UNIVERSITY OF JOHANNESBURG

CCRED

Centre for Competition, Regulation and Economic Development

REGULATING RADIO-FREQUENCY SPECTRUM TO ADVANCE THE DIGITAL ECONOMY: ISSUES OF ECONOMIC REGULATION FOR THE ELECTRONIC COMMUNICATIONS SECTOR

Lucienne Abrahams, Yolisa Kedama, Elicia Naidu and Kiru Pillay
LINK Centre, University of the Witwatersrand, Johannesburg

6 June 2014

This paper is an output of the Regulatory Entities Capacities Building Project that was undertaken by the Centre for Competition, Regulation and Economic Development, funded by the South African government's Economic Development Department under an MoA with the University of Johannesburg.

LIST OF ACRONYMS

ECA	Electronic Communications Act
ECNS	Electronic communications network service
ECS	Electronic communications service
ICASA	Independent Communications Authority of South Africa
IEEE	Institute of Electrical and Electronics Engineers
IMT-bands	International mobile telecommunications spectrum bands
ISP	Internet service provider
NDP	National Development Plan
WBS	Wireless Business Solutions (Pty) Ltd.
WRC	World Radio Conference

TABLE OF CONTENTS

1 Executive summary: Economic regulation of spectrum 7

2 Structure of the case study 8

Section A 9

3 An overview of radio-frequency spectrum regulation and questions for the future 9

3.1 Spectrum regulation: What is spectrum management? 9
3.2 Spectrum demand 9
3.3 Spectrum regulation, ownership rights and broadband access 10
3.4 Spectrum management policy and regulatory approaches 11
3.5 Spectrum pricing approaches 12
3.6 Summation 13

Section B 14

4 Overview of historical spectrum regulation and regulatory proposals of 2011 for high demand spectrum 14

4.1 Summary of spectrum allocation in South Africa and emerging issues 14
4.2 Increasing demand for spectrum 15
4.3 Proposals for spectrum allocation in the high demand bands 2011: Complexity in spectrum regulation 16
4.4 Additional issues on the medium-term spectrum regulation agenda 17

Section C 18

5 Review and analysis with respect to proposed spectrum policy and regulation 18

5.1 Access to spectrum 18
5.2 Lack of spectrum strategy 19
5.3 Supply and demand side studies to inform regulation 19
5.4 Clarity of regulatory models 20
5.5 Clarity on the role of government and SOEs 20
5.6 Introduction of secondary markets and spectrum sharing 21
5.7 Underutilised spectrum and utilising the television white spaces band 22
5.8 Introducing services-based competition 22
5.9 No clear definition for UAS and no clear obligations 24
5.10 Comparative roles of the policy-maker and the regulator 24
5.11 Concluding remarks on the review of proposed spectrum regulation 25

Section D 26

6 Findings and analysis with respect to spectrum trading and pricing 26

6.1 Spectrum trading perspective 26
6.2 Spectrum pricing perspectives 27

Section E **29**

7 Conclusion and recommendations **29**

7.1 Spectrum strategy **30**

7.2 Paradigm shift: Economic regulation of spectrum for digital services and media markets **30**

7.3 Spectrum pricing approaches **30**

Glossary of Terms

Department of Communications (DoC)	The Department of Communications has the mandate to formulate ICT policy and legislation that creates favourable conditions for accelerated, shared and sustainable growth for the South African economy, and which positively impacts on the wellbeing of the population.
Digital dividend (DD1/DD2)	The digital dividend refers to the spectrum that will be released in the process of digital TV migration.
First come-first served, beauty contests, command and control	Traditional spectrum licensing models operational in the historical phase of low spectrum demand under partially competitive markets and low supply of broadband.
Independent Communications Authority of South Africa (ICASA)	The Independent Communications Authority of South Africa is the regulator for the South African communications, broadcasting and postal services sectors.
Managed spectrum park	Refers to a sharing model where a number of entities apply to participate in sharing a block of common spectrum on self- managed basis and according to some regulations and/ or agreed procedures.
National Development Plan (NDP)	South Africa's National Development Plan offers a long-term economic development perspective. It presents desirable goals and identifies the role different social and economic sectors should play in achieving the stated goals.
State owned enterprise (SOE)	A legal entity that is created by government in order to participate in commercial activities on government's behalf. A state-owned enterprise (SOE) can be either wholly or partly owned by government.
Television white spaces band	Portions of spectrum left unused by broadcasting, also referred to as interleaved spectrum.
Universal service and access (USA)	Universal service and access requires that all consumers and households have access to basic electronic communications services at affordable prices.
Universal service obligations (USO)	The obligation on electronic communications operators and/or service providers to contribute to the achievement of universal household or consumer service with respect to electronic communications, as provided for in license conditions or through other regulatory measures.
Wholesale open access	Wholesale open access means 'no locking' i.e. encouraging interoperability, 'no blocking' which refers to no restrictions on legal content and applications, and 'no retail' referring to no service provision to end user.

Wi-Fi	Wireless local area network protocol based on IEEE 802.11 standard
WRC 12	World Radio Conference 2012 of the International Telecommunication Union.

1 Executive summary: Economic regulation of spectrum

Electronic communications sector regulation requires attention to the regulation of scarce resources, among which access to radio-frequency spectrum has become an urgent agenda item, because of high demand for wireless broadband and ultra-broadband services. At the same time, the market is moving to digital TV, which will free up spectrum for new innovative mobile, wireless and other communications services and therefore requires re-regulation in the current broadcast spectrum bands. The Electronic Communications Act, No. 36 of 2005 (ECA) created a legal framework for the licensing of radio-frequency spectrum in South Africa.

An important research question relating to spectrum regulation is: How can regulators best facilitate electronic communications infrastructure expansion for the mobile digital economy through spectrum regulation? This research question raises a number of issues for attention, including (i) a contemplation of selected initiatives in spectrum regulation; (ii) analysis pertaining to the shift required by regulators from regulating technological advancement (spectrum regulation to enable particular devices to operate in particular ranges) to regulating for advancement towards a digital economy (economic regulation of spectrum to encourage competition in broadband network and services provision); and (iii) consideration of pricing options for spectrum trading. While these issues can be treated as distinct areas of research, the value of this case study is that it raises the three research issues in the same discussion, in order to enable an understanding of a few of the many issues that require attention in undertaking a paradigm shift in spectrum regulation towards broadband-enabled services. A related element in the spectrum regulation discussion is the regulatory requirements for deriving benefit from the digital dividend arising from the shift from analogue to digital broadcasting technologies. This latter issue is addressed only briefly in this case study, and should be considered as part of the same, broader spectrum regulation agenda.

The research on spectrum regulation, from which this case study is drawn, seeks to understand the complexity of spectrum policy and regulation approaches, in the context of the emerging digital services and digital media markets in South Africa. Digital services markets include broadband access for consumers, for particular social sectors such as the education sector, and for uneconomical areas such as rural towns, as well as access to e-transactions, e-government, e-health, and other e-services. Digital media markets include access to online news and magazines (or e-zines), to Internet broadcasting, to online music and film, to social media and other emerging online media formats. Digital services and digital media markets require high-speed broadband access for online viewing of data or downloading/uploading, however the limited competition in the sector means that broadband access prices are high. Encouraging competition in the broadband access market could impact favorably on urban and rural consumers, and on fostering the environment for access to public e-services, by reducing the cost of access over the medium to long term. Future spectrum regulation approaches should seek to encourage competition in the provision of broadband services. This can be done through providing sufficiently large spectrum

assignments to existing spectrum license holders in order to reach high speeds, while also permitting a reasonable number of new small-scale entrants, either through spectrum licensing, or spectrum trading, or spectrum sharing, where these entrants could be viable localised wireless broadband infrastructure operators, covering those geographic areas where mobile broadband access remains low or non-existent.

2 Structure of the case study

This investigation into spectrum regulatory approaches that would best foster the growth of digital services markets (whether producing social value or economic value) is based on the understanding that the heightened demand and supply of new digital services requires advanced spectrum regulation to promote greater broadband penetration. The case study poses three broad issues for consideration by regulators: (1) Promoting private and public value in the electronic communications sector through spectrum regulation; (2) Increasing demand for advances in spectrum regulation including introduction of spectrum trading and pricing models; and (3) Paradigm shift required for regulating radio-frequency spectrum in the medium term.

Spectrum regulation is a broad and challenging area of study, of which only a few issues are highlighted in this paper. The scope of the paper is limited to addressing a few critical issues that may appear disconnected from each other, but are nevertheless key issues in regulation. It was not the aim of the paper to present a full picture of the spectrum regulatory environment in South Africa.

The case study is structured as follows:

Executive Summary

Section A Overview of radio-frequency spectrum and questions for the future.

Section B Overview of historical spectrum regulation and regulatory proposals of 2011 for high demand spectrum

Section C Review and analysis with respect to proposed spectrum policy and regulation.

Section D Findings and analysis with respect to spectrum trading and pricing.

Section E Conclusion

In effectively utilising the case study, it will be important for the reader to refer to the references listed in the text and at the end of article.

