	$ 1.902	$ 10.700	$ 12.602	$ 3.102
Residential Wi-Fi	Internet access for devices that lack a wired port	$ 22.510	N.A.	$ 22.510	N.A.
	Avoidance of investment in in-house wiring	$ 13.570	N.A.	$ 13.570	N.A.
	Subtotal (*)	$ 36.080	N.A.	$ 36.080	N.A.
Wireless ISPS	Aggregated revenues of 1,800 WISPs	N.A.	N.A.	N.A.	$ 1.439
Wi-Fi Only Tablets	Difference between retail price and manufacturing costs for a weighted average of tablet suppliers	N.A.	$ 34.885	$ 34.885	N.A.
	Difference between willingness to pay for entry level tablet and prices of iPad and Android products	$ 7.987	N.A.	$ 7.987	N.A.
	Subtotal	$ 7.987	$ 34.885	$ 42.872	N.A.
Wireless Personal Area Networks	Sum of revenues of Bluetooth-enabled products	N.A.	N.A.	N.A.	$ 1.739
	Sum of revenues of Zigbee-enabled products	N.A.	N.A.	N.A.	$ 0.267
	Sum of revenues of WirelessHART-enabled products	N.A.	N.A.	N.A.	$ 0.160
	Subtotal	N.A.	N.A.	N.A.	$ 2.166
RFID	RFID Value in Retailing	$ 26.26	$ 68.58	$ 94.84	N.A.
	RFID Value in Health Care	$ 4.03	$ 31.96	$ 35.99	N.A.
	Subtotal	$ 30.29	$ 100.54	$ 130.83	N.A.
TOTAL		$ 76.26	$ 146.13	$ 222.38	$ 6.707

Source: Katz (2013)

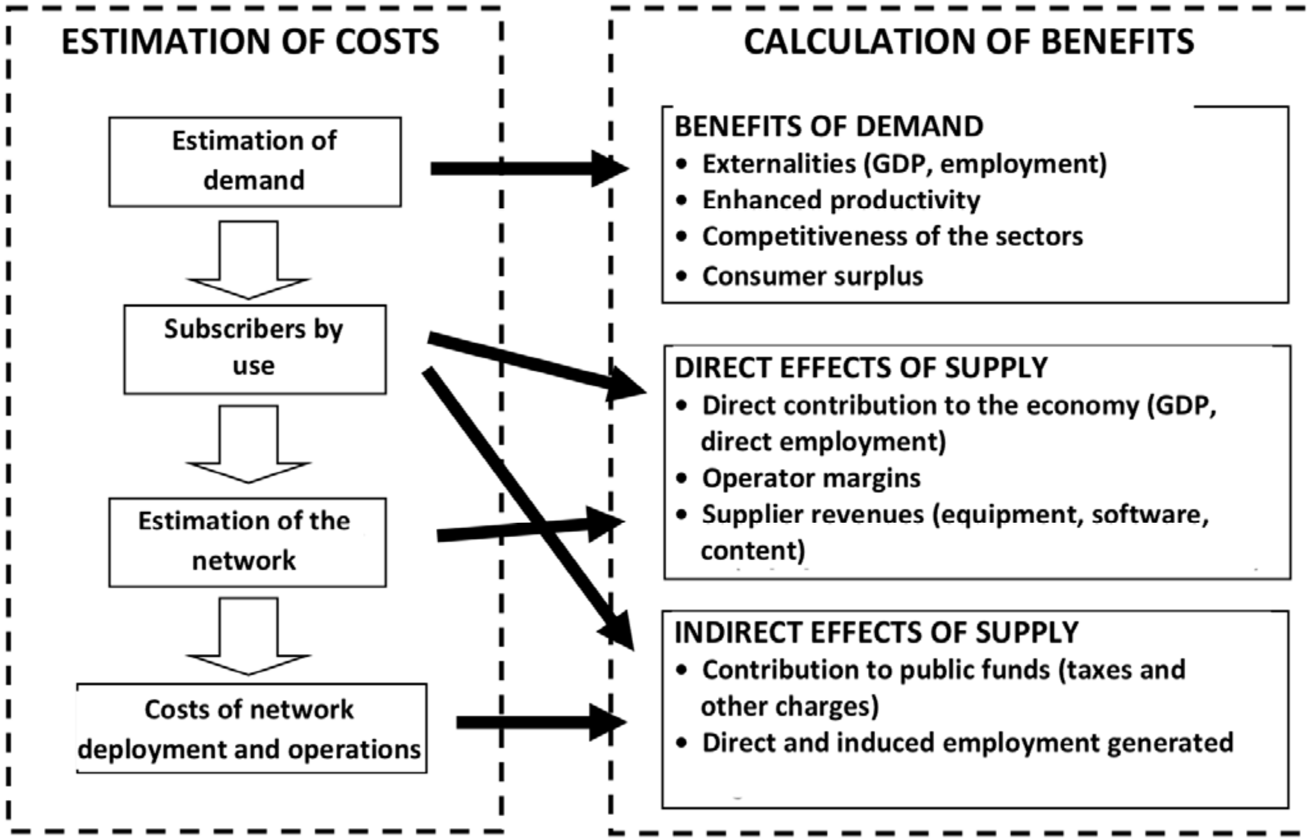
A SIMILAR APPROACH CAN BE USED FOR VALUING ALTERNATIVE ALLOCATION SCENARIOS IN THE CASE OF DIGITAL DIVIDENDS

