The state of spectrum management reforms and the mobile broadband industry in the SADC region

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24 October 2017

A research report submitted to the Faculty of Humanities, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Arts (in the field of ICT Policy and Regulation)

Abstract

Spectrum management reforms involve a departure from state-commanded administrative methods to market-driven property rights and or technology-enabled spectrum commons. This study explores spectrum management reforms that have been undertaken in the last decade, between 2006 and 2016, in the Southern African Development Community (SADC) region, with specific focus on the mobile broadband (MBB) industry. As a result, only spectrum bands allocated to terrestrial mobile and identified for International Mobile Telecommunications (IMT) by the International Telecommunication Union (ITU) in ITU Region 1 (Europe, Middle East and Africa) were considered.

The purpose was to firstly analyse the progress thus far in reforming spectrum management practice in the region and secondly to critically analyse the effects of these reforms on the MBB industry in SADC within the framework of high demand for more spectrum as the cornerstone for rapid diffusion of MBB. Using a constructivist case study methodology, qualitative research was conducted in three SADC countries, namely, Botswana, Zambia and South Africa, representing small, medium and large markets respectively. The study draws on published documents such as policies, legislation, regulations and directly from individuals tasked with spectrum management in public and private sector organisations in these countries.

The findings reveal that several market-driven reforms such as technology and service neutrality, spectrum re-farming and administrative incentive pricing (AIP), together with technology-enabled reforms such as commons or license-exempt spectrum for MBB technologies are all becoming widespread in the region. However, secondary trading and auctions have been stillborn concepts, partly due to market concentration concerns and appropriateness issues. The artificial scarcity of MBB spectrum supply in SADC is laid bare against a backdrop of general scarcity for demand and a discord over how this spectrum should be assigned and to whom. Vast amounts of allocated mobile spectrum in SADC lie fallow or are encumbered by other services such as broadcasting or at times are historically assigned to Fixed Wireless Access (FWA) applications.

Analysis of the data from these three country case study provides insights that may be relevant to many other countries in the region. In conclusion, the study advances that the implementation of spectrum management reforms should be nuanced as these can impact, positively or negatively, on the distributive agenda of government. This research further advances knowledge by positing a novel conceptual framework for spectrum management reform based on the finding that the latter is not a binary exercise of a departure from administrative approach to either a market-driven or a technology-enabled one. However, spectrum management reform can be a continuum on which different elements of administrative, market-driven and technology-enabled approaches can be applied to varying degrees, depending on the respective country's context.

Dedication

To the Father of celestial lights, who does not vary or change like the shifting shadows (James 1:17), thank you for the gift of life. To *Jah* be the glory!

To the love of my life Ndileka, and my boys, Thabiso and Ntsika who sacrificed their time with me, thanks for the love and support.

Acknowledgements

This study rests on the scholarship, theoretical and empirical, of many experts. I stand on the shoulders of giants, too many to enumerate. Responsibility for any errors or omissions rests with the researcher.

I would be remiss if I did not acknowledge the guidance, motivation and support of my supervisor Dr Lucienne Abraham through the most difficult times of this long and arduous journey.

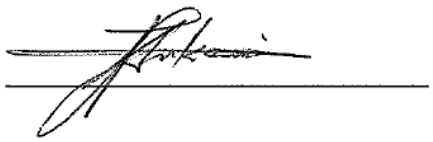
While I hesitate to single out anyone, I have to mention my *sounding board,* Ade, whom I have abused extremely and I benefited enormously from those intellectual discussions. *Aah Thithiba!*

I owe my intellectual debts to the respondents who found time in their hectic schedules to participate in this study and share their insights. *Maz'enethole!*

Declaration

I hereby declare the following;

I declare that this report is my own, unaided work. It is submitted in partial fulfilment of the requirements of the degree of Master of Arts (in the field of ICT Policy and regulation) in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.



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2G	Second-generation cellular technology
3G	Third-generation cellular technology
4G	Fourth-generation cellular technology
ASA	Authorised Shared Access
BITRI	Botswana Institute for Technology Research and Innovation
BOCRA	Botswana Communications Regulatory Authority
BTA	Botswana Telecommunications Authority
CAGR	Compounded Annual Growth Rate
CAQDAS	Computer Aided Qualitative Data Analysis Software
CEPT	European Conference of Postal and Telecommunications
CRS	Cognitive Radio System
CSIR	Council for Scientific and Industrial Research
DSA	Dynamic Spectrum Allocation
EMEA	Europe Middle East and Africa
ETSI	European Telecommunications Standards Institute
FAP	Frequency Allocation Plan
FCC	Federal Communications Commission
FDD	Frequency Division Duplexing
FWA	Fixed Wireless Access
GDP	Gross Domestic Product
GSM	Global System for Mobile
HSPA	High Speed Packet Access
IA	Information Asymmetry
ICASA	Independent Communications Authority of South Africa
ICT	Information and Communications Technology
IEEE	Institute of Electrical and Electronic Engineers
IMT	International Mobile Telecommunications
ISM	Industrial Scientific and Military
ITA	Invitation to Apply
ITFA	International Table of Frequency Allocation
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union – Radiocommunication sector
LAA	Licensed Assisted Access
LDC	Least Developed Country
LSA	Licensed Shared Access
LTE	Long-Term Evolution
LTE-A	LTE-Advanced
LTE-U	LTE-Unlicensed
MBB	Mobile Broadband
MIMO	Multiple Input Multiple Output
MNO	MBB Network Operator
NDP	National Development Plan
NRA	National Regulatory Authority
NTFA	National Table of Frequency Allocation
QAM	Quadrature Amplitude Modulation
RBW	Republic of Botswana
RSA	Republic of South Africa
RSPG	Radio Spectrum Policy Group

RZM	Republic of Zambia
SADC	Southern African Development Community
SADCC	Southern African Development Coordination Conference
SDR	Software Defined Radio
SIDS	Small Island Developing States
TDD	Time Division Duplexing
TVWS	Television White Space
WOAN	Wholesale Open Access Network
WRC	World Radiocommunication Conference
ZICTA	Zambia Information and Communications Technology Authority

Contents

Chapter 1: Background: What has succeeded and what hasn't

1.1 The evolution of spectrum management

Radio frequency spectrum (spectrum) is the range of electromagnetic waves between 3 kHz and 3000 GHz (ITU-R, 2016b, RR 2.1). Spectrum is used by a wide range of services such as broadcasting, aeronautical and maritime communications, astronomy, mobile communications, etc. Spectrum management is a combination of administrative and technical activities that seek to achieve the goal of efficient and effective utilisation of spectrum by government and non-government users, and that of stimulating socio-economic development (ITU-R, 2015b). Furthermore, spectrum management activities include spectrum allocation,[1] spectrum assignment,[2] international coordination, and spectrum monitoring and enforcement. Although the terms allocation and assignment are commonly used as synonymous, they actually have different meanings. Monitoring and enforcement entail verifying the use of spectrum, whether it is in conformity with the specified licensing conditions, and taking preventative and corrective measures to ensure conformance. This study focuses on spectrum management reform related to the radio-frequencies applicable for mobile broadband (MBB), namely the relevant spectrum bands between 700MHz and 3600MHz (see Table 4) for the Southern African Development Community (SADC) region, using three countries, namely Botswana, South Africa and Zambia in a case study.

Spectrum management has traditionally been based on the concept of scarcity, where the spectrum management agency such as the ministry or the national regulatory authority (NRA) typically made decisions on the use of a particular band and by which users (Bohlin, Blackman, Forge, & Renda, 2007, p.1). Freyens (2009) refers to spectrum management as a delicate balancing act between addressing demand and managing interference. The traditional administrative methods of managing spectrum, commonly known as "command and control," have created an artificial scarcity of spectrum, where demand usually exceeds supply (El-Moghazi, Digham & Azzouz, 2008; Faulhaber, 2005; Freyens, 2009; Minervini, 2014). Chapin and Lehr (2011) argue that the unprecedented exponential growth of MBB has exacerbated pressure for more spectrum to be apportioned for mobile services.

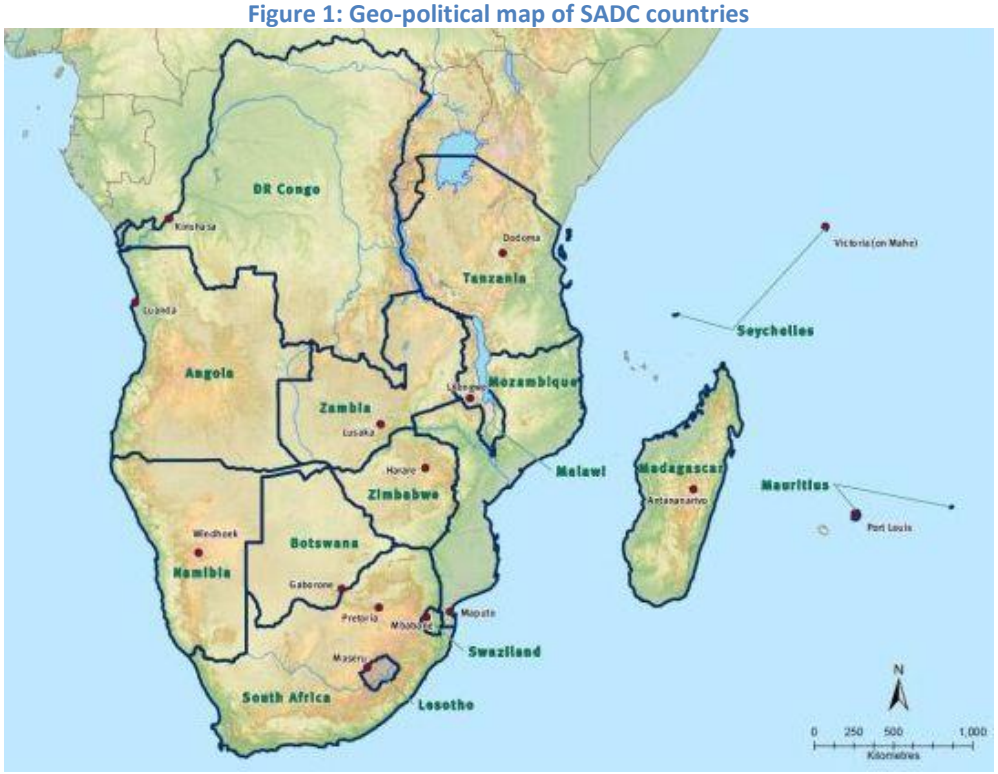
SADC region experienced a significant growth of data traffic in MBB networks similar to other developing regions in the world. Since the advent of mobile communications in the region in the early nineties, spectrum management for MBB and other services in SADC has been based largely on administrative methods. From around 2005 several countries, prompted by technological evolution and lobbying from the industry, began to explore innovative ways of managing MBB spectrum. During this time, two alternative regimes emerged as the means to find efficient and flexible ways of managing spectrum through "spectrum management reform" process. The first alternative is a market-driven spectrum property rights that features technology and service neutrality, refarming, auctions and secondary trading; the second is a technology-enabled spectrum commons with license-exempt and unlicensed spectrum as its cornerstone (Bohlin *et al.,* 2007).

[1] Allocation means an "entry in the table of frequency allocations of a given frequency band for the purpose of its use by one or more terrestrial or space radiocommunication services under specified conditions" (ITU, 2016b, RR 1.16).
[2] Assignment refers to an "authorization given by an administration for a radio station to use a radio frequency or radio frequency channel under specified conditions" (ITU, 2016b, RR 1.18).

1.2 Socio-economic development and spectrum management in SADC

SADC is an inter-governmental organization for socio-economic development made up of fifteen member states, namely, Angola, Botswana, Democratic Republic of Congo (DRC), Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe (SADC, 2015) (see Figure 1). It evolved from the Southern African Development Coordination Conference (SADCC), which was founded in 1980 by the frontline states to establish a coordinated policy and response to both South Africa's apartheid regime and its liberation movements (SADCC, 1981). The frontline states were a group of Southern African states that sought to reduce their dependence and liberate themselves from the colonial, white minority domination of Southern Africa by the apartheid government in South Africa. Socio-economic issues took the centre stage within the SADC developmental objectives at the Heads of State Summit in Gaborone in 1992 where economic growth and sustainable utilisation of natural resources were elevated to Treaty status (SADC, 1992).

Figure 1: Geo-political map of SADC countries



Source: SADC, 2015

Population density is generally low in the majority of SADC countries, with the exception of the island states of Mauritius and Seychelles. The lowest Gross Domestic Product (GDP) per capita figure for 2015 in the region was 372 US dollars and the highest was 15,476 US dollars for Malawi and Seychelles respectively (World Bank, 2016). Table 1 shows the heterogeneous socio-economic developmental statuses of the SADC countries. More than half have least developed country (LDC) status and two are Small Island Developing States (SIDS), as defined by the United Nations (UN) (United Nations, 2015). On average, around 60 percent of the SADC population lives in rural areas; with more than 80 percent in Malawi residing outside urban areas, but less than 40 percent in South Africa living in rural areas. The total population in the region is just over 321 million (World Bank, 2016).

Table 1: SADC Socio-Economic Development Indicators for 2016

Country	Population (millions) 2016	Rural population 2016	Surface Area (km², thousands) 2016	GDP per capita (current USD, 03/2018)	GDP Growth 2016	UN classifications 2015
Angola	28.8	55%	1,246,7	3,308.7	-0.7%	LDC
Botswana	2.3	42%	581.7	6,924.1	4.3%	-
Congo, DR	78.8	57%	2,344.9	405.5	2.4%	LDC
Lesotho	2.2	72%	30.4	1,039.7	2.4%	LDC
Madagascar	24.9	64%	587.3	401.7	4.2%	LDC
Malawi	18.1	84%	118.5	300.3	2.5%	LDC
Mauritius	1.3	60%	2.0	9.630.9	3.8%	SIDS
Mozambique	28.8	67%	799.4	382.0	3.8%	LDC
Namibia	2.5	52%	824.3	4,415.0	1.1%	-
Seychelles	0.1	46%	0.5	15,075.7	4.5%	SIDS
South Africa	55.9	35%	1,219.1	5,274.5	0.3%	-
Swaziland	1.3	79%	17.4	2,770.2	1.4%	-
Tanzania	55.6	68%	947.3	877.5	7.0%	LDC
Zambia	16.6	59%	752.6	1,269.6	3.6%	LDC
Zimbabwe	16.2	68%	390.8	1029.1	0.6%	-

Sources: World Bank, 2016; United Nations, 2015

1.2.1 The state of the mobile broadband industry in SADC

The mobile industry's development indicators in SADC follow a pattern similar to that of the socio-economic development statistics in the region; please refer to Table 2. Countries with a low GDP per capita generally have a low mobile penetration rate and an even lower MBB penetration figure. While countries such as Malawi and Madagascar have a paltry mobile penetration of 30 percent and 35 percent respectively, five countries in the region have mobile penetration rates well above 100 percent. The unique mobile penetration and MBB penetration figures paint a gloomy picture, across the whole region. Unique mobile penetration refers to every person or subscriber that holds one or more mobile subscriptions, i.e. SIM cards, whereas mobile penetration simply refers to the number of mobile connections per 100 people in a geographic area (GSMA, 2014).

Table 2: SADC Mobile Industry Indicators 2016

Country	Mobile Penetration (SIMs)	Unique Mobile Penetration	Mobile Broadband
Angola	64%	38.7%	12.0%
Botswana	156%	73.5%	21.1%
Congo, DR	59%	30.2%	2.1%
Lesotho	84%	52.3%	10.5%
Madagascar	30%	18.2%	3.1%
Malawi	35%	22.6%	2.1%
Mauritius	129%	75.8%	25.6%
Mozambique	58%	28.2%	7.3%
Namibia	113%	47.1%	18.4%
Seychelles	138%	77.3%	18.8%
South Africa	148%	69.7%	33.1%
Swaziland	70%	55.8%	5.1%
Tanzania	62%	38.0%	11.8%
Zambia	73%	40.6%	7.5%
Zimbabwe	98%	47.0%	13.3%

Source: GSMA, 2016

1.2.2 Spectrum management in SADC

Spectrum management function is generally split between the information and communications technology (ICT) or the telecommunications sector policymaker and the sector regulator. For example, in the case of South Africa the Department of Telecommunications and Postal Services (DTPS) sets the national spectrum policy and represents the country in the ITU matters in respect of allocation and international coordination (RSA, 2005, s.3 & s.34), whereas, ICASA "controls, plans, administers and manages the use and licensing" of spectrum (RSA, 2005, s.30). Table 3 outlines the respective policymakers and regulators in the region tasked with this function. All the countries in SADC have an independent ICT sector regulator, with only one exception, in Seychelles, where the ministry acts as both the policymaker and regulator. All three countries that are subjects of this study, Botswana, South Africa and Zambia, are active members of Communications Regulators' Association of Southern Africa (CRASA). CRASA strives to harmonise the ICT regulatory environment, including spectrum management, in SADC in the quest to create a favourable investment environment for business (CRASA, 2016).