Section A

3 An overview of radio-frequency spectrum regulation and questions for the future

3.1 Spectrum regulation: What is spectrum management?

Spectrum management is a process of regulating radio-frequency spectrum, which includes planning, assignment, equipment registration, licensing, monitoring and compliance, and otherwise managing the use of the electromagnetic spectrum as a resource supporting electronic communications across wireless networks (Pogorel, 2007). The International Telecommunication Union (ITU) explains spectrum management as the application of technical and regulatory mechanisms to optimize the use of radio-frequency spectrum in electronic communications through multidisciplinary approaches including knowledge of international politics, policy, regulation, economics and engineering (ITU, 2005, p.14). Foster (2010, p.29) argues that a more extensive understanding of the management issues arising from availability of digital dividend spectrum is needed to advance market growth, innovation and efficiency, as well as social and development objectives. Spectrum management policy is concerned with long-term planning for the technologies that may require spectrum, while licensing is a short-term procedure assigning access rights to applicants (Cave, 2006). Spectrum regulation gives operators in the broad electronic communications sector usage rights to spectrum through various licencing approaches. Spectrum licensing is a subset of spectrum management. Pogorel (2007, pp.170-174) observes nine spectrum management regimes, broader than the "standard trilogy" of command and control, market-based and commons approaches. For the purposes of this case study, it is important to understand the basic concepts of the standard trilogy and the broad concept of a variety of hybrid models of spectrum regulation.

Policy makers and regulators have historically employed spectrum management policy, regulation and authorization of use to define the scope of the electronic communications market. In the past decade, technological development has taken place at such a rapid pace that spectrum management policy and regulation often lags behind technological advances, and the regulatory paradigm has shifted in such a way that market development now influences the decisions of policy makers and regulators. From a manufacturer's perspective, "Regulatory policies are now being challenged by a convergent world, whereby new technologies blur the existing distinction between fixed/mobile/broadcast services…There is a need to define new spectrum management rules that accommodate [both] former and newer technologies…" (Bondelind, Brito, & Tan, 2007, p1). Television and Internet available on mobile handsets are examples of the arena of converging technologies.

3.2 Spectrum demand

Particular spectrum bands are considered as being in "high demand" because these are the bands that mobile and broadband operators require to build next generation mobile and

wireless broadband networks, using the shorter frequencies in urban environments and the longer frequencies in rural environments. These high demand bands include the 450-470MHz, 690-800MHz, 900MHz, 1800MHz, 2100MHz, 2.3GHz, and the unassigned portions in the 2.6GHz and the 3.5GHz bands. A frequency migration process is required, which could take several years. A further development is the investigation into the possible approval of technologies that use white spaces to provide broadband services, including TV white spaces. White spaces are those spectrum channels that are under-utilised and can be accessed by other services without causing interference. These white spaces can be detected using technologies like dynamic spectrum access or cognitive radio.

3.3 Spectrum regulation, ownership rights and broadband access

Economists and mobile operators, for example Buddhikot (2007), have advocated for market-based spectrum assignment models, which take into account the very large investments made in setting up commercial mobile networks. The rationale for this view was that operators would compete for exclusive access to a particular block of frequencies. Engineers on the other hand, for example Lehr (2005), argued that shifting from the traditional spectrum licensing models and increasing spectrum available through unlicensed models would encourage innovation, favoring interoperability. Faulhaber and Faber (2002) argue that spectrum sharing models should be introduced to address “artificial scarcity”. Their view was that the best way to deal with artificial spectrum scarcity, which arose by operators hoarding licensed spectrum, was to introduce a legal regime of spectrum property rights ownership, which would support both market-based and spectrum commons regulatory approaches. This view is similar to that of Banerjee, Mishra, Brik, Shrivastava and Bahl (2006), who advance the case for introducing secondary markets and spectrum trading.

Most regulators have historically licensed spectrum to an operator giving rights to its use but not ownership. Authors such as Faulhaber and Faber (2002) have suggested a move away from this regime and argued that regulators should relinquish spectrum ownership to licensees. “The full property rights approach differs by higher degree of flexibility with regard to technological standards and license use, and is assigned by auctions or similar competitive mechanisms rather than administrative rule” (Freyens, 2009, p22). Foster (2010) argues that the digital dividend arising from the migration to digital broadcasting introduces new dimensions to spectrum policy and regulation. In particular, the discussion implies that policy-makers and regulators must carefully consider the economic value of digital dividend spectrum (and by further implication all usable spectrum), and the effective utilization of spectrum in the hands of operators, to regulate in ways that promote further technological advancement, for example universal access through mobile broadband. Such regulation involves a very complex set of regulatory tasks (Foster, 2010, pp.16-17):

> Measuring this value requires the development and assessment of economic, financial and infrastructure models; a deep understanding of local markets and sectors such as education, banking and manufacturing and an understanding of the interaction of the sectors with new technologies…and the impact of the Digital Dividend on incomes, employment, investment in new technology, growth in productivity, etc. Development of robust models and determination

of reliable estimates play a central role in deciding how to use the Digital Dividend.

3.4 Spectrum management policy and regulatory approaches

The three spectrum management regulatory models deployed most extensively in the past two decades have been command-and-control (administrative), market-based (including spectrum property rights) and spectrum commons. These models were driven respectively by government, market and technology innovation. The regulatory models employ a range of spectrum assignment approaches, each with relative strengths and weaknesses: first-come, first-served (economically efficient if no scarcity), beauty contest (subjective decision), lottery (not economically efficient), auction (economically efficient but may set barriers to entry), combinatorial (any appropriate combination of the other models) (Marcus, Nett, Scanlan, Stumpf, Cave & Pogorel, 2005). Market-based mechanisms, which have been considered, include auctions, secondary trading, administrative incentive pricing and liberalised usage of frequencies (Marcus, et al. 2005).

In the command-and-control approach, also known as administrative, centralised planning and decision-making system operates, whereby the policy-maker and/or the regulator dictates what technology and applications are allocated for a specific range of radio frequency spectrum. To initially award spectrum licences in this approach, a beauty contest is held whereby the regulatory authority selects a licensee or licensees based on the firm's financial capability, technical expertise and services offerings. The spectrum management authority or the regulator decides the duration of the spectrum usage, which may include rollout obligations.

The market-based or spectrum property rights approach is based on the introduction of property rights and can be characterised by three elements, i) well defined exclusive rights to the use of the spectrum, ii) a market-type primary assignment mechanism for the initial allocation of spectrum rights and iii) a secondary market in which these rights can be traded. The main argument for the market-based approach is that it would dramatically increase the economic efficiency of spectrum use. However a consequence of putting all spectrum on the market would be that so much spectrum would be freed up that the price would drop significantly, potentially limiting the value for rights holders.

Another major driver in the spectrum debate is technological innovation. Radio technologies now coming to market or under development allow for more efficient use and easier sharing of the spectrum and may render spectrum scarcity obsolete. This type of approach is known as the spectrum commons approach. In the spectrum commons model, radio frequency spectrum is allocated on a non-exclusive rights basis and the licensees and users can use this allocated spectrum unrestrained. This spectrum can be referred to as licence exempt frequency bands. Due to the uses of these frequency bands, there are several rules that the users have to adhere too, such as restricted power levels to avoid creating interference to other services. Typical services supported in commons bands include remote control car locking mechanisms, microwave ovens, Bluetooth and other short-range devices.

Wellenius and Neto (2005) have critiqued the traditional rule-based spectrum management

practices, which gave insufficient attention to the economics of wireless services and ICT use. Research argued that what was required was "a new system for spectrum management…that permits different models of spectrum licensing (the traditional administrative, unlicensed and new market-based approaches) to coexist so as to promote economic and technical efficiency…" (Cave, 2008). Such a system should allow new market entrants, operating in the digital services and media markets, to build or access small wireless networks. This view is supported by Cave (2008) who states that spectrum regulation and economic regulation should have the common goal of pursuing the long-term interests of the end users of technologies and services – not market players or government, but the ones at the "end of the spectrum". Thus, in approaching the reform of spectrum regulation, the objective should be to create a competitive environment that supports sustained growth of the digital media and services markets, not profitability for only a few firms. Foster (2010, pp.14-17) argues that spectrum regulation should consider both economic and public value:

> In choosing how much spectrum to allocate and for whom, regulators not only place emphasis on market valuations and economic efficiencies but also on social, development and cultural goals. Market mechanisms do not necessarily or easily take public policy priorities into account…Measuring (this) value requires the development and assessment of economic, financial, and infrastructure models; a deep understanding of local markets and sectors such as education, banking and manufacturing and an understanding of the interaction of the sectors with new technologies …

Transition in spectrum management regimes and policy processes requires an evolutionary process, as governments must consider spectrum requirements for the communications, safety and security, maritime and scientific research sectors. In order to take advantage of the digital dividend and provide the spectrum needed for advanced telecoms and broadcast infrastructure, African regulators will need to focus on both economic (market) and development (public value) needs in their changing spectrum regulatory regimes. In particular, regulators must address the problem of artificial scarcity (hoarding), which has arisen from traditional spectrum licensing models (Ikeda, 2002) and avoid creating new barriers to entry through mechanisms such as auctioning (Klemperer, 2002). This poses a challenge as market-facing models and public value models (such as command and control or open access models) (Marcus, et al. 2005) would need to operate side by side and the contradictions between the selected models would need to be carefully worked out.