THEORETICAL FRAMEWORK OF REALLOCATION VALUATION METHODOLOGY



Source: Telecom Advisory Services

ECONOMIC AND SOCIAL IMPACT OF 700 MHZ SPECTRUM REALLOCATION TO MOBILE TELECOMMUNICATIONS



Source: Telecom Advisory Services

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AN EXAMINATION OF THE TOPICS RELATED TO ECONOMIC ANALYSIS OF SPECTRUM MANAGEMENT ENABLED US TO DRAW UP GUIDELINES FOR REGULATORS

- Define the national economic and social development objectives that are to be pursued when allocating and using spectrum
- Implement long-term planning in spectrum assignment and use based on economic impact analysis
- Use long-term planning as an analytical framework allowing tactical decisions in response to changes in the environment
- Long-term planning and tactical adjustments must determine how much spectrum is to be distributed, and how many operators must participate in a given national market
- Carefully define the appropriate auction model
- Consider development of secondary markets and alternative approaches to facilitate efficient spectrum use
- Develop internal capacity to calculate the economic value of spectrum; it is important to implement the changes required in terms of organization and human resources in order to build internal analytical capacity of the spectrum management authority
- Consider that, in cases of spectrum assignment through auctions, lack of transparency may affect the estimated economic value of the spectrum
- Implement ongoing economic analysis with a view to maximizing the economic and social benefits ensuing from appropriate spectrum management

PLANNING FUTURE USE AND VALUATION OF THE SPECTRUM MUST START BY FORMULATING THE NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT TARGETS TO BE ACHIEVED

- The spectrum is a public resource and its use is of fundamental importance in multiple areas
  - Rapid and effective development of mobile broadband
  - Consequent reduction of the digital divide by extending coverage of mobile services in rural and isolated areas
  - Promotion of public services
  - Generation of revenues for governments through public auctions and the levying of taxes
- Defining the objectives entails formulating and prioritizing those national objectives
- International experience of spectrum distribution shows that some of the objectives referred to above can come to be mutually contradictory
  - Maximization of revenue for the national treasury may be at odds with the promotion of service coverage, with a potential negative impact on the universal deployment of mobile broadband

PLANNING FOR SPECTRUM MANAGEMENT NEEDS TO BE BASED ON RIGOROUS ECONOMIC IMPACT ANALYSIS

- Demand for spectrum, as a basic resource, is evolving rapidly and requires frequent regulatory decisions, the absence of which could have adverse effects on quality of service and negative economic consequences for the development of a general purpose technology and the best interests of consumers
- Consequently, NRAs must above all develop a long-term policy including:
  - Analyses of the radio technologies best suited to meeting these objectives: evaluating technology standards in order to define the most appropriate frequency allocation and channel plans with due regard to the harmonizing recommendations of international bodies such as ITU Recommendations
  - Assessing the impact of these technologies on spectrum planning: assessing the potential impact of spectrum allocation on the development of new technologies and services
  - Implications of these technologies for the national frequency allocation table and revisions of regulations and standards: once preliminary analysis is concluded in this area, compare the results with plans developed by other countries
- This strategy must include as one of its inputs the views of other public bodies and organizations (for example ministries of education, health, security, and so on), as well as reflecting the points of view of public and private mobile operators
- Given the margin for uncertainty in the longer term as regards evolution of spectrum supply and demand, it is advisable to use analytical techniques such as construction of scenarios and assessment of their relative probabilities in the national strategy