Table 3: SADC ICT Sector Policymakers and Regulators

Country	Sector Policymaker	Sector Regulator
Angola	Ministério das Telecomunicações e Tecnologias de Informação	Instituto Angolano das Comunicações (INACOM)
Botswana	Ministry of Communications, Science and Technology	Botswana Communications Regulatory Authority (BOCRA)
Congo, DR	Societe Congolaise des Postes et Telecommunications	Autorite de Regulation de la Poste et des Telecommunications du Congo (ARPTC)
Lesotho	Ministry of Communication, Science & Technology	Lesotho Communications Authority (LCA)
Madagascar	Office Malagasy d'etudes et de Regulation des Telecommunications	Autorite de Regulation des Technologies de Communication (ARTEC)
Malawi	Ministry of Information, Tourism and Civic Education	Malawi Communications Regulatory Authority (MACRA)
Mauritius	Ministry of Information Technology and Telecommunication	Information and Communications Technologies Authority of Mauritius (ICTA)
Mozambique	Ministry of Transports and Communications	Instituto Nacional das Comunicações de Moçambique (INCM)
Namibia	Ministry of Information and Communications Technology	Communications Regulatory Authority of Namibia (CRAN)
Seychelles	Ministry of Information Technology and Communication (MITC)	No separate/independent regulator
South Africa	Department of Telecommunications and Postal Services	Independent Communications Authority of South Africa (ICASA)
Swaziland	Ministry of Tourism, Environment and Communications	Swaziland Communications Commission (SCCOM)
Tanzania	Ministry of Works, Transport and Communication	Tanzania Communications Regulatory Authority (TCRA)
Zambia	Ministry of Transport Works Supply and Communications	Zambia Information and Communications Technology Authority (ZICTA)
Zimbabwe	Ministry of Information Communication Technology, Postal and Courier Services	Postal and Telecommunications Regulatory Authority of Zimbabwe (POTRAZ)
SADC	SADC Secretariat – ICT Desk	Communications Regulators' Association of Southern Africa (CRASA)

Source: Author's compilation

Spectrum is a critical input in the production of MBB services. Spectrum offers mobility, portability and it is relatively cheaper to rollout a mobile network compared to a fixed network (El-Moghazi et al., 2008). Effective and efficient management of spectrum can contribute positively to the attainment of national and global economic objectives. Therefore, spectrum management reform by policy-makers and regulatory authorities should enable countries to benefit fully from MBB and improve their economic prospects.

1.3 A snapshot of telecommunications sector liberalisation in SADC

Telecommunications sector liberalisation is beyond the scope of this research, however, in order to contextualise spectrum reforms for mobile broadband it is worth taking a brief overview of this phenomenon in the three SADC countries of study, namely, Botswana, Zambia and South Africa Zambia. Liberalisation or the introduction of competition and termination of monopolies brought about significant changes in market structures globally (Melody, 2001b, p.333). It has resulted in an increase in the number of privately-owned service providers in SADC and increased competition (SADC, 2012, p.30). Melody (2001b) argues that liberalisation has been adopted largely because of technological changes and the need to attract the necessary financial investment to modernise the telecom infrastructure. The World Bank also pushed for sector liberalisation by promoting privatisation of the former public enterprises and at the same time introducing a sector regulator as an antidote to a new form of monopoly coming from private firms (Melody, 2001b, p.26). Meanwhile, telecommunications infrastructure increased to a large extent since the dawn of sector liberalisation, leading to a more vibrant and competitive market. An increase in telecommunications infrastructure and the number of service providers, together with evolved MBB technologies, resulted in an increased demand for spectrum for this service. Nevertheless, the extent of liberalisation in the region differs from country to country; this is partly due to a lack of a coordinated transition plan from a fixed line monopoly to a fully integrated liberal market and also the different economic development aspirations of the different Member States (SADC, 2012, p.65).

1.3.1 Botswana telecommunications liberalisation

Telecommunications sector liberalisation in Botswana began with the now repealed Telecommunications Act of 1996 and the Telecommunications Policy for Botswana of 1995. Prior to the advent of liberalisation, Botswana Telecommunications Corporation (BTC) was both a player and a referee in the sector as it assumed the policy, regulatory and operations functions for everything to do with telecommunications in the country (Sebusang, Makepe & Botlhole, 2007, p.9). The liberalisation process was kicked off with the establishment of the first independent regulator, Botswana Telecommunications Authority (BTA) in 1996, and the licensing of two mobile operators, Mascom and Vista Cellular (now Orange Botswana) in 1998 (BOCRA, 2016b). Subsequently, the Communications Regulatory Authority Act of 2012 provided the framework for the establishment of a converged regulator, Botswana Communications Regulatory Authority (BOCRA), which succeeded BTA in 2013. BOCRA was formed by a merger of the telecommunications regulator, BTA, and the broadcasting regulator, National Broadcasting Board (NBB) (Esselaar & Sebusang, 2013).

Further reforms ensued from around 2006 when operators where conferred service and technology-neutral licenses (Sebusang *et al.,* 2007, p.14). Service-neutral licenses allow operators to offer both fixed and mobile service under the same license. Meanwhile, technology-neutral licenses granted the operators the much-needed flexibility on spectrum usage. Spectrum that was initially licensed for voice or narrowband data, 2G GSM only, could now be used for broadband data, 3G or 4G technologies. HSPA and LTE technologies are now provided in Botswana, partly using spectrum

that has been re-farmed from 2G. These reforms in Botswana came about as a result of the market or operators demanding flexibility with their spectrum licenses. Meanwhile, some trials for dynamic and opportunistic spectrum use have been conducted in Botswana during 2015 and 2016; however there is currently no regulatory framework in place (BOCRA, 2016). A new government entity which is intended to provide wholesale access to all players in Botswana, Botswana Fibre Networks, or BoFiNet, was formed in 2012 (Esselaar & Sebusang, 2013). BoFiNet was a result of a split of BTC into two entities, namely, the restructured and lighter BTC which will focus on retail only and all wholesale business transferred to the newly formed entity, BoFiNet. According to government, this split was essentially done in the interests of competition and governance purposes.

1.3.2 South Africa telecommunications liberalisation

The South African Posts and Telecommunications (SAPT) acted as both a post and telecommunications services (PTS) operator and a regulator simultaneously until 1991 when reforms began in earnest in South Africa (Horwitz, 2001). PTS became separated and Telkom SA, a telecommunications company solely owned by the state, was incorporated in the same year under the South African Companies Act and it was mandated to run the fixed line business. It was during this time when the regulatory function and staff were moved temporarily to the then Department of Communications (Horwitz, 2001). The South African Telecommunications Regulatory Authority (SATRA) was only formed in 1997 and it was later succeeded by ICASA in 2000 when SATRA was merged with the broadcast regulator, the Independent Broadcasting Authority (IBA) (Gillwald, 2005). The South African telecommunications sector went through a process which was then referred to as "managed liberalisation" in the mid-nineties (Zimri, 2013, p.29). South Africa followed the so-called international best practice model of telecommunications liberalisation "through partial privatisation of the incumbent and extension of its monopoly, the introduction of competition in mobile telephony… and establishment of a sector regulator" (Gillwald, 2005, p.485). This managed liberalisation effectively curtailed competition as it allowed incumbents to further entrench their dominance ahead of the introduction of new entrants. As a result, universal access and service suffered because competition was stifled and incumbents were pretty much protected.

Telkom SA became privatised in 1996 when 30 percent of the company was sold to a strategic equity partner (SEP) with 28 percent floated on the stock exchange in 2003 (Gillwald, 2005). On the other hand, the MTN and Vodacom duopoly was licensed in 1993 prior to the first democratically elected government of 1994 and the establishment of an independent regulator, SATRA, in 1997 (Horwitz, 2001). While the third mobile operator Cell C obtained their license in 2000 but started operations almost two years later due to a protracted legal challenge by one of the losing bidders, Nextcom (Zimri, 2013, p.141). Many authors observed that the sector regulator and policymaker's history is riddled with regulatory uncertainties created by the lack of agreement on jurisdiction between sector policy-maker and regulator (Horwitz, 2001; Gillwald, 2005; Zimri, 2013). Notably, ICASA has the authority to license spectrum through an auction process in cases where demand exceeds supply, whilst the policymaker insists that the Minister must first issue a policy directive (Zimri, 2013, p.142). The Electronic Communications Act (ECA) of 2005 mandates the regulatory authority to manage and plan radio frequency spectrum for commercial purposes (RSA, 2005, s.30 (1)).

ICASA's attempt to license additional IMT spectrum through an auction in 2011 was scuppered by the policymaker's interventions (Zimri, 2013, p.113). On the other hand, ICASA approved the acquisition of some entities, together with their spectrum assets, thus indirectly

permitting spectrum trading. In 2015 ICASA approved, with conditions, the Vodacom buyout of Neotel and also the acquisition of WBS by Multisource (Vodacom/Neotel merger, 2015; ICASA, 2015d). However, the Vodacom-Neotel deal was later nullified by the High Court in Pretoria after it was challenged by competitors. On the other hand, ICASA also initiated a process to regulate dynamic and opportunistic spectrum use through a discussion document, which sought comments from interested parties, and later a findings document (ICASA, 2015a). An administrative incentive pricing (AIP) scheme was introduced by the regulator in 2011 to discourage spectrum hoarding by all public and private institutions using spectrum (Zimri, 2013). The ECA provides for a technology and service neutral framework in managing spectrum. As result, the regulator has since converted spectrum licenses to allow spectrum re-farming and migration to newer and advanced mobile broadband technologies.

1.3.3 Zambia telecommunications liberalisation

Zambia telecommunications sector liberalisation begun in earnest during the mid-nineties when the national government through the Telecommunications Act of 1994 split the then Zambia Posts and Telecommunications Corporation (ZPTC) into two commercial vertical entities (Habeenzu, 2010). The resultant entities were the Zambia Telecommunications Company (ZAMTEL) and the Zambia Postal Corporation (ZAMPOST). Furthermore, an independent regulatory body for the telecommunications sector was formed, namely, the Communications Authority of Zambia (CAZ). Prior to liberalisation, PTC performed the regulatory functions and post-liberalisation, these functions were transferred to CAZ. Spectrum management was also transferred to CAZ through the Radio Communications Act of 1994. The ICT Act of 2009 renamed CAZ the Zambia Information and Communications Authority (ZICTA), mandating it to manage and ensure efficient use of scarce resources such as radio frequency spectrum (Republic of Zambia (RZM), 2009).

Both the Zambia ICT Policy of 2005 and the Zambia ICT Act of 2009 recognized convergence and unified licensing as emerging trends in the ICT sector. These instruments provided for two new licensing categories, namely, a network license and a service license. The former “authorises its holder to construct, own or make available an electronic communications network, or to provide a network service,” while the latter “permits its holder to provide one or more electronic communications services.” Of critical importance to this study is the technology-neutrality which was introduced by these reforms which basically enabled the spectrum users to deploy any technology of choice to provide a similar or better service. Accordingly, mobile broadband operators have been authorized to re-farm spectrum that was initially licensed for 2G only and use it for 3G or 4G technologies such as HSPA and LTE.

1.4 Efficient spectrum utilisation for economic development

According to the ITU, efficient utilisation of radio spectrum can lead to economic development as it can play a crucial role in the expansion of broadband services to the broader population (ITU, 2015c, p.70). Meanwhile, the spectrum scarcity in developing regions such as SADC has been challenged by many authors (Calandro, 2011; Chapin & Lehr, 2011; Durantini & Martino, 2013), with vast amounts of spectrum lying fallow due to challenges that may be technical, economic and or political. Calandro (2011) puts the blame squarely at the door of centralized “command and control” radio spectrum policies employed in many countries. He argues that these policies have resulted in inefficiencies and created artificial scarcity of radio spectrum.

Radio spectrum as a limited resource for broadband, particularly in the SADC region, lies at the core of the political economy of the mobile broadband industry. This resource is one of the main

determinants for market entry and growth, and a barrier at the same time. Since the advent of MBB, spectrum has turned out to be both a competitive and an anti-competitive tool for the incumbent network operators and a barrier to entry for new entrants (Calandro, 2011). Calandro further argues that the technology-neutral radio spectrum licenses have inadvertently created an artificial spectrum scarcity as they seem to entrench oligopolistic market structures, denying new entrants access to this critical resource. Technology-neutrality allows incumbents to migrate to the latest MBB technologies using the same spectrum that was previously assigned for older technologies whilst new entrants are scrambling for access to spectrum to roll out new services.

MBB managed to thrive in developing countries like SADC on the back of regionally harmonised spectrum policies as per ITU regions. This study focuses on the commonly used bands in the SADC region which are as per Frequency Arrangements for ITU Region 1[3] and the Third Generation Partnership Project (3GPP) harmonised bands for the same region (ITU-R, 2015a; 3GPP, 2015). Table 4 depicts the leading MBB spectrum bands that are currently used in SADC, in full or in part, and some have not been assigned or licensed yet, although they have been allocated to mobile services and identified for International Mobile Telecommunication (IMT) at the ITU level for Region 1, and at the SADC level and in various countries. It is worth noting that a mere allocation of spectrum to mobile does not necessarily guarantee availability of that spectrum to IMT as there are several competing radio-based services, hence the need for IMT identification. Identifying spectrum for potential use by IMT reduces the cost of IMT networks and terminals as it increases the economies of scale. IMT identification also facilitates international roaming and cross-border coordination, and it reduces interference possibilities (ITU-R, 2015a, p.4).

Table 4: Mobile broadband spectrum bands used in SADC countries

3GPP Band No.	ITU Frequency Arrangement	Frequency Division Duplexing (FDD)		Time Division Duplexing (TDD) [in MHz]	Bandwidth [in MHz]
		Uplink [in MHz]	Downlink [in MHz]		
1.	B1	1920 – 1980	2110 – 2170	–	120
3.	B2	1710 – 1785	1805 – 1880	–	150
5.	A1	824 – 849	869 – 894	–	50
7.	C1	2500 – 2570	2620 – 2690	–	140
8.	A2	880 – 915	925 – 960	–	35
20.	A3	832 – 862	791 – 821	–	60
22.	F2	3410 – 3490	3510 – 3590	–	160
28.	A5	703 – 733	758 – 788	–	60
38.	C1	–	–	2570 – 2620	50
40.	E1	–	–	2300 – 2400	100

[3] ITU Region 1 includes Africa, Western Europe, Russian Federation, other Eastern European countries as well as the Middle East west of the Persian Gulf including Iraq (SADC, 2016, p.3; El-Moghazi, Whalley & Irvine, 2013, p.4).

41.	C3	–	–	2496 – 2690	194
42.	F1	–	–	3400 – 3600	200

Sources: 3GPP, 2015; ITU, 2012a

1.5 Increasing demand for mobile broadband and limited radio spectrum

Wireless or MBB data has experienced unprecedented growth in the last decade (Minervini, 2014), and it continues to grow at exponential rates, not only in the developed world but also in the developing countries (Ericsson, 2016, p.8). MBB networks are now carrying more traffic and more subscribers than before. Ericsson estimates that the total global mobile data traffic growth between the year 2016 and 2022 will increase at a compound annual growth rate (CAGR) of around 45 percent, while at the same time traffic generated by smartphones will experience a tenfold growth. Meanwhile, Cisco (2016) predicts a 71 percent CAGR of mobile data traffic increase between 2016 and 2020. Ericsson (2016) forecasts a threefold growth in mobile broadband subscriptions in Middle East and Africa region between 2016 and 2022. Smartphone adoption rate in the SADC region will increase from 24 percent in 2015 to 57 percent in 2020 (GSMA, 2016, p.19).

The technology migration for mobile broadband subscriptions varies across world regions with the Middle East and Africa region changing from predominantly GSM/EDGE technologies in 2016 to HSPA & LTE in 2022. It is worth noting that, due to the lack of fixed broadband access in SADC, MBB network remains the primary means to connect to the internet for many, using a mobile device such as a smartphone or a low-cost tablet. Although second generation (2G) based network technologies are still dominant, accounting for more than 60 percent of the total connections in Africa, MBB connections based on third and fourth generation (3G & 4G) technologies will increase to almost 60 percent by 2020 (GSMA, 2016, p.11). At the same time, the ITU reported that MBB network coverage globally has reached more than two-thirds of the world's population (ITU, 2016a). However, in the same report it is also recognised that more than half of the world's inhabitants are not connected to the internet; in Africa the figure is almost three quarters of the region's population. According to industry estimates, more than 50 percent of Africa's population was still without internet access to mobile services by the end of 2015 (GSMA, 2016, p8). The double-digit growth of MBB subscriptions in the developing countries is indeed fuelled by the lower subscriber base (ITU, 2016a). A lot more still needs to be done to increase the diffusion of broadband and bring more people online. Broadband affects all sectors of the economy, from finance to agriculture; it has impacted the way social services such education and health are delivered. Broadband technology has transformed many aspects of life, work and entertainment. In the absence of fixed broadband infrastructure in the developing countries, MBB remains the only viable means of access to the digital world and bridge the digital divide.