3.5 Spectrum pricing approaches

This section briefly explains three models for spectrum pricing in a spectrum trading environment, namely market equilibrium, competitive pricing and cooperative pricing models (Hossain, Niyato, & Han, 2009). In the market-equilibrium approach, it is assumed that the primary service provider is not aware of other service providers and hence there is no competition or cooperation. The spectrum price is set based on spectrum demand from secondary users (demand-side function) and on the willingness of the primary service provider to sell spectrum (supply-side function). The supply-side function indicates the size

of radio-frequency spectrum shared by a primary user with the secondary user, whereas the demand-side function indicates the size of radio-frequency spectrum required by secondary users. In the competitive pricing model, each of the primary service providers is aware of the competition in the specific market and each of the primary service providers aims to maximise their own profit. The primary service providers compete through price adjustment, in other words, given the spectrum prices offered by other primary service providers, one primary service provider will choose the price for its own spectrum such that its individual profit is maximised. In the cooperative pricing model, the primary service providers collude with each other to attain the highest total profit by selling spectrum to secondary users. All the service providers are aware of each other and fully cooperate with each other.

3.6 Summation

A summation of the perspectives outlined above indicates that policy-makers and regulators should adopt a broad yet clearly defined agenda, as multiple issues in spectrum policy and regulation require attention, each affecting the other in an ecosystem of spectrum resources, broadband infrastructure extension, new converged devices and universal access imperatives. Regulators should carefully consider the range of regulatory approaches that are possible including spectrum auctions, spectrum sharing approaches and the valuing, costing and pricing of spectrum from the operator perspective, the consumer perspective and the universal access perspective. This very brief overview raises the following questions for the case study:

(1) What are the strengths and weaknesses of selected initiatives in spectrum regulation?

(2) How should the electronic communications sector regulator best approach the paradigm shift required with respect to future spectrum regulation in South Africa?

Section B

4 Overview of historical spectrum regulation and regulatory proposals of 2011 for high demand spectrum

4.1 Summary of spectrum allocation in South Africa and emerging issues

From the general guidance on spectrum allocation to specific uses given by the ITU, see Figure 1a below, the South African regulator ICASA has allocated spectrum as per Figure 1b below.

Figure 1a.ITU international spectrum allocation

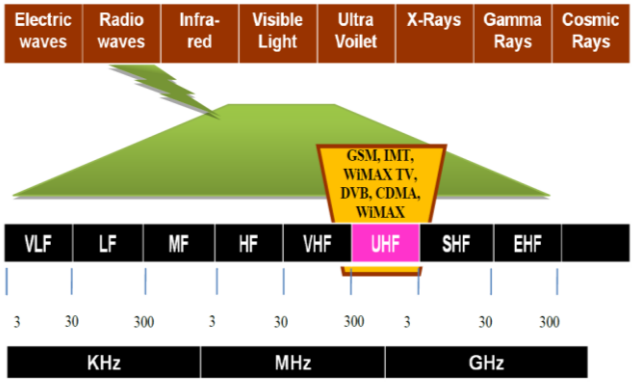
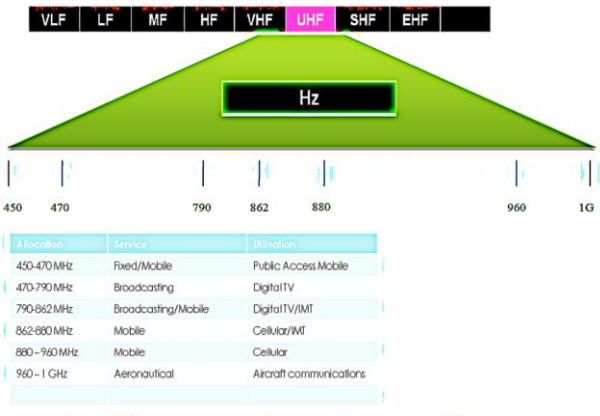


Figure 1b.ICASA SA spectrum allocation



Source: *Zimri, 2013 as adapted from Cave, 2002*

This spectrum allocation is historical and a new phase of spectrum regulation is needed (i) as the digital dividends (DD1 and DD2) are opened up; and (ii) as demand grows for specific uses in particular segments of the radio-frequency spectrum, such as demand for mobile broadband, or for nomadic broadband used in WiFi hotspots, or for ultra-broadband at speeds exceeding 250Mbps. Sectors where future broadband demand is likely to be high include the public education and health services, where public value considerations arise with respect to spectrum assignment for promoting broadband availability. However, the spectrum needs for broadband diffusion in these sectors, through adoption of technologies such as WiFi and WiMax, which would provide the infrastructure platforms for services such as VOIP and IPTV, as well as access to e-books and other broadband-enabled services, have not been widely researched to inform regulatory decision-making.

Traditional spectrum licensing models (first come-first served, beauty contests, command and control) gave exclusivity for spectrum that has economic value (high demand, IMT or access spectrum) to a limited number of operators i.e. MTN, Vodacom, Cell C, Telkom, Neotel, Sentech and WBS. Following initial award of GSM spectrum licenses (900MHz) to mobile operators Vodacom and MTN in the 1990's, spectrum assignment has received limited attention in the last decade, with mobile operators awarded licenses to operate in the

1800MHz band (GSM) and the 2100MHz band (3G). The fixed line entrant, Neotel, was awarded a license to operate CDMA in the 800MHz band and licenses were awarded to iBurst, Sentech and Telkom for wireless broadband services (WiMAX) in the 2.6GHz and 3.5GHz bands (Song, 2010; Kedama, 2014). The historical spectrum assignment has not contributed to advancing wireless broadband infrastructure availability or affordability to a large proportion of households, schools and public health clinics.

4.2 Increasing demand for spectrum

Heightened demand for spectrum and therefore also for spectrum regulation is experienced in two components of the broad electronic communications sector:

(1) Telecommunications infrastructure: The shift to Internet-based communications creates opportunities for all services and media to migrate into the digital communications environment in parallel with traditional counter-based or face-to-face services. Major services such as e-commerce and e-banking, e-government, e-education and e-health will require high speed broadband, which will need high demand spectrum to operate effectively. Three aspects of historical spectrum regulation have stifled the extension of Internet access in South Africa (Abrahams, Akinsanmi & Zimri, 2011): (a) universal access and service obligations in spectrum licenses proved inadequate to extend Internet access to schools; (b) no new entrants were invited to apply for spectrum, not even Internet service providers, despite their apparent interest in building wireless infrastructure networks in the early 2000's and (c) regulation has tended to focus on incumbent market players (users), rather than on required outcomes (uses). With respect to e-health, interested parties can learn from research on e-health projects in India, where many sites have connectivity, but very few have wireless broadband connectivity preferred for rural health projects (Ramukumar, 2011, p. 10):

> All of them used bandwidth of 1 Mbps or less at the point of care. … This is in a sharp contrast with expectations that remote sites of most projects would have utilized the country's base of over 560 Million mobile + DSL landline connections…

South Africa, like India, has many rural health clinics where mobile broadband access would be an advantage to health care facilities and communities in providing access to health information and research, access to remote diagnostic capability through telemedicine and opportunties for knowledge sharing across the urban-rural knowledge divide.

(2) Since broadcasting content can be delivered over Internet Protocol (IP) networks, including fixed line and mobile networks (provided that sufficient spectrum is assigned to mobile operators), the question arises whether broadcasters (including community broadcasters) would benefit from allocations of broadcast spectrum and broadband spectrum? What spectrum will be awarded to broadcasters to enable high definition content? The trend towards Internet-based communication creates the opportunity for all communications (voice, broadcast, video, other) to be via the Internet – also referred to as 'triple play' or multi-play' in a converged electronic communications sector. How can

the economic regulation of spectrum foster greater access and reduce the divide with respect to digital media markets? These are important issues raised for regulatory attention, but spectrum for digital broadcasting is not examined in this case study.

4.3 Proposals for spectrum allocation in the high demand bands 2011: Complexity in spectrum regulation

The regulatory transition in spectrum, as discussed above, is complex and requires a well-designed strategy to ensure that the various components of the transition (migration) are effective, that the interests of the various stakeholders are met and that the broader public or national interest in economic development is served. Balancing this range of interests will require the sector regulator to consider the strategic utilisation of a variety of regulatory measures, including spectrum licensing, spectrum trading, spectrum sharing, open access spectrum and spectrum pricing arrangements. Since there has been limited spectrum regulation in the recent past and no finalisation of the draft policy and regulations for assignment of high demand spectrum, it is relatively difficult to understand and analyse the advantages and disadvantages of the approaches mentioned above. The case study examines the policy and regulatory proposals of 2011 for the award of high demand spectrum, as a way of gaining insight into the options available to the regulator for the future.

In December 2011, the sector policy-maker (Ministry of Communications) and the sector regulator (ICASA) introduced proposals for further assignment of high demand spectrum in the 800 MHz and 2.6 GHz bands. Two years later, the policy directive has not been finalised. This has delayed the finalisation of ICASA's spectrum assignment plan and the invitation to apply for licenses (ITA), resulting in delays in licensing highly sought after spectrum. Such assignment is important for promoting broadband connectivity as required by the demands of digital services markets in a 21st century economy, as well as for realising the goal of broadband connectivity for all as expressed in various policy documents such as the National Development Plan: Vision for 2030 and the National Broadband Policy 2013. One of the reason's cited for the delay (Kedama, 2014) is the outcome of the World Radio Conference (WRC) 2012, which officially made an allocation of the 700 MHz band, the second digital dividend (694-790 MHz) or (700 MHz band), to mobile services in Region 1 (includes Africa), giving an opportunity to assign and licence the 700 MHZ and 800 MHz in the same regulatory process. While the draft policy and regulation were never finalised, they provide an important perspective on the views of the policy-maker and regulator, as a way of thinking through the issues that will arise in the next phase of spectrum regulation.