FURTHERMORE, LONG TERM PLANNING SHOULD BE USED AS ANALYTICAL FRAMEWORK TO FACILITATE TACTICAL DECISIONS

- Given the highly dynamic nature of technological supply and demand for wireless traffic, the strategy to be applied should be sufficiently flexible to allow periodic adjustment (annual or biannual)
- Adjustments must be based on tactical decisions which must be examined in an holistic way
  - Evaluating spectrum allocation in the context of any recent changes in supply and demand
  - Simulating possible modifications to the strategic decision
  - Assessing the possible systemic effects of those changes on general spectrum allocation

LONG-TERM PLANNING AND TACTICAL ADJUSTMENTS MUST DETERMINE HOW MUCH SPECTRUM TO DISTRIBUTE AND THE INDUSTRY'S MARKET STRUCTURE

- Beyond the technological and capacity constraints that guide spectrum distribution, governments must consider which type of industrial organization and competitive model are to be established in the telecommunication/ICT industry at the national level
  - Analysis of the telecommunications market structure indicates that there are optimal points in competitive intensity that favor the interests of consumers (lower prices, greater innovation), while also ensuring the sector's long-term sustainability (allowing continued capital investment at an adequate level)
  - Spectrum policies that stimulate unrestricted competition among multiple (five or more) operators can lead to friction effects (such as low profitability, which can lead to early exit from the market) that are not conducive to harmonious development of the sector
  - At the same time, spectrum distribution policies that lead to the creation of duopolies may be counterproductive from the consumers' point of view
- Spectrum distribution must be based on clear principles that relate to the intended competitive model
- It is also appropriate to analyze international experience in terms of the quantity of spectrum that has been distributed, and the way in which it has been assigned in terms of the numbers of operators or service providers

AVOIDING MECHANICAL EMULATION FROM ANOTHER COUNTRY'S EXPERIENCE, REGULATORS NEED TO SELECT THE AUCTION MODEL MOST SUITED TO THE COUNTRY'S SPECIFIC CONDITIONS

- Type of band(s) to be auctioned
- Type of valuation of the band (private or communal value)
- Behavior of participants (neutrality or risk-aversion)
- Desired characteristics for the new market
- Type and amount of information to be made available on development of the auction
- Spectrum caps (multi-band, multi-auction)
- Medium- and long-term auction plans
- Coverage requirements
- Inherent fiscal charges
- Infrastructure sharing / secondary markets

CONSIDERING INCREASING NEEDS FOR SPECTRUM, REGULATORS SHOULD EVALUATE THE IMPLEMENTATION OF ALTERNATIVE APPROACHES FOR ENHANCING EFFICIENT USE

- To meet growing demand for traffic, there are basically four options
  - Improved technologies --> more Mbps/MHz
  - Better reuse (femto cells, etc.) --> more MHz/km
  - Network integration (e.g. Wi-Fi offload)
  - More spectrum
- Regulators should define spectrum efficiency indicators and consider alternative maximization approaches
  - The development of secondary markets will allow the introduction of greater flexibility and efficiency in spectrum use. This must be done gradually in order to prevent distortions such as accumulation, hoarding and speculative behavior
  - Possible application of technologies such as systems for using software-defined radio spectrum and cognitive radio systems to boost possible reuse of a scarce resource
  - Using unlicensed spectrum for deploying Wi-Fi technologies can be especially useful for solving problems such as urban network congestion (by routing and coordination of networks) and broadband provision in rural and isolated areas
- These alternative allocation technologies and mechanisms must be accompanied by greater flexibility in the legal framework governing spectrum use, so as to adapt to constant technological innovation and market dynamics

ALL THESE INITIATIVES CAN ONLY BE ACHIEVED IF THE REGULATORS DEVELOP THE INTERNAL CAPACITY TO ESTIMATE THE ECONOMIC VALUE OF SPECTRUM

- An estimate of the economic value of the spectrum to be assigned will enable us to determine the expected auction revenues
- This valuation will allow a reserve price to be determined for each block and define the recurring charges levied on operators so as not to compromise their financial sustainability
- For this, it is essential to:
  - Use an analysis of comparable prices
  - Calculate the opportunity cost associated with participation in an auction
  - Use the resulting spectrum cost as an input in overall valuation of deploying a given network
  - Consider macroeconomic factors (for example, limited availability of capital) or competitive factors (for example, over-supply of spectrum, or auctions in neighboring countries) that could adversely affect the valuation
- Apart from the criteria of technical and micro-economic efficiency, management decisions must constantly take into account, through rigorous economic analysis (in this case based on estimates of consumer surplus), the impact on users, in terms of quality of service, coverage and innovation

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