The mobile broadband growth, fuelled by the increasing demand to support more functions has increased the pressure for more radio spectrum (Minervini, 2014). As a result of this increasing pressure for more radio spectrum for MBB, there is a school of thought that argues that at some point demand will outstrip supply, therefore spectrum management practices should be reformed considerably (Durantini & Martino, 2013). Spectrum management reforms constitute essentially the adoption of a more efficient and more liberal approach to how this resource is controlled or managed, whereby the market or technology, or both, dis-intermediates the centralized administrative role of the state or its institutions. While technology development has continued to

evolve at ever increasing rates, spectrum policies have failed to keep abreast with these adjustments (SADC, 2012, p.63).

1.6 Problem statement

The telecommunications sector in the SADC region went through a process of liberalisation in the nineties where ownership and control moved away, partially or completely, from the state to market control. This phenomenon brought about some efficiency in the industry as access to telecommunications or teledensity in these countries increased significantly; more people now enjoy access to this service. This accomplishment by the mobile industry has contributed to the economic development of many countries in SADC. The increased access to telecommunications services has been mainly for voice telephony and in some instances limited data services. Spectrum management reform phenomenon is in a way similar to telecommunications sector liberalisation in the sense that control and management of this resource moves away, partially or completely, from the state to the market and or the technology. However, in this instance the end-game is not clear.

The MBB industry has been clamouring not only for more harmonised radio spectrum, but also for reform of how this resource is managed as MBB services increase pervasiveness. Spectrum management reform aims for a flexible approach that introduces market-driven concepts from spectrum property rights such as technology and service neutrality, re-farming, secondary trading and auctions. At the same time, technology-enabled concepts of spectrum commons such as dynamic and opportunistic use of spectrum, spectrum sharing, unlicensed or license-exempt use are also being lobbied for. In some jurisdictions, regulators have introduced AIP schemes for spectrum to encourage more efficient utilisation of this resource and also attempt to bring spectrum fees closer market value of this resource. The problem investigated in this study is the advances in spectrum management reform and the effect of particular reforms on the MBB industry in the SADC region.

1.7 Purpose and objectives of the study

This study considers spectrum management reform in the SADC region, within the context of MBB industry, thus only spectrum bands allocated to terrestrial mobile and identified for IMT at the ITU level are considered. The purpose is to analyse the progress thus far in reforming spectrum management practice in the region. Broadband and MBB in SADC countries is widely regarded as an enabling infrastructure for socio-economic development, as a result, an injudicious management of this resource can adversely impact the society's prosperity. Advancement of MBB in the context of this study refers to accelerating diffusion of this technology and service, making it more pervasive and accessible to more users for more uses.

Secondly, this study critically analyses the effects of spectrum management reform on the MBB industry in SADC against the backdrop of high demand for more spectrum as the cornerstone for rapid diffusion of MBB. This research uses three SADC countries, namely, Botswana, Zambia and South Africa, representing the small, medium and large markets in the region as case studies to provide a detailed examination of this topic. The study essentially considers spectrum management reforms that have been undertaken in these countries over the last decade, between 2006 and 2016. Analysis of the data from these three country case studies will provide insights that may be relevant to many other countries in the region.

This research is justified by the somewhat slow progress in implementing flexible, market-driven and or technology-enabled spectrum management reforms which is perceived as a barrier to rapid diffusion of broadband and, by extension, socio-economic development. Traditional spectrum

management practices based on administrative methods tend to be slow and bureaucratic in nature, and yet, the bulk of MBB spectrum in SADC has been indeed licensed through this approach. At the same time, the rate of technological change has been unfolding at an increasingly rapid pace, widening the gap even further with spectrum management practices. Given the mounting pressure on relevant authorities to relinquish their spectrum management responsibility and assign it to technology and or the market, all in the name of spectrum management reform, this study examines these factors in the quest to answer the research questions below.

1.8 Research Questions

The main research question of this study is:

What is the effect of spectrum management reform in the SADC region on the evolution of MBB industry?

The following research sub-questions will be used to explore the main research question:

1. What is the current state of spectrum management reform for the MBB industry?
2. How is mobile frequency spectrum assigned or licensed and to whom?
3. How has spectrum management reform affected the MBB industry?

1.9 Research significance

This research uses the three SADC countries (Botswana, Zambia and South Africa) out of the fifteen, as a case study that broadly examines the state of affairs for MBB industry with regards to spectrum management reform. Only spectrum that has been allocated to terrestrial mobile and identified for IMT at the ITU level and that applies to Region 1 will be considered. This study enabled the researcher to draw lessons that may be relevant to other countries in the SADC region. In limited number of instances where lessons are not necessarily generalizable, the study has nevertheless provided an initial set of cases and analytical highlights for the SADC region.

1.10 Conclusion

This chapter set the scene for spectrum management reform in the SADC region by way of providing a global and a regional overview for this trend. A snapshot of telecommunications sector liberalisation in the three countries of study was presented with a view to contextualise of MBB evolution and spectrum management reform. Regional socio-economic development statistics have been contrasted with MBB industry indicators and one of the conclusions drawn is that countries with a low GDP per capita have a low mobile penetration rate generally, and even a lower MBB penetration, and vice versa. The increasing demand for MBB services increases the demand for more spectrum and more flexible ways to manage this resource. The problem statement outlined the context for the main research question and sub questions in this chapter. The next chapter provides a literature review of the main spectrum management models.

Chapter 2: Political economy of spectrum management reform

In order to advance knowledge and contextualise this research with the previous studies, a review of what has been published already on spectrum management reforms was conducted (Babbie & Mouton, 2005, p.565). This chapter reviews literature for spectrum management models currently employed in SADC, from administrative command and control to market-driven spectrum property rights and technology-enabled spectrum commons. The literature review was also done in order to enhance the theoretical and conceptual framework of the research (Kombo & Tromp, 2014, p.62). A critical analysis of the literature will advance the limited knowledge in this field of spectrum management in the SADC region.

2.1 Administrative spectrum management approaches

2.1.1 The chronic repurposing of spectrum to mobile by the ITU and its members

Policymakers and regulators in SADC, and other parts of the world, have up to now responded to the demands from the MBB industry for more radio spectrum by increasing its supply (Chapin & Lehr, 2011). Every three to four years, at the international level, the ITU World Radiocommunication Conference (WRC), repurposes and allocates spectrum to various services such as mobile, broadcasting, astronomy and so forth (El-Moghazi, Whalley & Irvine, 2013). As a result, governments around the world have come under pressure to transfer more spectrum to MBB or IMT as it is commonly known in ITU parlance. The WRC is the ITU structure that is mandated to revise Radio Regulations (RR), which is the international treaty governing the use of radio-frequencies and satellite orbital slots (ITU, 2015a, Article 13).

Because spectrum respects no political or geographic borders, it is necessary to coordinate the use of this natural resource across the globe. International coordination of spectrum is the role of the ITU RRs and it is binding on the ITU Member States. The ITU RRs contains the International Table of Frequency Allocations (ITFA) (ITU, 2016b, Article 5). The different National Table of Frequency Allocations (NTFAs) are based on the ITU-ITFA. An NTFA is a legal framework adopted by different administrations as the embodiment of the spectrum planning function. It contains the allocations of different spectrum bands to different services, and it is normally consistent but not equal to the ITU RRs. At the SADC level, the most recent SADC Frequency Allocation Plan (FAP) was adopted in 2016, shortly after the WRC-15 (SADC, 2016). The SADC FAP 2016 promotes the ITU goal of global spectrum harmonization (SADC, 2016, p.3). Respective NTFAs in the SADC Member States are generally consistent, as far as practically possible, with the SADC FAP but are not equal to it, just like the ITU RR. This means that the NTFAs are harmonized as far as practically possible with the ITFA but there will be deviations in some instances, within the framework allowed by the ITU RR. According to SADC (2016, p.4) these variations in the region can be due to legacy deployments in some countries and radio technologies harmonised to ITU Region 2 and 3 creeping into some markets in Region 1.

Additional allocation of spectrum to mobile and identification to IMT has been discussed at recent ITU WRCs, even when it was not on the initial conference agenda at times. For example, in an unprecedented move, WRC-12 resolved to allocate the 694–790 MHz band (700 MHz band) to mobile in ITU Region 1 on co-primary basis with broadcasting service, the incumbent service in this

band (ITU, 2012b, Resolution 232)[4]. This allocation was subject to coexistence studies being undertaken by the relevant ITU Study Groups during the 2012 to 2015 study period (El-Moghazi, Whalley & Irvine, 2012, p.12). Subsequently, the 700 MHz band allocation to mobile was finalised at WRC-15 after intense discussions, lobbying, bargaining and bartering. The fact that SADC as a region assented to this allocation very early on is demonstrated by the pronouncement of the intent to implement IMT in the 700 MHz band, way before the studies were concluded and final allocation done by WRC-15 (SADC, 2013, p.42).

2.1.2 Infrastructure-based competition and market oligopolies

As far as allocating more radio spectrum to MBB is concerned, Chapin and Lehr (2011) contend that there will be some degree of success however, it won't necessarily be sufficient to sustain the market oligopolies – the traditional business models and spectrum management practices will need to be reviewed considerably. The high demand for spectrum for MBB is also related to competition and structural issues of the industry, whereby in most markets in SADC there are usually three or four players offering MBB services, using exclusively licensed IMT spectrum. Extremes do exist in some countries within SADC such as in Tanzania where there are eight operators using the IMT spectrum and in Swaziland there has only been one until early 2017. Chapin and Lehr (2011) further postulate that infrastructure-based competition cannot be sustained by continuously responding to spectrum demand through adding more frequency bands to the available lot. Nevertheless, this continuous repurposing of spectrum to IMT is supported by the mobile industry because it costs less to add more spectrum to existing radio sites than to build new ones. The bone of contention however within the mobile industry is how this spectrum should be apportioned between the incumbent players and the new ones who are itching to enter the market.

El-Moghazi *et al.* (2008) have also pointed out that the artificial spectrum scarcity that exists is not necessarily a result of the unavailability of spectrum but is largely due to the inefficiency of spectrum management practices that have been employed up to now. The administrative approach, which might have been suitable in monopoly and oligopoly markets where one or few firms dominated, licensed spectrum on a first come first served basis. Access to radio spectrum has been sometimes used anti-competitively as an artificial barrier to entry against new market entrants and a barrier to growth against incumbents who are demanding access to even more of this resource (Wellenius & Neto, 2006, p.19). Some spectrum lies unutilized or under-utilized in time or space, while other spectrum bands might have been historically licensed to government agencies and the military who have limited, if any, opportunity cost to use this resource more efficiently (Durantini & Martino, 2013, p.87). Although the central administration of radio spectrum by government has focused more on providing technical efficiency by limiting interference, this approach has resulted in some technical, economic and social inefficiency for spectrum use (Wellenius & Neto, 2006, p.19). Thus the current spectrum management approach will not be sufficient to sustain the growth of MBB, and piecemeal improvements to the systems have been found wanting.

The two models that emerge as candidates for spectrum management reform are the market-driven spectrum property rights and the technology-enabled spectrum commons, with possibilities of hybrid models that combine different elements of these models (Bohlin *et al.,* 2007; Durantini & Martino, 2013; El-Moghazi *et al.,* 2008; Wellenius & Neto, 2006). It is worth noting that in the last few years the debate around spectrum management reform has been a permanent

[4] Resolution 232 was abrogated at WRC-15 following the conclusion of the matter as of 28 November 2015 (ITU, 2016b, Resolution 99).

feature of a number of ITU conference agendas, however with little or no tangible agreement or outcome. For instance, some of the topics that were hotly contested at WRC-12 included methods to enhance global spectrum management framework and the regulatory instruments required to introduce Cognitive Radio System (CRS) technologies (El-Moghazi *et al.,* 2013, p.10).

2.2 Market-driven spectrum property rights

The market-driven spectrum management approach is concerned with transferring the control and management of spectrum from government to competitive markets. Ronald Coase, an American Economics Nobel laureate, conceptualized spectrum property rights back in the fifties when he argued for more spectrum management functions to be placed in private hands (Coase, 1959, p.18). Coase's approach contrasted efficiency of market allocations against the inefficiency of government allocations. He highlighted the information asymmetry that exists between the market and the state with regards to the intrinsic value of spectrum, and the extent of benefit and cost provided by the market by using this resource. Government ways to establish the economic value of spectrum can be long and drawn out processes and the decision-making that has to follow is usually extensive. According to Faulhaber (2005), this approach conceptualised by Coase only gained some traction in 1989 when the first spectrum auction was conducted in New Zealand. The US regulator, FCC, conducted the country's first spectrum auction in 1994 and since then this approach has become the order of the day when assigning high-demand spectrum in most developed markets (Melody, 2001a, p.6). Wellenius and Neto (2006) argued that while technologies such as MBB have evolved and became more efficient in their use of spectrum, spectrum management by government administrations on the other hand has failed to keep up with the rate of technology development. The administrative spectrum management practices have resulted in artificial spectrum scarcity, which is creating a barrier to entry for new entrants, at the same time entrenches the incumbents. El-Moghazi *et al.* (2008) refer to this phenomenon where spectrum is available to a few players and unavailable to some as a "spectrum divide."

Various forms of spectrum property rights include secondary trading, leasing, altering the original spectrum license by for example spectrum pooling, and spectrum re-farming (Faulhaber, 2005). El-Moghazi *et al.* (2008) postulate that forms of secondary trading of spectrum can broadly be grouped into two categories. In the first category, spectrum changes hands between two licensees who essentially provide the same service. Depending on the country's spectrum policy and regulatory framework, these transactions may require the regulator's approval. An example of this type of spectrum trading is where an existing network operator is acquired together with its spectrum resources by another entity. In the second category of spectrum trading, spectrum remains under the control of the same licensee or entity, however, the licensee might, during the life of the license, decide to migrate from one service or technology to another. In this instance, the spectrum license does not espouse a particular service or technology and this concept is referred to as service or technology neutrality (El-Moghazi *et al.,* 2008, p.3).

2.2.1 Technology-neutral spectrum licenses and spectrum trading

Technology-neutrality is the most commonly practiced form of spectrum trading in the SADC region. Technology-neutral licenses allowed network operators to refarm spectrum that was initially assigned for GSM and use it to launch evolved MBB technologies such as HSPA and LTE (Calandro, 2011, p.6). Refarming not only facilitates a quick launch of newer broadband technologies with existing spectrum, but it also allows the operators to manage the delays and uncertainties associated with the issuing of new spectrum licenses. The propagation characteristics of lower

frequency bands such as 900MHz, which was initially used for GSM, have made it more attractive to refarm this band for HSPA, especially in rural and sparsely populated areas.

2.2.2 Mergers and acquisitions as a form of spectrum trading

Calandro (2011) argues that the demand for more infrastructure and more spectrum by the established incumbents invariably led to mergers and acquisitions in the industry. As a result, smaller operators have become the acquisition target of larger incumbents as the latter are after frequencies such as 2600 MHz which was traditionally used by wireless internet service providers (WISP) for technologies such as Wimax and now commonly used for LTE. At the end of the day, such a transaction may be regarded as secondary trading due to the change in ownership or licensing that takes place. The successful buyout of WBS and its spectrum resources by Multisource in South Africa in 2015 is an example of spectrum trading in the SADC region (Competition Commission of South Africa, 2015). At the time of the transaction, WBS had spectrum licenses for the much sought after 3GPP Band 3 (1800 MHz Band) and a TDD block of spectrum within Band 7 (2600 MHz).

Vodacom's attempt to acquire Neotel and its spectrum assets in South Africa, also an indirect spectrum acquisition, and secondary trading by extension, was vehemently opposed by competitors on the grounds that it would give Vodacom an unfair advantage as the latter will become richly endowed with the coveted MBB spectrum (Vodacom/Neotel merger, 2015). Vodacom's interest in Neotel was indeed influenced by the latter's spectrum resources, including 3GPP Band 5 (850 MHz band) and Band 3 (1800 MHz band). Vodacom launched a R7bn application with the regulatory authorities to buy Neotel and its assets, during May 2014, including spectrum. In its application to the Competition Commission, Vodacom submitted that this acquisition will greatly enhance its spectrum capacity (Vodacom/Neotel merger, 2015, p.16). This acquisition was approved, with conditions, by both ICASA and the Competition Commission (Vodacom/Neotel merger, 2015, p.9). The following year, in February 2016, due to pressure from competitors, mainly Cell C, MTN and Telkom, the North Gauteng High Court in Pretoria set aside ICASA's approval of Neotel takeover by Vodacom (Cell C & others v. ICASA, 2016).