The draft policy direction with respect to high demand spectrum (MoC, 2011) aimed to promote wholesale open access to network infrastructure, while proposed regulation offered three spectrum license packages for the high demand bands 800MHz and 2.6 GHz (ICASA, 2011). However, new broadband infrastructure market entrants were not explicitly envisaged, as Sentech and Neotel were candidates for two of the three licenses, with the third license possibly set aside for a new entrant. There was also lack of clarity on whether the licensees would be able to provide infrastructure only, or also provide services.

Proposed universal access license obligations required licensees to cover a large proportion of rural South Africa in terms of both geographic and population coverage (licensee 1: 70% geographic coverage in 5 years of which 50% must exclude the three largest metropolitan municipalities; licensees 2 + 3: 50% population coverage in 4 years).

This licensing approach would exclude the possibility of many smaller players creating localised (possibly lower cost) wireless broadband networks for towns with small to medium-sized (50,000–100,000) populations. The remedy, contained in the draft proposals, is a hybrid model: (a) a wholesale open access infrastructure sharing model ('no locking', 'no blocking', 'no retail') in the 800MHz and 2.6GHz bands and a 'managed spectrum park', which was envisaged as a spectrum sharing model, exclusively in the 2.6GHz band. The model proposed a combination of beauty contest and auction approaches for the award process.

4.4 Additional issues on the medium-term spectrum regulation agenda

Allocation of spectrum for next generation broadband and for novel uses and technology innovation in, for example, cognitive radio is beginning to emerge on the agenda, but the pace of regulatory development here is very slow. A frequency migration plan has been finalised and ICASA has proposed to conduct a complex migration feasibility study (Kedama, 2014). The National Broadband Policy adopted in 2013, entitled South Africa Connect: Creating Opportunities, Ensuring Inclusion: South Africa's Broadband Policy (DoC, 2013, p.9) espouses spectrum sharing and pooling as one of the means to reducing wholesale costs encouraging services-based competition and points to many requirements pertaining to spectrum regulation throughout the document. While the policy document does not present a focused view on spectrum regulation, it provides a basis for extracting the issues related to spectrum regulation, which when combined with concerns raised by other stakeholders, can then be translated by ICASA into a broader regulatory agenda.

Section C

5 Review and analysis with respect to proposed spectrum policy and regulation

In light of the range of theoretical possibilities for spectrum regulation for the next decade referred to in Section A above, and in light of the draft regulations on licensing high demand spectrum briefly set out in Section B above, what are the approaches that would best serve to support the transition to universal broadband access and service and advancement of the electronic communications sector? While it is unlikely that the draft regulations will be finalised in their historical form, from a case study perspective, an analysis of the views relating to the proposed regulations can offer ideas for future application. Interviews conducted in 2013 and 2014 with key industry players from the fixed and mobile operators, the manufacturers, industry experts and the regulator, revealed the following perspectives on the strengths and weaknesses in the spectrum regulation approach proposed in 2011. The respondents generally commended ICASA for commencing the process of licensing the highly sought after digital dividend spectrum bands and the remaining available high demand spectrum but all raised serious concerns with the approach taken. Key discussion points are set out below, drawn from research on draft spectrum regulation (Kedama, 2014).

5.1 Access to spectrum

Interviewees, with the exception of some of the smaller players, agreed that the exclusion by the regulator of the incumbents in the process of licensing the 800 and 2600 MHz bands would be inappropriate. The National Development Plan: Vision for 2030 (National Planning Commission, 2012) states that spectrum policy should favor competition, but should not exclude incumbents from gaining access to the bands needed to build advanced electronic communications networks. The incumbents own the existing second-generation mobile voice telephony infrastructure that covers the majority of the population and have been introducing LTE/4G technology, which was a natural progression from the 2G and 3G technologies and networks (respondent PR22, 20 January 2014). Another interviewee warned against creating standalone networks (respondent MA3, 20 January 2014), as consumers would want continuous connection even when outside LTE/4G coverage areas.

A comprehensive regulatory approach will be required to design the arrangements to make the relevant spectrum bands available to spectrum users, including incumbents and possibly multiple new entrants. Access to spectrum should be carefully considered and an in-depth ex-ante regulatory impact assessment could be conducted to consider the best possible options out of a range of options for enhanced spectrum access. The sector should be presented with a regulatory impact discussion paper on the subject of access to spectrum, analyzing the strengths and weaknesses of each option, rather than a draft regulation and invitation to apply (ITA).

5.2 Lack of spectrum strategy

Operators acknowledged that the proposed regulation coupled with the ITA was a step in the right direction, but cited specific issues that required further investigation before finalisation. The concerns expressed included the absence of a broad spectrum strategy to direct and guide the regulator on how to licence spectrum: which spectrum, for what services, to whom, and how much. It was argued that "the regulation was too broad and talking in numbers, the regulation must drill down and mention e.g. which municipalities require what ICT services and what kind of infrastructure exists currently, do a proper needs analysis" (respondent PR22, 20 January 2014). For example, the connectivity needs of public e-services such as e-health, e-education and other government services and the related spectrum implications have not been set out in a detailed spectrum strategy and were not specifically addressed in the draft regulations.

5.3 Supply and demand side studies to inform regulation

The proposed spectrum policy (Ministry of Communications [MoC], 2011) and regulation (Independent Communications Authority of South Africa [ICASA], 2011) points to the broader economic and social objective of spectrum assignment, to "grow the economy by improving the education system, health and government system amongst others….and to stimulate the usage of broadband services to promote economic development and growth acting as an enabler for further social benefit" (ICASA, 2011), but is not explicitly informed by a supply and demand side analysis for e-services and associated spectrum needs for broadband. The National Broadband Policy 2013 (MoC, 2013) makes a strong case for universal broadband access and service, which will require an extensive spectrum regulatory agenda. The absence of supply and demand side studies to inform such an agenda would raise the risk that regulation would be informed almost exclusively by market-based views, with limited reference to public value considerations. A key issue is that spectrum licenses have historically been awarded only to the fixed and mobile operators and broadcast players, while Internet service providerss (ISPs) have been granted electronic communications network service (ECNS) and electronic communications service (ECS) licenses, which do not include spectrum assignment. Thus, ISPs cannot build small, localised wireless networks or create competition in the wireless broadband market to service low-income environments in cities and rural towns. Some of the incumbent operators argue that ISPs would not have the capital to build wireless networks, but this view has not been tested in research and alternative models to licensing could be considered.

Furthermore, municipal broadband infrastructure is being built by four metropolitan municipalities, though service provision has yet to be launched, while the Gauteng provincial government awarded a tender in early 2014 to build provincial broadband infrastructure. Provincial (and municipal) governments will face challenges of last mile connectivity to schools, clinics and low-income households, where access to spectrum is a barrier (personal communication, Gauteng Shared Services Centre, 2011). These are the broader group of players with potential future requirements for spectrum assignment, hence supply side

studies are needed for regulators to understand the requirements that will inform assignment.

Historically, sectors that have fuelled broadband Internet use include commerce, trade and banking, with social networking pushing through as a strong new sector of demand (Abrahams & Goldstuck, 2012) and emerging sectors with demand potential include e-education and e-health. It is therefore argued that regulatory decision-making should also be informed by an understanding of demand-side factors, even where it is focused on regulating the supply side.

5.4 Clarity of regulatory models

It became apparent from the interviews that the concepts of wholesale open access and managed spectrum parks used in the draft regulations were not sufficiently clearly defined to enable the sector to share a common understanding of the proposed models and as a result operators and other interested parties had different interpretations (respondent IN5, 9 January 2014; respondent MA1, 8 January 2014). One of the manufacturers operating from the technical regulatory environment stated that "these models are untested and complex and can only be successful through thorough discussion among all stakeholders" (respondent MA3, 20 January 2014). The incumbents were anxious about getting clarity on the proposed models as one asked "where is the business model especially with no retail" (IN5, 09 January 2014).

The absence of clarity in definitions and approaches used makes it difficult for operators to define their business models within the new environment as it is not explicit what the regulator is proposing and how it would be implemented. ICASA only gave a 'no locking', 'no blocking', and 'no retail' position as the way of defining the wholesale open access model and this is inadequate for operators who need a clear view in terms of how to adjust their business models in the new environment.

A concern raised by a number of interviewees was the lack of clarity on the definition of wholesale open access. An interviewee stated that "there is nowhere where WOA is clearly defined since there are so many different models of wholesale open access…(there is) no one understanding on what wholesale open access is and what model government and ICASA are introducing" (NE3, 09 December 2013).

5.5 Clarity on the role of government and SOEs

With respect to the 2011 proposals, it was considered that Sentech would be given access to spectrum in the 800 MHz band in exchange for the return of some spectrum in their 2600 MHz assignment which had lain dormant for many years, making Sentech one of the potential wholesale open access operators. This was a difficult approach to understand, given the different characteristics and the differences in economic value of the 800MHz and 2600 MHz bands. With the introduction of administrative incentive pricing (AIP), Sentech has since returned all the spectrum in the 2600 MHz band. At the time of the proposal, incumbent operators were interested in competing for access to the 800 MHz band

spectrum. Greater clarity was needed on the role the regulator saw for Sentech and the role the regulator envisaged for fixed and mobile operators.