2.2.3 The antipathy and the apprehension towards spectrum auctions

Proponents of market-driven approaches such as spectrum auctions cite increased transparency and economic efficiency – placing spectrum in the hands of those who are willing to pay the most for this resource, as motivation for this approach (Wellenius & Neto, 2006). However, new or late entrants may not necessarily be readily disposed or eager to compete for spectrum through market auctions; this is usually due to limited financial resources they may have at their disposal. Melody (2001a, p.3) laments the hoarding of spectrum by inefficient users in different radiocommunication services. Users with a stagnant demand for spectrum have been traditionally allocated excessive amounts of spectrum whilst those with a rapidly growing demand found it hard to justify any increase to the allocations they already have. This has resulted in what is termed "artificial spectrum scarcity." Blame is attributed to the administrative practice where spectrum has been licensed on a first-come first-served basis, sometimes to users or licensees who have had little or no economic appreciation of the value of this resource.

Infodev (2015) recommends spectrum auctions and spectrum trading as the most economically efficient ways of licensing spectrum in cases where demand outstrips supply. However, it must be borne in mind that the political economy of the initial 3G auctions in Europe was based on the extraction of maximum revenue from the limited number of incumbent and new operators who had been pre-qualified to bid for the spectrum (Melody, 2001a, p.9). The fact that the success of

most spectrum auctions has been determined by the amount of revenue collected can only confirm that these transactions have been used as a means of collecting maximum revenue for the government *fiscus*. It is true that the increase in economic value of the spectrum follows the increase in the demand for this resource and auctions can be the best licensing tool to reflect this. However, a risk lies in the way the auction is designed – for instance, market structure issues and competition concerns of the industry need to be carefully considered and balanced, and the implementation of policy objectives, such as developing the information society, must be spelled out clearly from the outset (Melody, 2001a, p.10).

The indecisive and failed attempts to auction the spectrum in the SADC countries, particularly Mozambique in 2013 and South Africa in 2011 and lately in 2016, bear testimony to the importance of paying due regard to the auction design principles and broader policy objectives (TeleGeography, 2013; ICASA, 2011a; ICASA, 2016b). In March 2013, the Mozambican regulator, *Instituto Nacional das Comunicações de Moçambique* (INCM), announced plans to auction five paired blocks of 5 MHz (2 x 5 MHz) in the 790 MHz to 862 MHz band with the reserve price of 30 million US dollar per concession. This turned out to be a dismal failure as there were no willing bidders and it became one of the text book cases of how not to perform spectrum auctions. Just a few months earlier, in December 2011, ICASA's attempt to license the 800 MHz and 2600 MHz combination through a "beauty contest" and an auction was scuppered by the then Department of Communications (DoC) in South Africa through a draft policy directive on the so-called high demand spectrum (RSA, 2011). ICASA had earlier announced plans to publish a draft Invitation to Apply (ITA), together with a spectrum assignment plan for these two bands. However, on 14 December 2011, DoC issued a draft spectrum policy directive which sought to provide a framework for the regulator to start the process of licensing spectrum. ICASA published its draft ITA and spectrum assignment plan literally on the following day, on 15 December 2011 (ICASA, 2011a). Both processes, ICASA's draft ITA and DoC's draft spectrum policy directive, were never concluded and the spectrum that ICASA intended to license remains idle up to this day. Zimri (2013) argues that one of the reasons for the delays in the licensing of MBB spectrum in South Africa is as a result of the contradictory views held by the regulator and the policymaker as to which institution between the two is the final arbiter on spectrum licensing.

2.3 Technology-enabled spectrum commons

Spectrum commons is generally used as a catch-all phrase to include concepts such as unlicensed spectrum, spectrum deregulation, or open wireless networks (Wellenius & Neto, 2006, p.22), license-exempt spectrum and dynamic spectrum access (ICASA, 2015a). At the core of this technology-enabled model is a commons approach which makes spectrum available to any user that complies with established technical standards to limit possible interference. Spectrum property rights and spectrum administration provides users or licensees with exclusive use, whereas the commons approach encourages spectrum sharing among all users, with no guarantees for interference-free operation. However, various techniques limit interference, these include capping the transmitted power and range or employing built-in protocols (Faulhaber, 2006, p.262). Another contrast is that spectrum commons is premised on innovative dynamic use, commonly referred to as dynamic spectrum access or DSA (Durantini & Martino, 2013). At the same time, new concepts and technologies that promise increased efficiency of spectrum management are emerging. Some of these technologies include cognitive radio systems (CRS), software defined radios (SDR), and concepts such as TV white spaces (TVWS) and dynamic spectrum access (DSA). New spectrum

commons concepts already being trialled in the MBB industry include Licensed Assisted Access (LAA), LTE Unlicensed (LTE-U), Licensed Shared Access (LSA) or Authorised Shared Access (ASA).

2.3.1 An attempt to introduce technology-enabled reforms through the ITU

Yoshino (2012) examined the ITU standardisation activities and studies on CRS and SDR. The genesis of ITU studies on these technologies is traced back to WRC-07 where a resolution was passed to consider regulatory measures required to facilitate the introduction of CRS and SDR. Yoshino goes to great lengths to unpack the relevant ITU and ITU-R structures in the context of initiatives that have been undertaken thus far to enhance spectrum management broadly. The tedious and lengthy WRC processes and the relevant instruments of the ITU-R are brought to bear to reflect on the current spectrum regulatory regime, what it would take to introduce any modifications thereto and the impact thereof on IMT or MBB spectrum. As per WRC custom, an agenda of the next conference is decided by the preceding one. An agenda item to consider the regulatory impact of introducing CRS and SDR at WRC-12 was adopted as Resolution 956 (WRC-07). The original proposal was for a consideration of spectrum requirements and a global allocation to support CRS and SDR (Yoshino, 2012, p.1037). However, the final resolution became a consideration of whether there is a requirement to update global regulatory framework to facilitate the introduction of CRS and SDR. During the 2007-2012 study period ITU-R Working Party 1B developed definitions for these concepts as follows:

> Cognitive radio system (CRS): A radio system employing technology that allows the system to obtain knowledge of its operational and geographical environment, established policies and its internal state; to dynamically and autonomously adjust its operational parameters and protocols according to its obtained knowledge in order to achieve predefined objectives; and to learn from the results obtained (ITU-R, 2009, p.3).
>
> Software-defined radio (SDR): A radio transmitter and/or receiver employing a technology that allows the RF operating parameters including, but not limited to, frequency range, modulation type, or output power to be set or altered by software, excluding changes to operating parameters which occur during the normal pre-installed and predetermined operation of a radio according to a system specification or standard (ITU-R, 2009, p.3).

Therefore, as far as the ITU-R is concerned, CRS and SDR are both not radiocommunication services but technologies that may be employed by any radiocommunication service to enhance its use of the spectrum. Since radio spectrum is only allocated to a radiocommunication service or a radio astronomy service, the ITU-R concluded that no spectrum would be allocated to CRS and SDR (El-Moghazi *et al.,* 2013; Yoshino, 2012). However, the ITU-R agreed that CRS and SDR may be used by any radiocommunication service, on conditions the provisions of the ITU RRs are followed (ITU-R, 2011). This report by the ITU-R opened the door for radiocommunication services such as land mobile to make use of CRS and SDR technologies. Although this report specifically excludes IMT systems, it is however relevant to this study insofar as DSA proponents seek to annex IMT spectrum that happens to be temporally or spatially idle.

2.3.2 Dynamic and opportunistic spectrum sharing in SADC

ICASA (2015a) published a discussion document on dynamic and opportunistic spectrum use, seeking comments from industry and interested stakeholders on opening the 470-694 MHz broadcasting band for broadband on secondary user basis. The regulator argued that it would be in the interest of MBB industry to open the 700 MHz and 800 MHz band to dynamic spectrum sharing

as this would conveniently shorten the long delay of waiting for digital migration to be completed (ICASA, 2015a, p.7). However, this proposal to circumvent the analogue to digital migration process was made despite conflicting with the IMT roadmap published that year by the same regulator (ICASA, 2015b). The ICASA IMT roadmap not only announced harmonised channel or band plans for current and planned MBB used in South Africa, but it also declared the availability dates for both the first digital dividend (790-862 MHz) and the second digital dividend (694-790 MHz). The discussion document undermined the regulatory certainty of the IMT Roadmap. Interestingly, in one of the survey questions in the discussion document, ICASA enquired whether dynamic and opportunistic spectrum sharing should be applied to other bands besides the broadcasting band (ICASA, 2015a, q.70). The MBB industry interpreted this initiative as a stealth and ingenious encroach on IMT spectrum that might temporally or spatially lie idle. The ITU-R definition for TVWS is worth noting in this regard:

> TV white space (TVWS): A portion of spectrum in a band allocated to the broadcasting service and used for television broadcasting that is identified by an administration as available for wireless communication at a given time in a given geographical area on a non-interfering and non-protected basis with regard to other services with a higher priority on a national basis (ITU-R, 2011, p.3).

In other words, according to the ITU-R, TVWS is neither a radiocommunication service nor a technology, but it is a portion of the spectrum allocated to broadcasting service that is made available to broadband or wireless communication on secondary basis in time or space. Any radiocommunication service using this spectrum cannot claim protection nor can it cause interference to the incumbent service in this band, hence the interference mitigation techniques such as a geo-location database have become the norm.

Meanwhile in SADC, countries such as South Africa, Botswana and others, TVWS pilots have been conducted by the likes of Google and Microsoft. The South Africa TVWS pilots, supported by the Council for Scientific and Industrial Research (CSIR), were conducted in Cape Town and Limpopo by Google and Microsoft respectively (Masonta, Lysko & Mekuria, 2015). The South African trials have been used to provide broadband internet access to schools in the surrounding areas of the transmitter and at the same time demonstrate coexistence with TV broadcasters without causing interference. The Botswana TVWS initiative, supported by the Botswana Innovation Hub, has been led by Microsoft and partners (BOCRA, 2016a). It was named “Project Kgolagano” and it has been used to improve broadband connectivity to healthcare facilities in regions that are poorly connected. CSIR is also collaborating with the Botswana Institute for Technology Research and Innovation (BITRI) on a TVWS trial to expand the research on dynamic spectrum access (CSIR, 2016). Similar to the Cape Town and Limpopo cases, the TVWS pilot in Gaborone will be used to provide broadband internet in nearby schools for the purposes of e-learning. In some instances, these pilots have been positioned as a game-changer for broadband connectivity, to put pressure on MBB industry and lower the barriers to entry. However, the business model for TVWS commercial deployment remains to be seen. Although the NRA in South Africa was intricately involved with TVWS trials, the same cannot be said about Botswana and Zambia regulators, their involvement only goes as far as authorising the trials to be conducted.

2.3.3 Mobile broadband industry makes overtures to spectrum sharing

Prytz and Wallstedt (2013, p.5) argue that there are essentially three ways to address the demand for more capacity in MBB networks. The first option is repurposing spectrum from other radiocommunication services to mobile, as has been repeatedly done at WRCs. The second is

improving the spectral efficiency of MBB technology through techniques such as enhanced modulation schemes (64QAM, 128QAM, etc.), employing smart antenna systems with multiple-input-multiple-output (MIMO) capabilities and aggregating different spectrum bands to form single virtually expanded carriers. These techniques allow MBB to be more spectrally efficient. Thirdly, is intensifying the existing networks by building more radio sites for MBB. Prytz and Wallstedt (2013) further argue that the industry is doing its fair share on the last two approaches, however, the first intervention of allocating additional spectrum to mobile is the prerogative of national governments through the ITU processes. However, these processes are lengthy by nature and fraught with extensive delays and disputes. The MBB industry is now beginning to make overtures to spectrum sharing as a complement to meeting the demand for more radio spectrum. LTE-U and LAA are some of the new and innovative concepts used by the MBB industry to exploit unlicensed spectrum with an objective to enhance the user experience. Both LTE-U and LAA are variants of LTE operating in unlicensed bands (Labib, Marojevic, Reed & Zaghloul, 2017). These technologies employ the services of carrier aggregation (CA) to add a secondary channel of unlicensed spectrum from the 5 GHz band over the licensed IMT spectrum and thus create a virtually wider carrier that delivers best effort MBB quality of service data (QoS). LTE-U uses existing features of 3GPP Releases 10/11/12 and adapts them to unlicensed operation in an effort to share spectrum and provide wider bandwidths. On the other hand, LAA has been standardised in 3GPP Release 13 with the same objective of exploiting the unlicensed 5 GHz band (Labib *et al.*, 2017, p.4). Both variants demonstrates overtures by the MBB industry to share spectrum, albeit unlicensed spectrum. Meanwhile, operators such as Vodacom and MTN have conducted trials in the region as part of the proof of concept process.

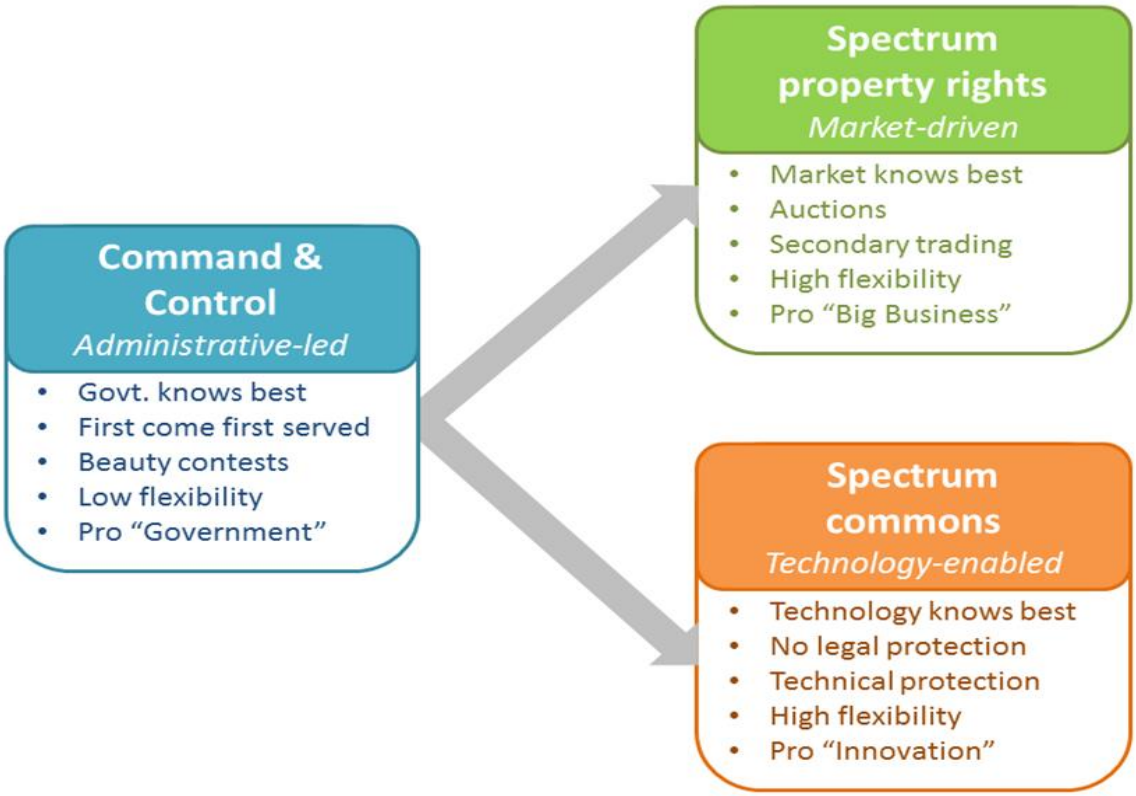
2.4 Conceptual and theoretical framework

The conceptual framework depicted in Figure 2 below emanates from the literature that has been reviewed. This framework is an adaptation of options for spectrum reform from Bohlin *et al.* (2007) and it acknowledges the government-led administrative command and control model as the primary model for spectrum management. Market-driven spectrum property rights and technology-enabled spectrum commons are introduced as spectrum management reform options that seek to enhance the efficiency of how this resource is utilised. The foundation for the traditional spectrum management model of command and control has been to minimize or manage interference. This model assumes that the government through the regulator will possess sufficient knowledge to make the decisions on behalf of spectrum users and uses. Under this model, licenses are normally granted to one or more users for specific services and or technologies, using: first-come-first-served, beauty contest, sometimes auctions or a combination of these methods as a means to arbitrate decisions.

The bulk of spectrum for MBB in SADC has been assigned through administrative mechanisms. However, technology evolution and market demands are putting pressure on governments to consider new alternative models and methods. Spectrum property rights and spectrum commons emerge as new alternatives purported to be more efficient and offering a higher degree of flexibility. Decision-making is left to the technology and or the market, whilst these methods respectively use algorithms to avoid interference or maximize the economic value of spectrum by apportioning rights to the highest bidder. The market-driven spectrum property rights model assumes the market knows best, while it guarantees users exclusive use to assigned spectrum. On the other hand, the technology-enabled spectrum commons regards technology as the arbiter in determining and regulating use and users of spectrum.

This study applies Information Economics theory in the analysis of certain actions and non-actions by the MBB industry in its "scramble for spectrum." Stiglitz (2002) highlights the information asymmetry (IA) that exists between government and markets and between markets themselves. As government gets disintermediated by the market and or technology in the provision of spectrum as a public good or in its intervention in the provision of this good, the IA widens to the detriment of the state. The study would argue that the systematic IA created by reformed market structures is not a result of accidental evolution but it is a deliberate creature of policy as postulated by Stiglitz (2013). At the same time, firms (MNOs) attempt to increase this IA in the quest to weaken competition and entrench themselves in the (MBB) market (Stiglitz, 2002, p.470).

Figure 2: Conceptual framework - major spectrum management models



Source: Adapted from Bohlin *et al.,* 2007

2.5 Conclusion

This chapter provided a critical review of different spectrum management models and related reforms that are currently underway in SADC, from administrative command and control to market-driven spectrum property rights and technology-enabled spectrum commons, all in the context of MBB. The review focused on the models and reforms that have been applied particularly in the SADC region. The conceptual framework at the end of the literature review connects the different concepts and lays the foundation for the research design applied in this research, namely the case study, which will illuminate the reasons behind certain actions and non-actions in spectrum management reform in SADC. The next chapter outlines the research design and methodology employed to answer the research question.

Chapter 3: Qualitative case study and research methodology

This chapter outlines the research design that was employed in this study, including the methodology that flows from the research questions, the data collection and data analysis methods. A survey or an archival analysis would have been an adequate research strategy if the purpose of this study was merely to determine which radio frequency spectrum is assigned to which entity in which country. In contrast, this study uses the three countries to examine not only who has been assigned what spectrum but also what process was followed to assign that spectrum and how spectrum management reforms have been implemented in SADC and the impact thereof on the MBB industry; hence a case study research methodology has been more appropriate. A case study can be defined as a thick description and analysis of a selected focus of study (Merriam, 2010). According to Schramm (1971) as cited in Yin (1994):

> The essence of a case study, the central tendency among all types of case study, is that it tries to illuminate a decision or a set of decisions: why they were taken, how they were implemented, and with what result.

The main research question is:

What is the effect of spectrum management reform in the SADC region on the evolution of mobile broadband markets?

The following research sub-questions will be used to explore the main research question:

1. What is the current state of spectrum reform for the mobile broadband industry?
2. How is mobile frequency spectrum assigned or licensed and to whom?
3. How has spectrum management reform affected the mobile broadband market?

3.1 The value of qualitative research methodology for understanding spectrum regulatory reform

The objective of this research is not a quantitative study about how much MBB spectrum is licensed and to whom. This study takes a qualitative view of how this resource was licensed over time, the amendments to the license conditions and the factors that have both caused and resulted from reforms to spectrum management frameworks. The constructivist research paradigm assisted the researcher to develop meaning and expand knowledge and understanding of the what, how and why questions of this study. A qualitative analytical case study from three Anglophone SADC countries, broadly representing the small, medium and large countries respectively, was conducted to investigate the why and how of decision making in spectrum management reforms in this region. The study countries, Botswana, Zambia and South Africa (see Table 5) have also been selected specifically due to the relative ease of sourcing information in these countries, and the similarities in culture and same *lingua franca* among them.

Although South Africa has been at the forefront of spectrum management reforms in the SADC region during the mid-2000s – with the passing of a technology-neutral licensing framework (RSA, 2005), and the subsequent conversion of technology-specific spectrum licenses by ICASA – there has not been much progress in awarding new spectrum licenses to new IMT bands in order to keep pace with the evolution of MBB technologies and services. Network operators in SADC have generally been able to roll-out LTE, and expand HSPA coverage, using re-farmed spectrum, thanks to technology neutral spectrum licenses. Meanwhile, new MBB technology concepts such as LTE-U and

LAA are enabling the mobile industry to exploit license-exempt or ISM spectrum, spectrum that was previously a *de facto* protectorate of technologies such as Wi-Fi.

Table 5: SADC countries grouped per size of the consumer market

Small market Population < 5 million		Medium-size market Population 5-50 million		Large market Population > 50 million	
Country	Subscriptions (million)	Country	Subscriptions (million)	Country	Subscriptions (million)
Botswana*	3.6	Angola	18.4	Congo D.R.	46.5
Lesotho	1.8	Madagascar	7.5	South Africa*	82.7
Mauritius	1.7	Malawi	6.3	Tanzania	34.5
Namibia	2.8	Mozambique	16.7		
Seychelles	0.14	Zambia*	12.1		
Swaziland	0.9	Zimbabwe	15.9		

Source: Author's calculations

* Case study countries

3.1.1 Small market – Botswana

For the purposes of this study, Botswana represents small market category with its estimated 3.6 million mobile subscriptions (see Table 5). Although mobile penetration is well above 100% according to GSMA (2016), the unique mobile penetration is just over 73 percent and MBB penetration is a modest 21 percent. Botswana NRA, BOCRA, is a converged ICT sector regulator and is responsible for radio spectrum management (RBW, 2012). The mobile market is split between three national operators, namely, BTC, Mascom and Orange. All three operators have rolled out HSPA using new spectrum in 2100 MHz band and re-farmed spectrum in 900 MHz band. Only Mascom and Orange have switched on LTE using re-farmed 1800 MHz spectrum. In March 2015, Botswana Innovation Hub (BIH) launched a TV white spaces (TVWS) pilot project in Botswana to test the feasibility of delivering broadband using DSA (BOCRA, 2016a).

3.1.2 Medium market – Zambia

Zambia fits in the medium market category with its 12.2 million estimated mobile subscriptions (please see Table 5). The mobile penetration is at 73 percent and unique mobile penetration is a modest 40 percent, and MBB penetration is at a low 7.5 percent. The Zambia NRA, ZICTA, is responsible for regulating the ICT sector and managing the use of scarce resources such as frequency spectrum (RZM, 2009). MBB in Zambia is offered by Airtel, MTN and Zamtel, while a number of fixed WISPs offer data and internet services over technologies such as WiMAX. All mobile operators have launched HSPA, whilst MTN and Zamtel have also launched LTE, using re-farmed spectrum in 1800 MHz band. There are currently no reported or publicised DSA or TVWS initiatives in Zambia.

3.1.3 Large market – South Africa

For the purposes of this study, the 82.7 million estimated mobile subscriptions put South Africa in the large market category (please see Table 5). South African mobile industry indicators are somewhat similar to Botswana's statistics with mobile penetration, exceeding 100 percent and almost 70 percent unique mobile penetration but a lower than expected 33 percent MBB penetration. The NRA in South Africa, ICASA, regulates communications and broadcasting, and is mandated by law to manage the radio frequency spectrum (RSA, 2000). Cell C, MTN, Telkom and Vodacom are converged licensed operators offering MBB in the country (GSMA, 2016), whilst Neotel and WBS offer fixed wireless broadband service. A number of fixed wireless internet service providers (WISPs) offer some fixed broadband services over license-exempt or ISM spectrum. The four MNOs have all launched HSPA using new spectrum (2100 MHz) and some have re-farmed spectrum for HSPA in the 900 MHz band. South African MNOs have also launched LTE in re-farmed spectrum using either 1800 MHz or 2100 Mhz. Google and Microsoft have conducted trials, in Cape Town and Limpopo respectively, for DSA in the broadcasting bands. Meanwhile, the regulatory authority, ICASA, also initiated a consultation process to evaluate the feasibility of dynamic and opportunistic use of spectrum (ICASA, 2015a).

3.2 Case study research design

Merriam (2010) argues that the unit of analysis or a bounded system, which in this case is the MBB industry in the selected countries, defines a case study. A case study as a form of qualitative research approach is preferred when the contemporary phenomenon being studied is beyond the control of the researcher and it needs to be considered against the backdrop of a real-life phenomenon (Yin, 1994). The impact of spectrum management reforms on the MBB industry in SADC was studied against the backdrop of high demand for spectrum driven by insatiable data consumption. This case study examined spectrum management reforms that have been undertaken in SADC over a decade between 2006 and 2016.

The qualitative case study provided a combination of statistical and qualitative data to produce a description and analysis of factors that have both caused and resulted from certain events. However, the methodology did not include any statistical analysis. Spectrum management reforms driven by the property rights doctrine have been introduced to varying degrees in various countries in SADC in the form of technology and service neutral spectrum licenses, spectrum re-farming, secondary trading and auctions. Spectrum commons approach is also being advocated in the form TVWS trials, LTE-U, LAA, etc. Proponents for spectrum commons school of thought asserts that more radio spectrum should be granted license-exempt status, and dynamic and opportunistic use of spectrum should be the order of the day. However, the MBB industry seems to be taking a cautious approach to spectrum commons, lest it becomes compelled to share licensed IMT spectrum with unlicensed players. In an attempt to discourage spectrum hoarding and promote efficient spectrum utilisation, policymakers and regulators have also considered policies such as "use it or lose it" and innovative pricing schemes such AIP. To understand these reforms and their effects, the case study methodology offers deep insights into the practices occurring in spectrum reform and the reasons why regulators chose particular paths.

3.3 Qualitative data collection

One of the most distinctive features of qualitative research is its endeavour to observe the phenomenon from the perspective of the actors (Babbie & Mouton, 2005, p.271). The reasons for

certain actions or non-actions related to spectrum management reform were clarified through open-ended semi-structured interview questions. Individuals tasked with radio spectrum engineering and management in these organizations were the primary interview participants (please refer to Table 6). Data was collected from NRAs in the three countries of study, a policymaker in South Africa, a global network equipment manufacturer (NEM) doing business across SADC, a South African science research institution with multilateral links to Botswana counterparts, three MNOs with presence and experience in multiple countries across SADC, and lastly, a regional regulatory body.

3.3.1 Ethical considerations in data collection

The researcher's right to search for the truth cannot trump over individual's rights to privacy and participation must be voluntary (Babbie & Mouton, 2005, p.331). Therefore, the researcher needs to perform a balancing act between the rights and interests of different parties. Since this research study involved collecting data from human participants, the researcher sourced ethical clearance from the academic institution before embarking on the primary data collection. Approval was granted by the institution's ethics committee, annexed hereto (Annexure E). During the data collection process, prospective interview participants were informed about the purpose, content, objectives and potential benefits of the study (Kombo & Tromp, 2014, p.102). The participants were also made aware of the fact that the content of their responses may be reported anonymously in the study's published outputs. Anonymity and confidentiality was highlighted from the onset and participants were informed of their right to decline to participate and even withdraw at any stage during the interview. The individuals who participated in this study have all signed the Informed Consent Form and were given the Participant Information Sheet which they were allowed to read before proceeding with the interview.

3.3.2 Primary data collection – semi-structured interviews

Primary data was collected using semi-structured interviews where an interview guide based questions were employed to elucidate the contours which the participants ascribe to various phenomena. One-on-one interviews were conducted with a variety of officials in the policymakers, regulators, network equipment manufacturer and mobile network operators. Babbie and Mouton (2005, p.282) emphasizes the importance of using multiple sources of data in case studies, such as a variety of informants providing multiple perspectives; this increases the confidence in the findings. Due to the polarising potential of the spectrum management reform topic and the possibility to digress during interviews, an interview guide was used to steer the semi-structured interviews and minimise any digressions from the main question. Basic interview questions with different emphases for different organizations or institutions, such as government administrations or regulators, industry and research organisation or network operators were used in the interview. At the same time, the probing questions were used throughout the interviews, based on the initial responses.

Table 6: List of participants

Naming convention	Interview participant
MNOSA1	Mobile-broadband Network Operator – number 1
MNOSA2	Mobile-broadband Network Operator – number 2
MNOSA3	Mobile-broadband Network Operator – number 3

GNEM1	Global Network Equipment Manufacturer - number 1
PMSA1	Policy Maker South Africa – number 1
SRISA1	Science Research Institution South Africa – number 1
SRBW1	Sector Regulator Botswana – number 1
SRRB1	SADC Regional Regulatory Body – number 1
SRSA1	Sector Regulator South Africa – number 1
SRZM1	Sector Regulator Zambia – number 1

3.3.3 Secondary data collection

Secondary data was collected from spectrum management instruments such as policies, legislation and regulations in the three countries of study, as well as spectrum policies at a regional level at SADC. These spectrum management instruments formed the secondary data composite. Other forms of secondary data that were considered include regulatory guidelines and codes of practice that govern radio spectrum or have an impact on it. The researcher conducted a preliminary review of the following documents, in the respective countries and at a regional level, to determine the extent of spectrum management reforms in SADC:

Botswana:

- Botswana Communications Regulatory Authority Act, No 19 of 2012
- A new policy for spectrum licensing and spectrum pricing in Botswana (2007)
- Service-neutral licensing framework in the era of convergence (2007)
- Draft national broadband strategy of 2014

SADC:

- SADC Regional Infrastructure Development Master Plan of 2012
- SADC Frequency Allocation Plan of 2013
- SADC Frequency Allocation Plan of 2016

South Africa:

- South African Electronic Communications Act, No 36 of 2005
- Radio frequency Spectrum Policy for South Africa of 2010
- South Africa Connect, South Africa's Broadband Policy of 2013

Zambia:

- Zambia Information and Communications Technologies Act, No 5 of 2009
- National ICT Policy of Zambia (2006)
- Zambia Telecommunications Licensing Guidelines (2010)

Spectrum management regulations that flow from these legal instruments were subsequently reviewed in the detailed analysis that succeeded data collection, please see Section 4.2 for a detailed list. In the selection criteria of identifying the preliminary documents, the researcher sought to review the main piece/s of legislation governing the sector in each country, a national and regional spectrum policy and a broadband or ICT policy, where the former is not present. The preliminary

review of these documents assisted the researcher to prepare for the primary data collection through interviews.

3.4 Qualitative data analysis

The data analysis strategy should be decided before commencing with the data collection process because the method of analysis is a function of how that data has been recorded and organised during the collection process (Kombo & Tromp, 2014, p.118). Data analysis involves making sense of the collected data and extracting meaning thereof, "making deductions and inferences," according to Kombo and Tromp (2014). Merriam (2010) recommends an iterative data analysis process that is done simultaneously with data collection. This approach enables the researcher to continuously improve the data collection tactics and strengthen the research findings.

3.4.1 Data organisation and coding

Before proceeding with the analysis, the collected data was processed by generating transcripts from each interview recording. The processed data was subsequently grouped mainly into two clusters of industry and government institutions. The industry cluster included all MNOs and NEM interviewed while the government institutions cluster was composed of the three NRAs from the relevant countries, the South African policymaker, SADC regional regulatory body and the science research institute involved in spectrum management research. The transcripts were imported into computer aided qualitative data analysis software (CAQDAS) where data was first coded before being analysed. Data coding involved identifying and labelling sections or portions of text that relate to research questions using code words. Saldaña (2009) defines coding as a transition between data collection and analysis. This process involved several iterations of sifting through data to find what is most relevant and what cogently responds to the research questions. Coding thus enables the researcher to search for relevance in data and conceptualise underlying patterns, "it is not just labelling, it is linking" (Saldaña, 2009, p.8).

3.4.2 Thematic analysis

Codified data was analysed thematically by grouping major issues that came up during preliminary analysis into categories as proposed by Kombo and Tromp (2014). Thereafter, relationships between categories were identified and themes were developed based on the coded data (Saldaña, 2009, p.11). Coding was also applied to secondary data that included spectrum management instruments such as policies, legislation and regulations in the relevant countries. During the iterative process of analysis, some codes were dropped by the researcher and some were assimilated by other codes whilst some morphed into new codes completely as Saldaña (2009) posits. In analysing the themes, the researcher also applied the conceptual framework presented in the literature review chapter to search for relevance in the data and to conceptualise underlying patterns with the objective of advancing knowledge.

3.5 Limitations of the research

This study sought to encapsulate a broad perspective from the market in the three countries selected for the study, the researcher endeavoured to solicit views from relevant stakeholders in these markets. However, two MNOs selected from Botswana snubbed email, telephonic and social media (LinkedIn) requests to participate in the study, whilst two MNOs from Zambia agreed in writing to be interviewed but later failed to participate. It was left to three South African based MNOs operating in multiple countries across SADC and involved in regional and international

spectrum management activities to enrich the study with their broad perspectives of the market. All NRAs in the three countries participated in the study and provided useful data; however, in the case of Botswana some of the requested data was classified by the regulator as confidential and thus could not be shared with the researcher. As a result, the researcher resorted to secondary data to answer some of the study questions about Botswana market.

3.6 Conclusion

This chapter highlighted the methodology applied in this study, which includes the research design, the selection of the representative countries for three market categories, the research instruments together with data collection and analysis techniques. The case study research design deepened the understanding of challenges and opportunities faced by the MBB industry with regards to spectrum management reforms in SADC. It has also enhanced the understanding of the effects of these reforms beyond the mere rhetoric. As pointed out by Yin (2003), the case study approach assisted in covering the contextual conditions, such as the growing data traffic, increasing demand for spectrum and occasional apprehension to reforms, as these are relevant to this research. Three themes that emerged during the thematic analysis are discussed in detail in Chapter 5 where the main research question is answered. Chapter 4 presents the research findings, grouped according to clusters of small, medium and large markets as per the three countries utilised in the case study.