There were mixed reactions on the involvement of state-owned enterprises (SOEs), though many interviewees agreed that universal broadband connectivity is only possible through a contribution from public funding. The question debated was how government should best be involved, whether through participation of the state owned entity or by making funds available. However, the proposals lacked clarity on the involvement of state owned entities such as Broadband InfraCo and Sentech. Comments in the interviews included views for and against state involvement, namely that "they need to be funded properly because the national broadband network can be done properly at the back of a state owned entity" (AC1, 11 December 2013) and "government involvement in making this country a digital country should be focused on the demand side and leave the supply side to the market forces" (IN3, 26 November 2013). "Broadband in rural areas cannot be done without infrastructure sharing, spectrum pooling, and government involvement", according to a manufacturer, who nevertheless voiced strong disagreement that Sentech should receive free spectrum in the 800 MHz band (MA1, 08 January 2014). Furthermore, the government entities concerned had not developed a clear perspective on their positioning with respect to the proposed spectrum licensing models as a basis for discussion in the sector.

5.6 Introduction of secondary markets and spectrum sharing

An interviewee from the policy and regulatory environment expressed the view that the regulator should draft regulations to introduce secondary markets but cautioned that "those secondary market regulations will have to be well defined as the auctions go hand in hand with spectrum trading" (PR11, 08 January 2014), noting that there was limited appetite for auctions in South Africa. Some operators and academics suggested that instead of licensing more operators, the regulator should create a level playing field, assist those firms that entered the market last by removing regulatory hurdles, and create secondary markets for spectrum trading and other forms of spectrum sharing, noting that "for access spectrum the regulator should introduce spectrum trading and allow operators to share spectrum". It was argued that the "responsibility still sits with operators and the fees goes towards offsetting the license fees and incumbents can lease or sublet spare capacity for regional operators where incumbents do not want to go" (AC1, 11 December 2013).

The preparation of regulations had earlier considered the introduction of secondary markets and spectrum trading, subletting and spectrum leasing, but these ideas were not included in the radio regulations published at the end of March 2011, nor in the draft regulations published in December 2011. The introduction of secondary markets would provide opportunities for the smaller players who would not want to build their own networks but who would potentially have an interest in providing services in areas that are uneconomical for the incumbents. As one academic stated "looking at the demand versus supply, the introduction of wholesale open access is justified for operators who don't have to build their own networks but want to have access to spectrum as and when needed like secondary

markets where spectrum is used and regulated on a website for operators to use for specific periods" (AC1, 11 December 2013). Introducing secondary markets could enable ISPs and other players to collectively build small localised wireless access networks in peri-urban and rural towns and other underserved areas, noting that there may be other possible disincentives. Each of these ideas requires further research to explore the real possibilities for spectrum sharing and trading.

5.7 Underutilised spectrum and utilising the television white spaces band

In the current spectrum licensing scheme, the radio spectrum allocated to licensed users cannot be used by unlicensed users while that spectrum is not in use. This static and inflexible allocation of spectrum forces legacy wireless systems to be able to operate only on a dedicated spectrum band, unable to adapt the transmission band according to the changing environment. Underutilised spectrum includes television white spaces (TVWS) or those portions of spectrum left unused by broadcasters. The spectrum in the 470 to 862 MHz bands, more commonly known as the TV spectrum, has been known to have desirable properties for mobile operators, due to its nature to travel further and penetrate buildings more easily than higher frequencies. TVWS are referred to as the currently unoccupied portions of spectrum in the terrestrial television frequency bands in the VHF and UHF TV spectrum (analogue or digital).

In relation to underutilised spectrum, the view was expressed that this should be sold directly to secondary users as a means of earning revenue with minimal involvement from the regulator to avoid delays (personal communication, industry expert, February 2014). In the current arrangements, the unused spectrum would need to be given back to ICASA who would then reassign spectrum. The regulator agreed that spectrum should be used more efficiently and that all bands could be used for spectrum trading as every band is underutilised dependent on geographical areas. Spectrum trading is seen as long overdue (personal communication, regulator, February 2014).

5.8 Introducing services-based competition

In the interviews, conflicting views were expressed with regard to introducing further competition in telecommunications markets, sometimes in the same interview and also across the whole group. The interviewees were asked to indicate to what extent they thought the proposed spectrum licensing models would encourage competition. The aim was to get a sense whether industry viewed the introduction of new entrants as a step that would assist South Africa become a digital country.

Most interviewees agreed that for the proposed models to be implementable, effective and achieve government's goals of introducing competition, reducing costs, and extending broadband to rural areas, there had to be some degree of collaboration amongst operators. The regulations however appeared to exclude the incumbents and aim to introduce another competitor to compete on infrastructure. An interviewee stated that "competition is good but when is competition enough? Why doesn't ICASA … try and assist the current incumbents

and create a level playing field, create effective competition with the current operators" (respondent IN5, 09 January 2014). This view was shared by the representative for the policy and regulatory institutions, who cautioned that "the regulation as is will increase the number of operators and insisted that "a market analysis study is needed to determine how many more operators to introduce into the market otherwise if the document is implemented as is, the country might even double the number of operators". An interviewee from one of the manufactures cautioned that "the new entrants might not survive, 3 or 4 maximum in terms of the number of operators is what is practical" (respondent MA1, 08 January 2014). The argument from the interviewees is that there is a limited number of operators that any country can sustain before it loses economies of scale.

The view was expressed that in general there should be competition at both infrastructure and services levels, but in areas that are not economically viable it was considered better to have competition at service level than at infrastructure level (respondent PR22, 13 January 2014). Services-based competition could encourage the formation of consortiums of small-scale operators and ISPs, or other types of consortia and investment. It is noted here that there would be limited if any scope for new national entrants, however, small-scale nimble new entrants using TV white spaces, or engaged in spectrum trading or sharing, could operate localised wireless networks in under-served segments of the broadband infrastructure landscape.

A word of caution from another operator was that "government should be careful of confusing competition and competitiveness, increasing the number of operators in the market does not guarantee or determine competitiveness" (respondent IN3, 26 November 2013). The respondent from the policy and regulatory institutions agreed with this statement, saying "Currently there are 4 'mobile' operators, why is there no competition…the fundamental question is, is the market big enough? Telkom mobile (is) supported by Telkom, why are they battling why are they not making it?...Cell C has been around for so many years, why can't they crack MTN and Vodacom duopoly, if you bring in a new guy, the conditions are the same, what is going to assist that guy to make it?" (respondent PR12, 13 January 2014).

The interviews contemplated the difficulties Cell C has experienced to become competitive with Vodacom and MTN despite their increase in market share, revenue, experience and technical expertise in the past 20 years. Operators like Neotel and WBS were also observed to be struggling to operate outside the golden triangle of Gauteng, Durban and Cape Town. The concern was expressed that the introduction of the fourth mobile operator through Telkom Mobile had saturated the market and was struggling to reach one million subscribers. In this regard, one of the incumbents asked "What makes ICASA think these new entrants will be any different especially in rural areas? Where is the business model, especially with no retail?" (respondent IN5, 09 January 2014).

An academic respondent asked "What mechanisms did ICASA put in place to assist the new entrants to compete successfully" (AC3, 08 February 2014). Secondary markets are not yet supported, there is currently no spectrum trading, leasing or subletting allowed by law.

Another academic's view was that the country may not need more operators but rather new investors to boost and assist those operators that are already in the market but struggling financially (AC1, 13 December 2013). The operators (both incumbents and new entrants) expressed the concern that no market study had been conducted by the regulator to determine the maximum number of operators that could be sustainable in South Africa.

Many other issues have to be taken into account in the process of regulatory design, including the limited availability of capital and other resources for new entrants to be competitive. Full-scale needs analysis and coordination with all stakeholders will be necessary to design an approach that will enable the regulator to clarify its views on infrastructure-based and services-based competition, to encourage the market to address those voice and broadband access gaps that can more easily be accommodated by the market, and to identify the true access gap and appropriate universality regulatory approaches. Such analysis and market review would enable greater clarity in the design of future spectrum regulation.

5.9 No clear definition for UAS and no clear obligations

In the interviews with operators, it became clear that the regulations were not explicit on universal service and access and there was a common feeling of uneasiness with respect to universal acess and service (UAS) obligations. ICASA published regulations on the definitions of under-serviced areas in 2012 but operators explained that the regulation does not assist in giving a clear definition for UAS or UAS obligations. Clear definitions with respect to UAS are required as they affect other areas of regulation such as spectrum regulation aimed at achieving the policy goal of broadband connectivity for all.

One of the incumbents raised the concern about lack of clarity on e-government services including e-health and e-education and how the proposed spectrum regulations would support broadband connectivity for these public services, particularly in rural areas. This relates to the need for a well-articulated spectrum strategy and the need for a baseline study to inform the regulatory proposals, as alluded to by one of the incumbents (respondent IN2, 18 November 2013). An interviewee from a state owned entity argued that, in the absence of a spectrum strategy, UAS obligations should be properly and explicitly defined in order to minimise disputes and communicate expectations upfront so that operators know the requirements when bidding for high demand spectrum licences (SO1, 06 December 2013). Regulatory clarity would give confidence to operators and investors.