Chapter 4: Review of SADC spectrum management frameworks

4.1 Introduction and background

This chapter presents the findings of a qualitative data analysis that was conducted in the SADC case study comprising of three sample countries, namely, Botswana, South Africa and Zambia. Multiple sources of evidence were used as a data collection tactic that sought to increase construct validity (Yin, 1994, p.34). Data was sourced from published documents such as policies, legislation, regulations and directly from individuals tasked with spectrum management in the different organisations from public and private sector. Hancock and Algozzine (2006) postulates that a combination of information from various documents, interviews and observations provides a useful source of data that must be used for analysis. For the purpose of this study, the focus will be on the legislative instruments concerned with spectrum management in the respective countries – the level of detail and sophistication of these instruments varies across the countries.

At a regional level, unlike in economic regions such as the European Union (EU) where numerous policies outline a common regional approach to coordinate spectrum management and reform of the practice, SADC lacks a regional framework to inform these processes in the various Member States. The SADC Frequency Allocation Plans (FAPs), updated after every WRC, characterises a regional attempt to outline a spectrum harmonisation framework that essentially speaks to regional allocation of this finite resource. This plan commands neither the legislative nor the regulatory powers and is only enforced by goodwill of Member States. SADC Member States do endeavour to harmonise their respective national FAPs with this regional blueprint. The SADC FAP 2016 can simply be regarded as a persuasive guideline as it only implores Member States to implement it "as far as is practically possible" (SADC, 2016, p.3). Spectrum management reform responsibility thus becomes a respective country's competence (SRRB1).

4.2 Overview of Member States' spectrum management frameworks

The three main spectrum management models outlined in the conceptual framework in Section 2.4 are the administrative command and control, the market-driven property rights, and the technology-enabled spectrum commons. Spectrum management in SADC countries is generally a national competence, usually split between the policymaker and the NRA. The policymaker is typically responsible for allocation, deciding on what services shall use a particular band of spectrum, and the regulator is responsible for assignment, authorising various users in different portions of assorted bands and pricing the spectrum. In some cases, similar to Botswana, the NRA is endowed with both functions of spectrum allocation and assignment, including international coordination. Notably, most allocations in the spectrum band in SADC predate the establishment of NRAs to the era when spectrum management was done by the Posts and Telegraph Offices (PTO's).

4.2.1 Botswana spectrum licensing framework

The Communications Regulatory Authority (CRA) Act of 2012 repealed the Telecommunications Act of 1996 (RBW, 2012, s.95). The new legislation effectively transferred the regulatory mandate of Botswana Telecommunications Authority (BTA) to the new regulatory authority, BOCRA. Section 47 of the CRA Act of 2012, dealing with spectrum management, is almost a replica of section 43 of the Telecommunications Act of 1996, with only a few exceptions where some words have either been altered or omitted. BOCRA is mandated by law to manage spectrum in Botswana and ensure that the needs of current and future radio services are adequately served

(RBW, 2012, s.47). Thus the needs of the ever evolving MBB technology and constantly increasing spectrum demands of the industry are thus catered for within this broader mandate of the regulator. BOCRA's mandate is indeed relatively more comprehensive than most of its counterparts, however, the Minister is still endowed with legislative powers over the NRA in a sense that the Board and CEO of the Authority are all appointed by the Minister, and spectrum licenses issued by the Board are subject to Minister's approval (RBW, 2012, s.46). This oversight prerogative puts the Minister squarely at the core of reforms which the regulator might wish to undertake. The following sub-sections examine the legislation, policies and regulations with significant pronouncements on spectrum management reform for MBB in Botswana.

4.2.1.1 Botswana legislation dealing with spectrum

The Telecommunications Act of 1996 was a bit thin on spectrum management content and since it was drafted during the early stages of sector liberalisation, before spectrum management reforms era, this study does not pay much attention to this piece of legislation. The CRA endows BOCRA with the powers to allocate spectrum to various services, including mobile, to license spectrum to different users and also to represent the country in international fora (RBW, 2012, s.12). While there is no explicit mention of technology and service neutrality or dynamic spectrum assignment (DSA) in the Botswana legislation, other instruments such as regulatory strategy documents and directives deal with this matter in some relative detail (BTA, 2007b). Technology and service neutrality provide for a predicate for market-driven reforms such as spectrum re-farming to new technologies, while DSA lays the foundation for opportunistic spectrum sharing. Section 6(2)(*x*) of CRA Act enjoins BOCRA to "promote and facilitate convergence of technologies" and section 47(d) mandates the authority to follow international regulatory frameworks in issuing standards governing the use of spectrum. Therefore, noting the international hysteria around practices such as dynamic spectrum and considering the technological benefits of spectrum management reform and the general silence of the legislation on this topic, it can be concluded that the Botswana NRA is mandated to undertake spectrum management reforms.

4.2.1.2 Botswana government policies related to spectrum

General reforms in the telecommunications market in Botswana were introduced by the Minister of Communications Science and Technology in 2006 through a policy directive (BTA, 2007a). This policy directive mandated the regulator to migrate telecoms licensees to a service and technology neutral licensing framework. A technology neutral framework allowed operators to utilise licensed spectrum as they see fit, as long as they don't cause undue interference to other users of spectrum. BOCRA's predecessor, BTA, published the spectrum licensing and pricing strategy in 2007 proposing further reforms to spectrum management in Botswana (BTA, 2007b). SRBW1 highlighted that this was part of the new set of spectrum management strategy documents that dealt with planning, allocation, assignment and pricing of this natural resource. This document compiled by external consultants, Teleplan AS of Norway and ICT Consultants of Botswana, contracted to assist the NRA with the review process, makes recommendations on spectrum management reforms that needed to be considered. SRBW1 maintained during interviews that this document actually served as a guiding framework and a cornerstone for BOCRA's reform initiatives. A number of market-driven and technology-enabled reforms necessitated by liberalisation of the sector were proposed in the document. For example, this strategy document recommended that the NRA should limit the administrative spectrum management practices and instead increase the market-driven and technology-enabled reforms by widening exclusive use and the commons model

simultaneously. However, very few of those market-driven reforms have actually been implemented by BOCRA. Economic efficiency was elevated above technical and spectral efficiencies as the main objective for spectrum management. While acknowledging the lag between technology and regulation, the proposed reforms represented an attempt to institutionalise flexibility on the regulator's side and usher in market-driven mechanisms such as auctions and trading, and at the same time introduce technology-enabled reforms in spectrum commons such as DSA (BTA, 2007b, p.8).

The draft national broadband strategy (NBS) of 2014 identifies spectrum as one of the key strategic areas that are necessary to improve broadband penetration in the country (RBW, 2014, p.9). This draft document makes broad suggestions about reviewing the current spectrum licensing framework and offers little or no detail on the exact implementation measures. Furthermore, the draft NBS calls for the licensing of the available spectrum for MBB to operators with some social obligations attached to these licenses. The digital dividend or 800 MHz band is acclaimed as a suitable spectrum to close coverage gap in rural and sparsely populated areas, and access to this spectrum will be subject to compliance to imposed obligations (RBW, 2014, p.40). However, there is still no sign of urgency from the NRA to license this spectrum to MBB in Botswana, notwithstanding the fact that digital migration has been completed and this spectrum is supposedly vacant. Technology-neutrality which is already implemented in the current licensing framework is further highlighted in the draft NBS, whilst calls are made for spectrum to be reserved for fixed wireless access (FWA) operations also (RBW, 2014, p.53). FWA technologies such as Wimax and most proprietary solutions utilise IMT spectrum which is also used for MBB. This would mean increased competition from both MBB and FWA fraternities vying for finite spectrum that has been allocated to mobile.

4.2.1.3 Botswana spectrum regulations

Botswana has instituted some market-driven spectrum property rights, however, to a limited extent and thus it lags behind in the countries of study. The NRA demonstrates signs of apprehension and unease against departing from state-led administrative spectrum management. According to SRBW1, technology and service neutrality were first introduced by the now repealed 2006 Policy Directive. This policy converted MNO licenses into public telecommunication operator (PTO) licenses and allowed them to offer both mobile and fixed converged voice and data services. Previously, MNOs could only offer mobile voice and limited data services only. BOCRA laments the unintended consequences of this reform as operators were inadvertently incentivised to behave anti-competitively and it increased the frequency of *ex-post* regulatory interventions (BOCRA, 2015, p.6). On the other hand, operators were allowed to utilise spectrum more efficiently as they were now able to re-farm spectrum for new technologies with higher data capacity such as HSPA and LTE.

The 2015 ICT licensing framework caters mainly for three categories, namely, network facilities provider (NFP), the services and applications provider (SAP) and the content services provider (CSP) (BOCRA, 2015b). The NFP license is a prerequisite to owning radio equipment and thus holding a spectrum license. This license category permits the MBB operators in Botswana to own network infrastructure, and apply for and hold a spectrum license. Just like the spectrum licensing strategy of 2007, the new licensing framework lists spectrum as one of the determining factors for the number of entities that may be licensed to operate under the NFP category (BOCRA, 2015, p.14). This proclamation by the regulator puts spectrum squarely at the core of the political economy of MBB market in Botswana, whereby it is being regarded and used as a barrier to market

entry and to competition. Nevertheless, SRBW1 was of the opinion that there is not much pressure in Botswana for more MBB spectrum, whatever pressure that may exist is not urgent and can be stayed.

4.2.1.4 Summary of spectrum management reforms in Botswana

Although the NRA in Botswana went through a consultative process in 2007 for spectrum management reforms as part of the broader objective to address broadband infrastructure deficit, a number of spectrum property rights and commons recommendations that emerged from the consultation have not been implemented. The crux of the recommendations was that the regulator should seek to find the right balance between the three main spectrum management models, namely, the administrative, market-driven and technology-enabled approaches. This has not materialised. Command-and-control continues to be the core spectrum management method applied by BOCRA. It emerged during the interviews that the 3400 – 3600 MHz spectrum which was relinquished by the former fixed line incumbent, now a converged operator, was being licensed through an administrative process using first-come-first-served, and a beauty contest method in the event of demand exceeding supply. Notably, the 2600 MHz band was also licensed through a first-come-first-served approach in 2008, shortly after the spectrum management reform consultation was concluded. It also emerged during the interviews that when the three MNOs approached the regulator for spectrum for LTE, they were "instructed" by BOCRA to utilise the 1800 MHz spectrum (SRBW1). Currently, the NRA cautiously supports DSA in TVWS as SRBW1 argues that the latter can be used to enhance spectral efficiency, particularly in bands where spectrum is either lying fallow or not fully utilised. According to SRBW1, three TVWS trials are currently underway in Botswana and the regulator is working on guidelines for TVWS operation in Botswana. In all its market interventions, the NRA seems to be restrained by a concern of an adverse impact on a thriving MBB industry.

4.2.2 South Africa spectrum licensing framework

South Africa seems to be caught between a rock and hard place with spectrum management reforms. On one hand the NRA wants to go all the way in reforming the function but on the other hand the policymaker is hell-bent on reversing whatever reforms have been initiated. This administrative inertia is indeed exacerbated by spectrum governance in the country and the blurred segregation of responsibilities between the policymaker and the NRA. Spectrum management function in South Africa is split between the regulator and the policymaker. ICASA functionally reports to the Department of Telecommunications and Postal Services (DTPS), but administratively reports to the Department of Communications (DoC). The DTPS is responsible for laws and policies governing spectrum and also takes the lead on matters related to the ITU and general international coordination of spectrum management. Meanwhile, ICASA authorises the use of spectrum to various users nationally and also determines and collects the fees for using this resource. Spectrum management reform, steered by the regulator, falls broadly within this framework. However, the Ministry as the policymaker plays a central role in defining the sector policy and legislation. Legal instruments that make significant pronouncements on spectrum management reform for mobile broadband in South Africa are examined in the next sub-sections.

4.2.2.1 South African legislation dealing with spectrum

Although the Telecommunications Act of 1996 has been repealed by the ECA of 2005, it is however relevant to this study to the extent that its amendment in 2001 granted the 1800 MHz

band spectrum licenses to MNOs (RSA, 2001, s.30). Telkom, the then fixed network operator, and the Second Network Operator (SNO), later became Neotel and now Liquid, were also assigned in principle spectrum in the 1800 MHz band, although they were not MNOs at the time (RSA, 2001, s.30A). This statute also made provisions for the so-called "third generation telecommunication radio frequency spectrum licenses" to be issued to MNOs and Telkom.

ICASA's mandate as it relates to spectrum is essentially to manage this natural resource "in accordance with bilateral agreements or international treaties entered into by the Republic" (RSA, 2000, s. 4(1)c). The latter function of representing the country in the international fora is tasked to the Minister (RSA, 2005, s.34). . The Electronic Communications Act (ECA) is the legislative instrument from which spectrum management reform in South Africa emanates, it facilitates the introduction of a technology-neutral licensing framework and promotes efficient use of spectrum (RSA, 2005). This piece of legislation introduced a flat licensing framework that broadly collapsed a plethora of licenses into three categories, namely, electronic communications network services (ECNS), and electronic communications services (ECS) and broadcasting services. MBB operators in South Africa require an ECNS license to enable them to apply for and be in possession of a spectrum license. One of the objects of the ECA is to ensure efficiency when it comes to the use of spectrum (RSA, 2005, s.2(e)). Chapter 5 of the ECA deals with spectrum related matters and it outlines the Authority's spectrum mandate alongside the Minister's functions. ICASA is mandated by law to manage spectrum, issue and amend spectrum licenses (RSA, 2005, s.30 & s.31).

All MNO participants asserted that section 31(3) of the ECA mandates ICASA to introduce alternative methods such as auctions for licensing spectrum in cases where demand exceeds supply (MNOSA1, MNOSA2 & MNOSA3). MBB spectrum has been declared by ICASA as high demand spectrum and as a result ICASA attempted on more than one occasion to license this spectrum via market-based means such as an auction. The latest auction attempt by ICASA was made in 2016 when the Authority published an invitation to apply (ITA) for a spectrum license for MBB using the 700 MHz, 800 MHz and 2600 MHz bands (ICASA, 2016b). Subsequent to ICASA's ITA, the Minister of Telecommunications and Postal Services successfully interdicted ICASA in court and set aside this planned spectrum auction by the regulator (Minister v. Acting Chair ICASA and others, 2016). The Minister argued that by initiating a spectrum licensing process through an auction, without waiting for a policy direction from the former, the latter acted illegally and effectively usurped Cabinet's role of policymaking. The Minister also indicated his concern with the planned auction was that it would only benefit the incumbent operators with deep pockets and that would fly in the face of sector transformation measures proposed in the new policy. Apparently, before publishing the ITA, ICASA had seen the ICT policy white paper which was about to be issued by the Minister but still went ahead with the planned auction, disregarding the planned intervention by the policymaker (RSA, 2016).

Notably, the ICT integrated policy of 2016 was published almost three months after the ICASA's invitation to apply (ITA) for almost 300 MHz of spectrum from the 700 MHz, 800 MHz and 2600 MHz bands, which sought to license spectrum via an auction (RSA, 2016).[5] These spectrum bands had been identified by the regulator as key to addressing the spectrum deficiency and increasing the diffusion of broadband. At the economic level, the Authority intended to use this spectrum in enhancing competition, stimulating investment and growing the sector (ICASA, 2016,

[5] The ICASA Invitation to Apply for 700 MHz, 800 MHz and 2600 MHz bands spectrum license was published on 15 July 2016 in Government Gazette 40145 of 2016. Meanwhile, the National Integrated ICT Policy White Paper of 2016 was published on 03 October 2016 in Government Gazette 40325 of 2016.

p.13). In a bizarre move though, the Minister asked the North Gauteng High Court to interdict ICASA and set aside the proposed spectrum auction (Minister v. Acting Chair ICASA and others, 2016). Meanwhile, Cell C, in a separate bid also challenged ICASA's mandate to auction spectrum and the validity of this process. Both interdicts were granted and ICASA was prevented from proceeding with the auction. The ICASA ITA for spectrum auction has since been deferred indefinitely, with no reasons explained by the regulator (ICASA, 2017c). The ICT integrated policy of 2016 is discussed further in Section 4.2.2.2.

4.2.2.2 South African government policies related to spectrum management

The Radio Frequency Spectrum Policy (RFSP) of 2010, which has now been superseded by the National Integrated ICT Policy White Paper of 2016, sought to promote efficient utilisation of spectrum and to broadly consolidate fragmented spectrum decisions into a single government policy (RSA, 2010; 2016). PMSA1 respondent indicated that this policy made an attempt to clarify the roles of the Minister and ICASA with regards to spectrum. MNOSA2 highlighted that besides the promotion of technical efficiency of spectrum use, this policy also endeavoured to position socio-economic development as an objective for spectrum management. MNOSA1 and MNOSA2 argued that this policy envisaged market-based mechanisms as an alternative in cases where spectrum demand exceeds supply, despite the obstructions that have been placed before ICASA in its attempts to auction spectrum.