5.10 Comparative roles of the policy-maker and the regulator

The interviewees agreed that the regulator, ICASA, introduced the models in a policy vacuum, one of the reasons cited by the majority of interviewees for why the regulations were not finalised. In terms of the Electronic Communications Act, 2005, Section 3(1)(a) states that "The Minister may make policies on matters of national policy applicable to the ICT sector, consistent with the objects of this Act and of the related legislation in relation to the radio frequency spectrum". Section 3(3) further states that: "No policy made by the

Minister in terms of subsection (1) or policy direction issued by the Minister in terms of subsection (2) may be made or issued regarding the granting, amendment, transfer, renewal, suspension or revocation of a license, except as permitted in terms of this Act". Section 4 states "The Authority, in exercising its powers and performing its duties in terms of this Act and the related legislation must consider policies made by the Minister in terms of subsection (1)…" (Republic of South Africa [RSA], 2005).

The Minister published a policy directive on high demand spectrum a day before ICASA published the regulations on licensing 800 and 2600 MHz bands. Does this mean ICASA had considered the policy directive before publishing its regulations? Can ICASA issue regulations where no policy or policy directive exists? Analysis of the applicable legislation suggested that there is no requirement for the minister to issue a policy directive regarding the licensing of spectrum or a requirement that the regulator must act in accordance with the policy directive. Limpitlaw (2009) attests to this and explains that:

> ICASA, in exercising its functions and performing its duties in terms of the ECA and the related legislation, is required to ''consider'' such Ministerial policy and policy directions but is no longer required to act in accordance therewith. The effect of this formulation is that ICASA would be free to depart from such policy and/or policy directions if it felt such a course of action was in the public interest.

The regulations were put on hold pending the finalisation of the policy directive on high demand spectrum. An academic interviewee commented that it was strange that the regulation and policy were managed hand in hand and yet this was not a requirement under the ECA (AC1, 11 December 2013).

5.11 Concluding remarks on the review of proposed spectrum regulation

The 2011 regulations around which this discussion revolves have been overtaken by events. The environment has changed since the draft was published. In particular, the World Radio Conference, WRC 12, identified the 700 MHz band as the second digital dividend to be made available in the African region for 'mobile broadband technologies'. Sentech gave back its assigned spectrum in the 2600 MHz band to the regulator.

While the anticipated decisions of the WRC 12 may have had a marginal effect on delaying the introduction of spectrum regulations and the view that incumbents would be excluded from obtaining access to high demand spectrum, no progress has been made in the ensuing two years 2012 to 2014. In retrospect, it can be argued that the regulator failed to act proactively in leading the industry with respect to introducing a new era of spectrum regulation in South Africa.

The immediate future presents an opportunity for a more strategic exercise in designing spectrum regulation. More bandwidth is now available for operators for higher speeds or for more operators to be licensed. The regulator, ICASA, has the opportunity to review and clearly define licensing models, based on an understanding of the broad range of options

from command and control, though market-based and spectrum property rights approaches, potential for the introduction of secondary markets and open access approaches.

Furthermore, spectrum regulation can be designed within the context of effective coordination with respect to mobile and fixed broadband services, and with respect to all spheres of government in order to promote broadband access to rural South Africa through partnerships, incentives or subsidies.

The discussion in Sections A and C above reveal a rapidly changing technology driven regulatory landscape. It is important for regulators to keep abreast and consistently conduct regulatory impact assessments in order to decide whether to act, how to act, or to do nothing. This case study alludes to one particular aspect of ICASA and the South African government losing an opportunity to diffuse broadband services sooner, in an economic environment where ICT access and skills can contribute to increasing economic potential in urban and rural communities. The national broadband policy adopted in 2013 may address some of these concerns in its implementation.

Section D

6 Findings and analysis with respect to spectrum trading and pricing

While spectrum trading has not been introduced in South Africa, it is an important option for consideration in future regulatory endeavors. It is therefore useful to understand the views of the South African electronic communications market with respect to competition, spectrum trading and related pricing approaches. This section reports on the research on secondary user pricing strategies in a cognitive radio environment (Naidu, 2014).

6.1 Spectrum trading perspective

The process of selling or leasing underutilised spectrum by primary users to secondary users is known as spectrum trading. Spectrum allocated to operators in a licensing process could be regulated in such a way that the operators can resell underutilised spectrum. Due to regulatory arrangements, the process of spectrum allocation in the primary market is often lengthy and inflexible. As the secondary market is not controlled by government or the regulator, it can be seen as an attractive tool to promote efficient use of the radio spectrum.

According to a limited number of interviews conducted in 2014, it appeared that the South African electronic communications market would welcome sharing underutilised white spaces in spectrum bands with secondary users, provided that this did not cause interference. Interference would cause degraded service resulting in lower revenue and unsatisfied customers and would undermine the ability to give guaranteed quality of service.

As stated in Section C above, the view was expressed that underutilised spectrum should be sold directly to secondary users as a means of earning revenue with minimal involvement from the regulator to avoid delays (conversation with industry expert, February 2014). The

regulator agrees that spectrum needs to be used more efficiently and spectrum trading was regarded as long overdue (conversation with regulator, February 2014).

6.2 Spectrum pricing perspectives

If and when spectrum trading is introduced, spectrum pricing will become an important focus for regulatory attention. Price is defined as the rate of exchange of commodities and the scarcer and more useful a commodity is, the higher the economic price. Radio-frequency spectrum is considered to be a very useful and scarce resource for the electronic communications sector, hence the price is high. From an economic pricing perspective, the pricing transaction may be considered from the view of the buyer, the seller, the wider industry or the economy as a whole.

In a primary market, the buyers would be telecom operators, who would act to maximise their utility under certain constraints, while the seller would be government. Government would aim to maximise their revenue and minimise budget deficits, whereas operators would aim to maximise their profit and wealth in the long run. Various buyer-seller scenarios would pose different price determination strategies and various scenarios should therefore be analysed under different forms of competition. The third aspect for consideration is the industry or economy as a whole pricing perspective, which has great influence on the buyer and seller.

In a cognitive radio network offering flexible access to underutilised spectrum, the problem of pricing is different to that in a traditional wireless network due to spectrum sharing and the adaptability of the licensed and unlicensed users. A licensed user can charge a price to an unlicensed user for spectrum access and this price can be dynamically adjusted according to the availability of spectrum opportunity. Spectrum opportunity is a function of traffic load in the licensed network and the demand from the unlicensed users. This demand is dependent on the number of ongoing sessions and applications used by the unlicensed users.

In research conducted on secondary user pricing strategies in a cognitive radio environment for spectrum trading in 2013, the simulation results showed that the competitive pricing model earned a higher revenue than the market-equilibrium or cooperative pricing strategy. However, a cooperative pricing model and strategy could encourage greater utilisation of spectrum based on spectrum sharing (Naidu, 2014). These are key issues for regulatory consultation and decision-making.

The regulator, ICASA, held the view that the best pricing model for the South African market is a cooperative scheme, as with infrastructure sharing the highest profit can be attained (Naidu, 2014). Infrastructure sharing assists in minimising the costs associated with installing and maintaining new infrastructure. The regulator could be involved in enforcing a cooperative pricing model, however if they were involved, they could not select who the spectrum is awarded to (personal communication, regulator, February 2014).

However, research showed that a decision on which pricing model to adopt was a complex matter. In the case of the market-equilibrium pricing model, spectrum supply depends largely

on the number of primary users and their bandwidth requirements and market-equilibrium exists only for certain values of offered prices and certain ranges of bandwidth requirement. In the simluation of the competitive pricing model, the optimal values for the prices offered by two primary service providers were obtained when one price was lower, as both primary service providers earned the same revenue. The competitive pricing model was observed to be relevant when the bandwidth requirement was neither too high nor too low and was dependent on the number of primary users and their bandwidth requirements (Naidu, 2014).

Issues for the regulator, ICASA, to consider are the transition to a cognitive radio environment, which would facilitate spectrum trading. ICASA should undertake in-depth research on the benefits of providing secondary trading to the market, clarify the definition of secondary trading markets and the cost effectiveness to the operators. ICASA should also consider a competitive pricing model for the interaction between primary services to determine the best price.

Section E

7 Conclusion and recommendations

The conclusion to the case study presents a few key points concerning the economic regulation of spectrum. The transition of emerging economies from services–based to digital, knowledge–based economies will require major innovations in creating private and public value through advanced electronic communications infrastructure. Historically, spectrum assignment in South Africa has been considered from the perspective of assignment to fixed and mobile operators, and broadcasters; to uses and users. Seldom, if ever, has spectrum regulation been considered from the perspective of the rapidly growing demand for broadband-enabled services and transition to an Internet-enabled services sector. What does this mean for the 21st century regulator? Regulating for a digital economy means regulation that will bring ubiquitous, high-speed broadband access to consumers in firms and households, as well as public access in schools to advance e-education and in clinics to advance e-health. This requires an e-services-oriented regulatory approach rather than a primarily industry-oriented regulatory approach.

The next phase of spectrum regulation must adopt regulatory approaches that address the needs of traditional market segments, such as mobile services, and see new entrants benefit from spectrum assignment. A spectrum assignment approach that invites a reasonable number of new entrants or introduces regulatory approaches such as secondary markets and spectrum trading, would potentially give greater value to consumers and foster more extensive broadband rollout. Even understanding the scarcity of resources for building capital-intensive networks, spectrum regulation can encourage new small-scale entrants and competition at localised levels through spectrum sharing or services-based competition.