South Africa (SA) Connect – the National Broadband Policy, outlines several public interest objectives of issuing spectrum, among which include efficiency (technical), sharing (commons) and socio-economic development (RSA, 2013, p.34). PMSA1 asserted that the Minister's role in issuing a policy directive as a means to ensure that high demand spectrum is licensed fairly, competitively and timeously is reiterated in the broadband policy. The Wireless Open Access Network (WOAN) is mentioned for the first time in this policy as a mechanism to meet national broadband requirements, and the policy proposes setting aside spectrum for that purpose. When the broadband policy was published in 2013, government also committed to accelerate the policy directive to facilitate the efficient and competitive release of broadband spectrum (RSA, 2013).

The National Development Plan (NDP) of 2011 represents a national blueprint for socio-economic development of South Africa (RSA, 2011b). The NDP identifies spectrum licensing as a bottleneck in the diffusion of broadband in the country and proceeds to suggest high-level and broad recommendations to alleviate this challenge.

> Mechanisms for allocating radio frequency spectrum need to be smarter (for example, spectrum auctions), with robust and transparent governance. Spectrum should be fully tradable once allocated. Regulators should not be too restrictive in dictating which technologies should be used with which spectrum…. Spectrum policy should favour competition, but incumbents should not be excluded from gaining access to bands they need to build networks using new technologies. In line with global trends, spectrum licenses should be technology neutral…. (RSA, 2011b, p.174).

The National Integrated ICT Policy White Paper of 2016 declared sweeping adjustments to spectrum management in South Africa and went further to introduce fundamental changes to licensing of MBB spectrum. SRSA1 and MNOSA1 lament that ICASA's role would simply be reduced to an administrative function and its independence eroded. Similar to other legal instruments dealing with spectrum, the white paper emphasizes the need to manage spectrum efficiently and goes further to introduce watershed measures whereby high demand spectrum, including MBB spectrum, will be licensed on non-exclusive basis to a WOAN that operates at wholesale level (RSA, 2016, p.69). All MNOs contended that this is a major deviation from the current global practice

where spectrum bands are sub-divided into smaller blocks and then apportioned exclusively to individual entities. The ICT Policy argues that spectrum scarcity is artificial and the infrastructure duplication and concentration in urban affluent areas to the exclusion of rural and less affluent areas is a consequence of the current market structure, hence the intervention. As a result, in an attempt to avail high demand spectrum for use by all licensed entities, the ICT Policy forbids trading of high demand spectrum and sanctions the NRA to embark on a process to take back from the licensees all exclusively assigned high demand spectrum (RSA, 2016, p.92 & 95). High demand spectrum will then be set aside for a WOAN that will sell wholesale access incumbent operators and new entrants.

4.2.2.3 South African spectrum regulations

Spectrum assignments in South Africa have been conducted administratively generally, to the extent that some bands were assigned by an Act of parliament, in spite the existence of an independent regulator, as highlighted above. However, broadly speaking the NRA has managed to achieve what the policymaker has failed to achieve through policies and legislation. PMSA1 conceded that the "use it or lose it" principle introduced by the RFSP of 2010 has never been successful in clawing back unused spectrum and discouraging hoarding and inefficient utilisation of this resource. This policy merely encouraged users or licensees to review their spectrum needs and relinquish any excess spectrum they might have (RSA, 2010, p.13). However, the ICASA spectrum license fees regulations which came into effect in April 2012 introduced the administrative incentive pricing (AIP) scheme (ICASA, 2010). Most participants regarded the AIP regulations as far more effective instrument of discouraging spectrum hoarding than the "use or lose it" principle. However, MNOSA1 argued that these regulations transferred the inefficiency from the licensees to the regulator's side because spectrum that has been returned is still lying fallow but in a different domain.

SRSA1 highlighted that one of the objectives of the final Radio Frequency Spectrum Regulations (FSR) of 2011 was essentially to lay the groundwork that will enable the Authority to "allocate and assign" spectrum for various services. This claim was later supported by MNOSA1 and MNOSA2. Regulations for high demand spectrum, which is spectrum that is normally used for MBB, and also the regulations for license exempt use, which includes applications such as Wi-Fi and LTE-U, were consolidated into a single regulation applicable to all services, applications and technologies (ICASA, 2011b, Annexure B & E). According to MNOSA1, property rights finds expression in these regulations whereby pronouncements are made, by the regulator, as to the framework that will be applied in instances where demand exceeds supply, the so-called extended application procedure envisaged spectrum auctions.

The Radio Frequency Migration Regulations and Radio Frequency Migration Plan (FMR-FMP) of 2013 for all intents and purposes focused on the spectrum bands that may be subjected to migration and a subsequent assignment plan for the new services that will move into these bands (ICASA, 2013). Section 34(16) of the ECA mandates ICASA to migrate spectrum users in cases where there is a need, however, this should be done in harmony with the national FAP. The regulator is further obliged to first consult with the Minister in cases where the migration involves government entities. The FMR-FMP of 2013 lists the 470 – 790 MHz and 790 – 862 MHz bands as some of the bands that are subject to migration (ICASA, 2013, p.24). Migration of services out of these bands will be in favour of IMT or MBB as per WRC-07 and WRC-12 ITU resolutions (Res.749, WRC-07; Res.232, WRC-12). South Africa is yet to implement these resolutions as broadcasting service is still using this spectrum and analog switch-off is yet to be exacted. SRSA1 participant maintained that the

migration of broadcasting services, including studio links, out of this band will follow the FMR-FMP and the Terrestrial Broadcasting Frequency Plan that incorporates the entire spectrum allocated to broadcasting.

Telkom in South Africa was historically assigned spectrum for fixed links within the band 2307 – 2387 MHz paired with 2401 – 2481 MHz. The 2300 MHz band has since been allocated to mobile and identified for IMT, and Telkom is now using 60 MHz of this spectrum for MBB service, LTE-TDD to be exact (ICASA, 2014, p.112). The SADC FAP 2016 indicates fixed links as a co-primary allocation with mobile/IMT in the 2300 MHz band (SADC, 2016, p.45). Meanwhile, during data collection, Telkom's competitors questioned the legitimacy of service-neutrality because spectrum that was licensed for fixed service is now being used for a mobile service by Telkom. Notably, the same players were beneficiaries of technology-neutrality (in IMT bands such as 900 MHz and 1800 MHz) and shared no misgivings about it.

According to GNEM1, ICASA's goal of spectrum harmonisation with the rest of ITU Region 1 finds expression in the IMT Roadmap published in 2014. This roadmap sets the tone for the specific range of spectrum bands available for IMT and also sheds light on the provisional dates of availability of these bands and the deployment thereof to support the SA Connect milestones (ICASA, 2014, p.14). The IMT Roadmap proposes migration scenarios and timelines for non-IMT applications that are still utilising the targeted spectrum; this will include broadcasting services in 700 MHz and 800 MHz bands. Radio Frequency Assignment Plans (RFSAP) for IMT of 2015 expands on the IMT Roadmap as it defines the conditions of use of the bands identified in the latter. These conditions include the channelling arrangements and the potential method of assignment or licensing (ICASA, 2015c, p.8). In the 2016 ITA, consistent with section 31(3) of the ECA, the NRA had subsequently elected to use spectrum auctions after a set qualification criteria has been met by prospective applicants. This indicates a move by the regulator to market-driven spectrum property rights using auctions.

Meanwhile, ICASA has also been laying the groundwork for technology-enabled spectrum commons approach. According to SRISA1 and SRSA1, since 2014, ICASA together with industry partners, the CSIR and academia have been involved in conducting trials for the introduction of technology-enabled spectrum management reforms in the form of DSA in the terrestrial broadcasting band of 470 – 694 MHz. In late 2015, ICASA initiated a process to regulate spectrum sharing in terrestrial broadcasting bands and even went further to propose the introduction of DSA beyond these bands (ICASA, 2015a). Broadcasters were generally against the introduction of DSA, especially before the successful completion of a digital switch-over (ICASA, 2016a). Although the proposal by the Authority to initiate TVWS regulation was generally supported by most respondents to ICASA's consultation, some broadcasters viewed the regulator's actions as an attempt to circumvent the Minister's role of allocation (ICASA, 2016a, s.4.1). These entities even questioned the regulator's mandate in introducing a broadband service in a band allocated primarily to broadcasting, 470 – 694 MHz band. Strangely, Cell C suggested that ICASA should focus only on licensing the high-demand spectrum bands and the application of licensing methods such as leasing, trading and sharing (ICASA, 2016a, p.11). However, Cell C had previously challenged the 2016 ITA in court, questioning ICASA's mandate to license high demand spectrum without a policy directive from the Minister (Minister v. Acting Chair ICASA and others, 2016).

Interestingly, MBB operators were generally in favour of DSA, but only in the broadcasting bands and definitely not in the IMT bands, *not in my backyard (NIMB)* syndrome. MNOSA2 and MNOSA3 respondents were also of the view that DSA could be flexible enough to be used in other

applications in future such as in internet of things (IOT) and machine-to-machine (M2M) communication. These respondents favoured a light-touch regulation, others even proposed an automated licensing, were the regulator's involvement will be merely facilitation – type approving the equipment, authorising geo-location database operator/s and *ex-post* interventions, only when there are disputes or unsolved interference issues. ICASA subsequently published, simultaneously, a position paper on the framework for dynamic and opportunistic spectrum management together with the draft regulations on the use of television white spaces in mid-2017 (ICASA, 2017a; 2017b). In both documents, ICASA asserts its mandate when it comes to DSA and TVWS as that of promoting research and innovation, stimulating the market and encouraging investment. The draft regulation signalled the Authority's determination to finally institute a regulatory framework for technology-enabled spectrum management reforms.

4.2.2.4 Summary of spectrum management reforms in South Africa

ICASA has clearly been on a path of reforming spectrum management processes in South Africa, to the extent that the legislation mandates the regulator. The reforms undertaken by ICASA have been anchored on various legal instruments that include the RFSP of 2010, the NDP of 2011, the SA Connect of 2013 and the ECA of 2005 (as amended). All these instruments envisaged the probability of high demand for MBB spectrum and some went on to propose market-based alternatives for licensing such as auctions and principles such as technology and service neutrality. ICASA's market-driven reforms have presented operators with a degree of flexibility in terms of utilising their assigned spectrum as they have been enabled to rollout evolved technologies such as LTE and HSPA in frequency bands previously licensed for GSM specifically and thus utilise spectrum more efficiently. When ICASA introduced AIP regime for spectrum pricing, where licensees have to pay for the opportunity cost of utilising various spectrum bands, the market, or spectrum licensees had to "voluntarily" return any unused spectrum that may have been kept for hoarding, or due to anti-competitive practices and even inefficient use of this finite resource. This has freed up MBB spectrum in bands such as 2600 MHz previously held by SOEs such as Sentech and this band has been one of the bands targeted for MBB licensing via an auction.

A spectrum license is regarded as an authorisation to enter the market or enhance ones competitiveness and lack thereof as a barrier to entry. Attempts by ICASA to license spectrum through market-based methods such as auctions have thus far been unsuccessful, partly because the NRA's approach failed to find the right balance to accommodate both the incumbents and new entrants. The 2011 attempt to auction was arguably skewed in favour of new entrants to the exclusion of incumbents and the last attempt in 2016 implicitly preferred incumbents more than the new entrants. On the other hand, ICASA has also embarked on a process of technology-enabled reforms such as TVWS using DSA in the broadcasting band, attracting the rage of the broadcasters who are unwilling to share spectrum with a different service and the incumbent MBB network operators who perceive license-exempt spectrum for TVWS as unfair regulatory practice and a threat to their business. This initiative has put South Africa in a lead position for technology-enabled spectrum management reforms in the region. DSA's objective as a technology-enabled spectrum commons method essentially avoids interference in contrast to market-driven property rights were the goal is to maximise the economic value of spectrum and license it, exclusively, to the entity that values it the most.

4.2.3 Zambia spectrum licensing framework

Spectrum management in Zambia is a function of both ZICTA (formerly CAZ) and the Minister. The now repealed Radiocommunications Act of 1994 engendered the then regulatory authority, CAZ, with the powers to manage and regulate spectrum utilisation in Zambia. Besides renaming CAZ into ZICTA, the ICT Act of 2009 repealed both the Radiocommunications Act and the Telecommunications Act of 1994 (RZM, 2009). Spectrum management functions which were performed by CAZ under the former legislative framework were transferred together with CAZ's mandate to ZICTA. ZICTA functions under the oversight of the Minister responsible for Communications and Transport (RZM, 2009, s.6). The Minister is responsible for policymaking for all matters related to the ICT sector, including spectrum management. Although section 5 of the ICT Act asserts ZICTA's independence, the Chairperson and the Board of the Authority are appointed by the Minister and section 6(3) of the ICT Act empowers the Minister to issue directives that must be implemented by the regulatory authority. Some of the directives that have been issued by the Minister since the promulgation of this legislation include directives related to administrative spectrum management, where licensing has been done generally under a "command and control" regime with first-come first-served and beauty contest practices. For more details see Section 4.2.3.3 below. The ICT Act is the only statute that makes significant pronouncements on spectrum related to MBB in Zambia and is examined in further detail in the next section.

4.2.3.1 Zambia legislation dealing with spectrum

Section 54 of the ICT Act deals with ZICTA's mandate insofar as spectrum management is concerned and issues related to this function. ZICTA is empowered by the ICT Act to allocate spectrum and to provide for the national frequency plan, and to foster the efficient utilisation of this natural resource (RZM, 2009, s.6). The Authority is further mandated to assign spectrum to various users. This legislation vests the NRA with the powers to issue spectrum licenses and to prescribe the terms and conditions for these permits (RZM, 2009, s.54). Furthermore, in terms of licensing, the ICT Act provides for a flat licensing framework with essentially two license categories, namely, a network license and a service license (RZM, 2009, s.10). Technology and service-neutrality are provided for both in this legislation and in policy. SRZM1 stated that similar to other jurisdictions where a unified licensing framework (ULF) has been adopted, a network license permits a licensee to possess and trade in electronic communications network. Needless to say, in the case of MBB operators, spectrum will also be required in the provision of electronic communications services.

According to sections 16 and 24 of the ICT Act, trading or selling of a network or service license also requires the blessing of the regulator. This means that should an entity wish to sell its network, together with its licensed spectrum resources to a third party, the regulator's consent must be first sought, and the latter shall also prescribe the terms and conditions for each spectrum trade transaction. This is another manifestation of administrative "command and control" spectrum management, conserving state control over this resource. The Zambia ICT legislation is silent on dynamic spectrum, which is a framework used to enable TVWS trials in other jurisdictions such as South Africa. However, it was confirmed during an interview with SRZM1 that there is currently a TVWS trial using DSA on-going in the country. According to SRZM1 respondent, this trial has entered the second and "final" six months phase. Apparently, there are paying subscribers on this TVWS trial and the operator in question does not have an alternative spectrum or the technology to migrate these users to when the trial comes to completion, it remains to be seen what will happen then, stated SRZM1 respondent. This lacuna has seemingly been created by the lack of legal and

regulatory clarity for spectrum commons such as DSA and also for technology trials or proof of concepts. SRZM1 conceded during the interview that this lack of a regulatory framework for trials has created the void which the market is now exploiting to its benefit.

4.2.3.2 Zambia government policies related to spectrum

According to the ICT Policy of 2006, in contradiction with the ICT Act of 2009, the responsibility of allocating spectrum to various uses in Zambia is the Minister's purview, whereas spectrum management, including assignment is the remit of the regulator (RZM, 2006, p.59). It is only in the Telecommunications Licensing Guidelines of 2010 and the ICT Policy of 2006 where reference is made to scarcity of spectrum (RZM, 2006; ZICTA, 2010). Other statutes dealing with spectrum are silent on the scarcity issue and the need for efficiency in managing this resource. SRZM1 indicated that MBB operators do not necessarily need more spectrum, they just need to roll out more infrastructure to increase coverage and capacity with the spectrum they already have. Surprisingly, it was revealed in the same interview with the regulator that preparations are underway for licensing the 700 MHz and 800 MHz to the same industry that is seemingly holding sufficient spectrum. This signalled an inconsistency in government's perception of MBB spectrum and a challenge experienced in most jurisdictions where administrative spectrum management by government is the order of the day. Whereas industry might demand more spectrum to be licensed for MBB, government is sometimes either apprehensive to the idea or the state's valuation of the spectrum can be completely misplaced, leading to an administrative inertia in reforms.