Three related issues arise for consideration by policy-maker and regulator: (1) The policy-maker must clearly and explicitly set out the strategy for spectrum assignment and its thoughts on utilising spectrum policy to promote private and public value in greater detail than in the National Broadband Policy 2013. It should clarify its thinking on the utilisation of licensed and unlicensed spectrum to promote broadband access; (2) The regulator must conduct supply and demand side studies to better understand the implications for the economic regulation of spectrum to achieve innovation in digital services and markets and to present clarity on its regulatory and licensing approaches; and (3) The regulator must carefully consider the strengths and weaknesses of specific approaches to spectrum licensing, spectrum trading, spectrum sharing, open access spectrum and spectrum pricing, whether these should be cooperative or competitive pricing models.

Spectrum management approaches for the next decade should consider the benefits of participation of new small-scale entrants who could build smaller, localised networks that address local needs, such as broadband access networks for education and health facilities.

7.1 Spectrum strategy

The policy-maker should explicitly include public value considerations, not just universal access considerations, in its strategy design, in order to balance market interests and public interest. Considerations should include meeting the needs of consumers of sector services and advancing the capacity of the sector as a whole. Such strategy must support the intentions of the National Broadband Strategy 2013 to encourage the regulator and the market to find innovative ways of getting high-speed broadband to public institutions such as schools, to households in rural areas and middle- to low-income communities, and to give greater push to commercial e-services.

7.2 Paradigm shift: Economic regulation of spectrum for digital services and media markets

Significantly stronger integration of ICT is needed as a platform technology for the future development of the broad services sector. The ICT, media and services sectors together create the foundations for economic advancement and for future generations of innovators and entrepreneurs, in particular in the education sector. Thus, spectrum assignment should promote a digital services-oriented approach, rather than incorporating an exclusively industry-oriented approach. Furthermore, as radio-frequency spectrum is one of several components of the broadband ecosystem, spectrum should be included as part of a broader package or portfolio of regulations alongside regulation of other key resources within the ecosystem.

The regulators should consider the strengths and weaknesses of various regulatory approaches, possibly combining market-based assignment (to promote private and public value) and a limited form of command and control (to address the true access gap), where the latter may be required to provide infrastructure in uneconomic areas. An options analysis of various formal mechanisms for the deployment of licensed and unlicensed spectrum, as well as for spectrum trading and spectrum sharing should be conducted, setting out the advantages and disadvantages of each option, not limited to the previously proposed open access models and managed spectrum park ideas. It has been argued that the market will only sustain three to four major infrastructure providers to build national and regional broadband networks (industry interviews 2013 to 2014). The regulatory analysis should consider how to construct a licensing regime that encourages Internet Service Providers (ISPs) and other ECNS licensees and small-scale investors (collectively regarded as new small-scale entrants) to build localised wireless infrastructure networks, in a capital-intensive, but resource-limited market. The detailed research should be set out explicitly in a regulatory discussion paper for consultation and public comment.

7.3 Spectrum pricing approaches

The regulator should not set out with the sole intent of gaining revenue, thus considering only regulatory tools such as spectrum auctions and beauty contests. It should adopt a position of valuing spectrum, regulating pricing in such a way to ensure that spectrum is

effectively utilised to get high-speed broadband connectivity to consumers, to public institutions and low-income households, through the design of spectrum pricing models that will enable greater investment in broadband. This may include a combination model of competitive pricing for spectrum trading and co-operative pricing for spectrum sharing.

This research is significant for a South African and a continental audience. For African regulators, it presents some foundational ideas to consider hybrid forms of spectrum regulation and pricing to promote both private and public value.

BIBLIOGRAPHY

The bibliography contains a few additional references than those listed in the text.

Abrahams, L. & Goldstuck, A. (2012). A decade of e-development in South Africa: sufficient for a services (r)evolution? In Hanna & Knight (eds.) *Strategies for the information society: Emerging international experience in e-development*. New York: Springer.

Abrahams, L., Akinsanmi, T., & Zimri, P. (2012). *e-Education: Regulating spectrum for digital services markets*. International Telecommunications Society India Regional Conference, Delhi.

Australian Government (2010). *Digital dividend Green Paper*. Department of Broadband, Communications and the Digital Economy. Available at http://www.dbcde.gov.au/consultation_and_submissions/digital_dividend/digital_dividend_green_paper_html

Banerjee, S., Mishra, A., Brik, V., Shrivastava, V., & Bahl. P. (2006). Towards an architecture for efficient spectrum slicing. UW-Madison, Computer Sciences Technical Report. Available at http://pages.cs.wisc.edu/~suman/pubs/spark.pdf

BMI-Techknowledge (2010). *USAO compliance review of licensees for ICASA*. Johannesburg: Author.

Bondelind, L., Brito, P., & Tan, Z. (2007). A manufacturers' perspective to spectrum management. Available at https://www.itu.int/osg/spu/stn/spectrum/workshop_proceedings/Background_Papers_Final/Huawei%20Contribution%20Paper%20v1.0.pdf

Buddhikot, M. (2007). *Understanding dynamic spectrum access: Models, taxonomy and challenges*. New Frontiers in Dynamic Spectrum Access Networks, DySPAN 2007, 2nd IEEE International Symposium, 649-663. doi: 10.1109/DYSPAN.2007.88

Caicedo, C., & Weiss, M. (2007). *Spectrum trading: An analysis of implementation issues*. New Frontiers in Dynamic Spectrum Access Networks, DySPAN 2007, 2nd IEEE International Symposium, 579-584. doi: 10.1109/DYSPAN.2007.82

Caicedo, C., & Weiss, M. (2010). *The viability of spectrum trading markets*. New Frontiers in Dynamic Spectrum, 2010 IEEE Symposium, 1-10. doi: 10.1109/DYSPAN.2010.5457846.

Cave, M. (2008). Market-based spectrum management in the UK and the European Union. *Telecommunications Journal of Australia*, *58*(2/3). Available at www.tja.org.au/index.php/tja/article/view/130

Cave, M. (2006). New spectrum-using technologies and the future of spectrum management: a European policy perspective. In Richards, E., Foster, R., & Kiedrowski, T. (Eds,) *Communications the next decade: A collection of essays prepared for the UK Office of Communications,* 220-234. Available at

www.culleninternational.com/cullen/presentations/martin_cave_communications_next_decade.pdf

Cave, M. (2002). *Radio spectrum management review: An independent review for the DTI and HM Treasury*. Available at http://www.Ofcom.org.uk/static/archive/ra/spectrum-review/2002review/1_whole_job.pdf

Cull, D. (2009). *Key considerations in telecommunications regulation: An overview of the South African position*. Johannesburg: Ellipsis Regulatory Solutions.

Department of Communications (2013). *South Africa connect: Creating opportunities, ensuring inclusion. South Africa's broadband policy.* Available at http://www.doc.gov.za/documents-publications/broadband.html

Department of Education (2004). *White Paper on e-Education*. Available at http://www.education.gov.za/DocumentsLibrary/Legislation/WhitePapers/tabid/191/Default.aspx

Faulhaber, G., & Faber, D. (2002). *Spectrum management: Property rights, market and the commons*. AEI-Brookings Joint Center for Regulatory Studies, Working Paper 02-12.

Fink, C., Mattoo, A., & Rathindran, R. (2003). An assessment of telecommunications reform in developing countries. *Information Economics and Policy*, *15*, 443-466. doi:10.1016 / S0167-6245(03)00007-6

Firth, L., & Mellor, D. (2005). Broadband: benefits and problems. *Telecommunications Policy*, *29*(2-3), 223-236. Available at http://www.sciencedirect.com/science/article/pii/S0308596104001120

Foster, A. (2010). *Spectrum in transition: The digital dividend*. Global Symposium for Regulators (GSR) 2010, International Telecommunication Union. Available at www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR10/documents/GSR10-paper3.pdf

Freyens, B. (2009). A policy spectrum for spectrum economics. *Information Economics and Policy*, *21*(2), 128-144. Available at http://dx.doi.org/10.1016/j.infoecopol.2009.03.003

GSM Association (2010). The digital dividend: How to provide broadband for all. Available at http://www.gsmworld.com/documents/DD_brochure_2010-FINAL.pdf

Goldstuck, A. (2011). *Mobility 2011*. Johannesburg: World Wide Worx.

Goldstuck, A. (2010). *Internet access in South Africa 2010: A comprehensive study of the Internet access market in South Africa*. Johannesburg: World Wide Worx.

Hernandez, J., Leza, D., & Ballot-Lena, K. (2010). *ICT regulation in the digital economy*. Global Symposium for Regulators 2010, International Telecommunication Union. Available at www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR10/documents/GSR10-paper2.pdf

Hossain, E., Niyato, D., & Han Z. (2009, July). *Dynamic spectrum access and management in cognitive radio networks*, Cambridge University Press, New York.

Ikeda, N. (2002). *The spectrum as commons: Digital wireless technologies and radio administration*. Research Institute of Economy, Trade and Industry (RIETI), RIETI Discussion Paper No. 02-E-002, SSRN-id309980. Available at http://papers.ssrn.com/so13/papers.cfm?abstract_id=309980

Independent Communications Authority of South Africa (2009). Notice: Individual electronic communications services. Available at www.icasa.org.za/LegislationRegulatory/LicensesandLicensees/ElectronicCommunicationsNetworkService/Individual/tabid/166/ctl/ItemDetails/mid/949/ItemID/183/Default.aspx

Independent Communications Authority of South Africa (2011a). Radio frequency spectrum regulations. Government Gazette 34172, 31 March 2011, Pretoria.

Independent Communications Authority of South Africa (2011b). General Notice 911 Electronic Communications Act (36/2005): Notice inviting comments regarding the draft spectrum assignment plan for the combined licensing of the 800MHz and 2.6GHz bands and General Notice 912 Draft invitation to apply for the radio frequency spectrum license to provide mobile broadband wireless access service for urban and rural areas using the complementary bands, 800MHz and 2.6GHz. Available at https://www.icasa.org.za/Portals/0/Regulations/Working%20Docmuents/Spectrum%20licensing%20framework%20for%20high%20demand%20bands%2031150/Draft%20ITA%20for%20Radio%20Frequency%20Spectrum%20to%20Provide%20Mobile%20Broadband%20Wireless%20Access%20800MHz%20and%202.6GHz%2034872.pdf

Independent Communications Authority of South Africa (2012). Erratum draft invitation to apply for radio frequency spectrum license: To provide mobile broadband wireless access service for urban and rural areas using the complementary bands, 800 MHz and 2.6 GHz. Government Gazette 34961, 23 January 2012, Pretoria.

InfoDev (2007). *Radio spectrum management: An executive summary*. ICT regulation toolkit Module 5. Available at http://www.ictregulationtoolkit.org/en/Section.2659.html

International Telecommunication Union (2005). *National spectrum management handbook*. Geneva: Author.

International Telecommunication Union (2006). *The regulatory environment for future mobile multimedia services: Towards more flexible spectrum regulation and its relevance for the German market*. Geneva: Author.

Kedama, Y. (2014). Advantages and disadvantages of ICASA's 2011 proposed spectrum licensing models. Unpublished research report, Master of Management in ICT Policy and Regulation, University of the Witwatersrand, Johannesburg.

Klemperer, P. (2002). 'How (not) to run auctions: The European 3G telecom auctions.' *European Economic Review*, *46*, pp.829-845. Available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=297907

Limpitlaw, J. (2009). South Africa, Chapter 30 in Long, C. (Ed,), *Global Telecommunications Law and Practice*. Thomson Reuters (Professional) Limited, (Sweet & Maxwell),

London. Updated version: Limpitlaw, J. (2012). South Africa, Chapter 30 in Long, C. (ed.), *Global Telecommunications Law and Practice* (Revision Service 30, 2012). Thomson Reuters (Professional) Limited, (Sweet & Maxwell), London, pp. 5201 – 5293.

Marcus, J., Nett, L., Scanlan, M., Stumpf, U., Cave, M., & Pogorel, G. (2005). *Towards more flexible spectrum regulation*. Bad Honnef, Germany: wik-Consult. Retrieved on 15 February 2012 from http://ens.ewi.tudelft.nl/Education/courses/et4248/flexspectrum_overview.pdf

Ministry of Communications (2011). Draft policy directions for electronic communications services in high demand spectrum. Government Gazette No. 34848, 14 December 2011.

Muller, R. (2011). Unused spectrum in SA: Should trading be allowed? Available at http://mybroadband.co.za/news/broadcasting/17969-unused-spectrum-in-sa-should-trading-be-allowed.html

Mureithi, M. (2010). *Open spectrum for development Kenya case study*. Johannesburg: Association for Progressive Communications.

Naidu, E. (2014). Secondary user pricing strategies in a cognitive radio environment. Unpublished research report, Master of Engineering in Telecoms Engineering, University of the Witwatersrand, Johannesburg.

National Planning Commission [NPC] (2012). *National development plan: Vision for 2030*. Pretoria, South Africa: Author.

Niyato, D., & Hossain, E. (2008a). Market-equilibrium, competitive and cooperative pricing for spectrum sharing in cognitive radio networks: Analysis and comparison. *IEEE Transactions on Wireless Communications*, *7*(11). doi: 10.1109/T-WC.2008.070546

Niyato, D., & Hossain, E. (2008b). Competitive pricing for spectrum sharing in cognitive radio networks: Dynamic game inefficiency of Nash equilibrium and collusion. *IEEE Journal on Selected Areas in Communications*, *26*(1). doi: 10.1109/JSAC.2008.080117

Noll, R. (1999). *Telecommunications reform in developing countries*. AEI-Brookings Center for Regulatory Studies, Working Paper 99-10. Available at http://papers.ssrn.com/abstract=181030

Odufuwa, F. (2010). *Open spectrum for development Nigeria case study*. Johannesburg: Association for Progressive Communications.

Ofcom (2007). *Digital dividend review. A statement on our approach to awarding the digital dividend*. Available at http://stakeholders.ofcom.org.uk/binaries/consultations/ddr/statement/statement.pdf

Ofcom (2009). United Kingdom response to 'Transforming the digital dividend into social benefits and economic growth in Europe'. Available at http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-policy-

area/projects/ddr/response.pdf

Pogorel, G. (2007). Nine regimes of radio spectrum management: A 4-step decision guide *Communications & Strategies*, *65*, p.169. Available at SSRN: http://ssrn.com/abstract=1804029

Ramkumar, P. (2011). *Tele-health in India: Landscape of tele-health infrastructure at points-of-service in India*. Geneva: International Telecommunication Union (ITU). Retrieved on 24 May 2011 from http://www.itu.int/ITU-D/cyb/app/docs/Tele-Health%20in%20India-e_final.pdf

Ray, S., Sharma, J., Chaturvedi, A., & Khan, F. (2012). *Telecom spectrum pricing strategies*. International Telecommunications Society India Regional Conference, Delhi. Available at http://www.iitcoe.in/ITS/topics/Spectrum%20and%20Technology/TelecomSpectrumPricingStrategies.pdf

Republic of South Africa (2005). Electronic Communications Act No. 36 of 2005. Pretoria: Author.

Song, Q., You, M., & Lv, T. (2009). *Incentives to spectrum trading*. Network Infrastructure and Digital Content, IC-NIDC 2009. IEEE International Conference, Beijing.

Waverman, L., Meschi, M., & Fuss, M. (2005). *Telecoms growth in developing countries*. Available at http://web.si.umich.edu/tprc/papers/2005/450/L%20Waverman-%20Telecoms%20Growth%20in%20Dev.%20Countries.pdf

Wellenius, B., & Neto, I. (2005). *The radio spectrum: Opportunities and challenges for the developing world*. World Bank Policy Research Working Paper No. 3742. Available at http://ssrn.com/so13/papers.cfm?abstract_id=823007

Wellenius, B., & Neto, I. (2008). *Managing the radio spectrum: Framework for reform in developing countries*. Policy Research Working Paper, The World Bank (Global Information and Communication Technologies Department, Policy Division).

Wilson, C., & McLeod, D. (2011). Spectrum trading in SA: A pipe dream? TechCentral. Available at www.techcentral.co.za/spectrum-trading-in-sa-a-pipe-dream/27439

Zimri, P. (2013). *Radio-frequency spectrum, the out of sight, out of mind, national strategic resource*. Unpublished research report, Master of Management in ICT Policy and Regulation, University of the Witwatersrand, Johannesburg.

Acknowledgements

This paper arises from a combination of research part-funded by ICASA in 2011 and 2012, and part-funded by CCRED through the Economic Development Department in 2013. This funding contributed to academic research and to supervision of the research performed by students on the Masters of Management in ICT Policy and Regulation and the Masters of Engineering in Telecoms Engineering, University of the Witwatersrand, Johannesburg. Acknowledgement is due to Peter Zimri, whose MM in ICT Policy and Regulation research report set out many of the key features of the spectrum regulatory landscape in South Africa.

Authors

Lucienne Abrahams	*LINK Centre, SLLM, University of the Witwatersrand*
Yolisa Kedama	*Graduate School of Public and Development Management, University of the Witwatersrand (registered for MM in ICT Policy and Regulation)*
Elicia Naidu	*School of Electrical and Information Engineering, University of the Witwatersrand (registered for M Telecom Eng)*
Kiru Pillay (PhD)	*LINK Centre, SLLM, University of the Witwatersrand*

LINK Centre

The LINK Centre is the leading academic research and training body in the field of electronic communications and ICT (information and communications technology) policy, regulation and management in Southern Africa. LINK focuses on knowledge production and capacity building for the broad ICT sector, including focus on the telecoms and broadcasting sectors (electronic communications), advances in the wider ICT sector, e-government in the public sector, and e-development in society and the economy.

Appendix A1 Sample of interviewees from the industry

Interviewee	Type of institution
AC1	Academic
AC2	Academic
CA1	Communications forum
IN1	Incumbent operator
IN2	Incumbent operator
IN3	Incumbent operator
IN4	Incumbent
IN5	Incumbent
MA1	Manufacturer
MA2	Manufacturer
MA3	Manufacturer
NE1	New entrant
NE2	New entrant
NE3	New entrant
PR11	Government policy
PR12	Government policy
PR21	Regulator
PR22	Regulator
SO1	Government entity
SO2	Government entity