4.2.3.3 Zambia spectrum regulations

SRZM1 professed that spectrum management reforms in Zambia have been few and far in between. Spectrum property rights exist in the country as for example MBB operators are conferred with two licenses, the network and the service licenses, which are both valid for 15 years (ZICTA, 2010). SRZM1 also highlighted that wireless internet service providers (WISPs) in Zambia are generally self-providing and some use the so-called IMT or high-demand spectrum bands that are commonly utilised for MBB, but in their case they use it for fixed wireless applications. Network licenses for WISPs are valid for 5 years only, compared to 15 year license validity for a MBB operator. Spectrum licenses for both the MBB operators and the WISPs are renewable annually throughout the life of the network license and the renewal process is normally an administrative one whereby in a process similar to a "beauty contest," licensees demonstrate their technical and financial viability to build, own and operate a network and the regulator performs an evaluation of those bids (ZICTA, 2010, p.17). According to the conceptual framework outlined in Section 2.4, this administrative process falls squarely within the command and control criteria where government is at the centre of deciding the use and the user of spectrum, maintaining state control over this resource.

A number of regulations called statutory instruments (SI) were issued in 2010 to operationalise the ICT Act, further entrenching administrative spectrum management in Zambia. These SI's include the ICT licensing regulations which provided a framework to move all licensees, including MNOs, to the new licensing regime under the new law (RZM, 2010d). Secondly, the ICT fees regulations revised all the spectrum assignment fees for different bands and applications. Administrative mechanisms employed in the new spectrum fees included fees associated with the receipt and renewal of licenses whereby the formulae applied considered factors such the amount of spectrum, the re-use and sharing factors (RZM, 2010c). Although the Zambia licensing framework is technology-neutral, allowing licensees to refarm spectrum, the two regulations that were used to license MBB spectrum in 2010, namely, the allocation of 2G frequencies and the allocation of 3G

frequencies regulations, were specific to which technology will be used for the 900 MHz, 1800 MHz and 2100 MHz bands (RZM, 2010a & 2010b). SRZM1 pointed out the fact Zambia regulations allow for market-driven property rights in a sense that MBB operators in Zambia have split some of their formerly 2G-only assignments in certain bands, for example 1800 MHz, into two technologies, 2G (GSM) and 4G (LTE), and this is testament to technology-neutral licensing by ZICTA.

4.2.3.4 Summary of spectrum management reforms in Zambia

Zambia generally lags behind with technology-enabled spectrum commons and the implemented market-driven property rights have been minimal while state control over spectrum has been largely preserved. MBB industry in Zambia benefited from limited market-driven spectrum management reforms such as spectrum re-farming facilitated by technology neutral spectrum licenses that have been introduced in this market. These reforms enabled the industry to rollout evolved technologies such as HSPA and LTE without the need to apply for and acquire new spectrum. The market has thus been allowed some flexibility to decide which MBB technology to utilise in which spectrum band. However, when it comes to further liberalising the market with spectrum management reform practices such as spectrum auctions and spectrum trading, the NRA seems to be apprehensive and actually in favour of administrative practices such as first-come-first-served and beauty contests. Spectrum management in Zambia is generally centralised in ZICTA, however, the latter does not seem to have a framework in place to deal with technology-enabled spectrum management reforms using DSA. The NRA's perception of spectrum demand for MBB industry in Zambia is characterised by inconsistencies and low flexibility which is normally experienced in markets under command and control form of spectrum management. Whilst ZICTA is of the view that MBB operators do not necessarily need more spectrum, the former is preparing to license 700 MHz and 800 MHz to the same MBB industry that is supposedly holding sufficient spectrum. It is also not clear as to which licensing method will be employed to assign these bands.

4.3 Conclusion

This chapter set the scene for data analysis that follows in the next chapter. Data was grouped in clusters of small, medium and large markets along the three SADC sample countries, namely, Botswana, Zambia and South Africa respectively. The legal instruments that include policies, legislation and regulations which are the epitome of spectrum management and reform of this practice were reviewed along the market clusters. Spectrum related policies being a set of principles or broad political statements intended to achieve a particular outcome, such as economic growth, social development, and so forth. Whilst legislation represents laws promulgated or enacted usually by Parliament, and regulations embody a set of rules that operationalise a particular piece of legislation. The level of detail and sophistication of these spectrum statutes varies across the region, depending on the size and maturity of the market. Semi-structured interviews that were conducted not only elucidated the contours which the different participants ascribe to various phenomena in spectrum management reform but also increased the construct validity as suggested by Yin (1994). The issues that emerged in this study within the realm of spectrum management reform in SADC that will be analysed in the next chapter include flexibility, competition and appropriateness.

Table 7 provides a brief summary of spectrum management frameworks in SADC, looking at areas such as governance for this resource, how it is manged and who or which institution is responsible which aspects. This table also summarises the pronouncements of the legal instruments on market-driven reforms such as secondary trading and technology and service neutrality. It concludes with a brief overview of technology-driven reforms such LAA/LTE-U. MBB industry-driven

concepts such as LSA have loomed large in mobile operators' responses to ICASA's consultation concerned with TVWS and DSA, hence the reference to the latter concepts in this summary and in this study broadly.

Table 7: Summary of spectrum management frameworks in SADC

	Botswana (small market)	Zambia (medium market)	South Africa (large market)
Spectrum management governance	Minister: 1. Policymaking. 2. Approves NRA's decisions. 3. Prescribes entities exempt from licensing.	Minister: 1. Policymaking. 2. May issue general directives which ZICTA must give effect to.	Minister: 1. Policymaking. 2. Spectrum allocation. 3. International coordination and representation at ITU. 4. Issues policy directives for spectrum management.
	NRA: 1. Spectrum allocation. 2. Spectrum assignment. 3. Spectrum monitoring. 4. Setting and collecting fees for spectrum use. 5. International coordination and representation at ITU.	NRA: 1. Spectrum assignment. 2. Spectrum monitoring. 3. Setting and collecting fees for spectrum use.	NRA: 1. Spectrum assignment. 2. Spectrum monitoring. 3. Setting and collecting fees for spectrum use.
Secondary trading	Secondary trading of telecommunications licenses is subject to BOCRA's approval; however, the law is silent on spectrum trading.	Subject to ZICTA's consent (RZM, 2009, s.61).	1. NDP (2011) advocates for spectrum trading (RSA, 2011b, p.174). 2. Integrated ICT Policy White Paper (2016) permits trading of non-high demand spectrum (RSA, 2016, p.84). 3. FSR (2011) enable trading (ICASA, 2011b).
Technology and service neutrality	1. HSPA launched in spectrum originally licensed for GSM (900 MHz). 2. LTE launched in spectrum originally licensed for GSM (1800 MHz).	1. LTE launched in spectrum originally licensed for GSM (1800 MHz).	1. HSPA launched in spectrum originally licensed for GSM (900 MHz). 2. LTE launched in spectrum originally licensed for LTE (1800 MHz). 3. Telkom launched a MBB service (LTE) in spectrum originally licensed for fixed links (2300 MHz).
Technology-enabled spectrum commons practices	1. TVWS trials underway (2017). 2. BOCRA preparing a regulatory process for TVWS.	1. TVWS trials underway (2017). 2. ZICTA is unaware of any forms of MBB industry-driven	1. TVWS trials completed in Cape Town and Limpopo. Cape Town trial report published in 2015.

(incl. ASA/LSA, DSA, LAA/LTE-U, TVWS)	3. NRA is oblivious to any forms of MBB industry-driven spectrum sharing practices.	spectrum sharing practices.	2. ICASA published draft TVWS regulation in 2017. 3. MBB industry conducted LTE-U trials between 2015 and 2016.

Chapter 5: The devil is in the spectrum licensing details

5.1 Introduction and background

The essence of this chapter is to analyse in detail the findings presented in Chapter 4 in relation to the literature review and conceptual framework expounded in Chapter 2. Data analysis is the process of searching for the meaning of phenomenon and explanation for the cause thereof (Saldaña, 2013, p.9). This study explored the prevalence of three major spectrum management models from government-led administrative spectrum management to market-driven reforms and technology-enabled spectrum commons. This analysis of spectrum management reforms in SADC is much more original and profound than a simple statistical review of the amount of spectrum that has been licensed to MBB industry, which is usually the case in some studies. The study not only evaluates the progress to date in spectrum management reform in SADC, but also critically examines the effects of these reforms on the MBB industry in the region.

Increasing the spectrum allocation for MBB has evidently been on the ITU agenda for as long as this technology has been around, to the extent that almost every conference since the World Administrative Radio Conference in 1992 (WARC-92), WRC's predecessor, has contributed to this objective (ITU, 1992)[6]. During data collection, MNOs anchored the MBB industry's demand for more frequency spectrum on the ITU's future spectrum requirements estimates for IMT in the year 2020 (ITU-R, 2013). This ITU document estimates that an amount of 1,340 MHz of spectrum will be required for low user density settings, while high user densities will require spectrum in the order of 1,960 MHz. Most countries in SADC will fall in the low user density category of this future spectrum requirements estimate for IMT. MNOs conveniently used the figures coming out of this ITU estimate to support their calls for more frequency spectrum for MBB. The question that arises, in the context of spectrum management reforms and the need to assign spectrum to the MBB industry, is how should this spectrum be licensed, what method should be applied. As part of answering the research questions, this study also took a brief look at how much spectrum is theoretically available for MBB in the region – what has been allocated compared to what has been assigned. Thereafter, the focus of the analysis turned on the effect of spectrum management reform in the SADC region on the MBB market, looking at how this spectrum has been assigned and what has been the impact of that process. This study followed a thematic analysis of data collected then coded, which was subsequently grouped into categories according to developed relationships, as theorised by Saldaña (2013). The grouped categories generated themes which were then synthesised to generate meaning of data.

5.2 Analysis of allocated mobile spectrum vs. assigned spectrum in SADC

The respective national FAPs and MBB spectrum assignments in small, medium and large markets in SADC have been scrutinised in this study as a *genesis* of the analysis of the effect of reforms on the MBB industry in SADC. This analysis revealed that there is no scarcity of MBB spectrum supply in SADC instead there is a general scarcity of demand. Vast amounts of spectrum allocated to mobile in SADC either lie fallow in different countries, is encumbered by other services such as broadcasting or at times is historically assigned to FWA applications. In instances where

[6] The frequency bands 1885-2025 MHz paired with 2110-2200 MHz were identified for Future Public Land Mobile Telecommunication Systems (FPLMTS). The term FPLMTS was changed to IMT-2000 at WRC-97 (ITU, 1997).

mobile industry has managed to exert some pressure on NRAs to clear and license the spectrum to MBB, NRAs have been held back by administrative inertia and uncertainty over how best to proceed, restraining them from applying market-driven and or technology-enabled approaches. All NRAs interviewed together with the regional regulatory body (RRB) opined that they do not foresee a spectrum crunch in the region with the exception maybe of South Africa, at some later stage for that matter. The researcher took stock of spectrum allocated to mobile in the region and further contrasted that with what has been assigned or licensed to MBB, to who and how was it assigned, and how the assignment procedures have evolved over time, if at all, and what has been the impact of these on the MBB markets.

5.2.1 Spectrum allocated to mobile in ITU Region 1, and SADC by extension

MBB in ITU Region 1, and SADC sub-region by extension obtained more than a 1,200 MHz of spectrum to date by way of allocation to mobile and identification to IMT at successive WRCs, please see Table 8 for more details. Table 8 expands on the initial data presented at the beginning of this study in Table 4; it provides the institutional memory to the different mobile allocations since WARC-92. At the last conference, at WRC-15, mobile in SADC received a windfall of almost 400 MHz of spectrum. About 91 MHz came from the L-Band (1427 – 1518 MHz) (ITU, 2016b, Resolution 223). A total of 200 MHz from the C-Band – (3400 – 3600 MHz) (ITU, 2016b, Resolution 154), a further 100 MHz also from the C-Band (3300 – 3400 MHz) band was allocated through a footnote since it did not garner sufficient support to qualify it as a regional allocation (ITU, 2016b, Footnote 5.429A). It is worth noting that the 3400 – 3600 MHz allocation had previously been allocated through a footnote at WRC-07 whereby support thereof included nine SADC Member States, namely, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe (ITU, 2008, Footnote 5.430A). The 3400 – 3600 MHz band has been utilised historically by IMT technologies such as Wi-Max and some proprietary FWA technologies and it is now on the LTE roadmap. This band has since garnered sufficient support to elevate it to a regional allocation in ITU Region 1 at WRC-15 when it was not fashionable to do so at WRC-07. SADC Member States have begun the process to implement these new mobile allocations into the regional FAP their respective national derivatives.

Earlier on, at WRC-12 mobile benefited from a 96 MHz allocation in the 700 MHz band (694 – 790 MHz), this happened in spite of the lack of a conference agenda item and studies being conducted prior to the conference (ITU, 2012b, Resolution 232). El-Moghazi *et al.* (2012) had argued that although this was unheard of in the history of the ITU WRC, where an item that was not on the agenda managed to make its way to the conference discussions and debates, despite the resistance to it. However, the African Member States were resolute with their demands and managed to resolve the issue in their favour. This allocation came to be known as the second digital dividend (DD2). The first digital dividend (DD1) was realised at WRC-07 where 72 MHz of spectrum from the 800 MHz band (790 – 862 MHz) was allocated to mobile in ITU Region 1 (ITU, 2008, Resolution 749). This spectrum was received with much fanfare by the MBB industry due to its favourable propagation characteristics. Lower frequencies such as this provide wide cost-effective coverage, especially in sparsely populated and economically less-viable rural areas.

There was no allocation to mobile at WRC-03; probably the MBB industry failed to lobby for the insertion of an agenda item at the preceding conference. Mobile had received a handsome allocation at WRC-2000 and might have been caught off guard in terms of doing the needful to prepare for the next conference. Almost 300 MHz in total was allocated to mobile in ITU Region 1 at WRC-2000 – 100 MHz of spectrum coming from 2300 MHz band (2300 – 2400 MHz) and 190 MHz in

the 2600 MHz band (2500 – 2690 MHz) (ITU, 2000, Res.223). ITU Member States were also encouraged to utilise their legacy mobile allocations for IMT (ITU, 2000, Resolution 223).

Some of the bands indicated in Table 8 have been utilised for illustrative purposes only and are subject to changes upon finalisation of administrative issues in the different countries. For example, the SADC countries have not as yet opted for a specific preference on the 450 MHz band out of the available 10 options. Meanwhile, ICASA has indicated inclination for one of the 4 channel arrangement options between D2, D3, D4 and D5. As a result, the researcher has selected option D4 simply because it offers a wider bandwidth of 10.95 MHz out of the options preferred by the NRA. Only about 2 x 5 MHz of the 850 MHz is useable in the SADC countries that have allocated 800 MHz and 900 MHz to mobile. 850 MHz is not an ITU Region 1 allocation, hence the complexities.

5.2.2 Spectrum assigned to MBB in SADC

In order to delineate what constitutes MBB spectrum for the purposes of this case study (Yin, 1994, p.22), the researcher took stock of what has been allocated to mobile in ITU Region 1 (EMEA), and SADC by extension. This analysis established that more than a 1,200 MHz of spectrum is theoretically available for MBB in the SADC region, this spectrum is allocated to mobile and identified for IMT by the ITU. Having defined MBB spectrum, the next step was to evaluate how this spectrum is being assigned and to whom and how the reforms are affecting the MBB market. Granted, some of the spectrum bands that were recently allocated at WRC-15, like the 1400 MHz band, are still subject to ITU processes of defining channel plans to determine exactly how they will be deployed. However, some of these bands such as 3400 – 3600 MHz can be referred to as recycled spectrum as they had been available before to IMT in the SADC region, the ITU allocation simply widened the economies of scale by adding more countries. In terms of the amount of spectrum assigned to MBB compared to the allocated spectrum, the large market, South Africa is leading the pack with a ratio of about 1:3. The small market, Botswana comes last with a ratio of 1:5, while the medium market, Zambia, is in the middle with a ratio of 1:4. The balance of the allocated mobile spectrum is utilised for FWA applications, or is still occupied by other services that should have vacated it, or is simply dormant. Figure 3 graphically depicts the comparison between the theoretically available mobile spectrum in SADC and what is actually utilised by MBB.

Although the large market leads the pack when the amount of spectrum assigned to MBB compared to the allocated spectrum in SADC is considered, however, the small market comes out top when the assigned spectrum is contrasted to the population. More MBB spectrum per inhabitants has been assigned in the small market. Using the population figures in Table 1 and spectrum amounts depicted in Figure 3 and Table 8 the ratios for small, medium and large markets are 9,200 people/MHz, 52,700 people/MHz and 130,000 people/MHz respectively. Nonetheless, it is posited that this feat can hardly be ascribed to an act of any regulator or government in these countries but it can easily be credited to population statistics. It is further posited that this ratio makes the large market more spectrally efficient than its medium and small counterparts as it uses less spectrum relatively to service more inhabitants.

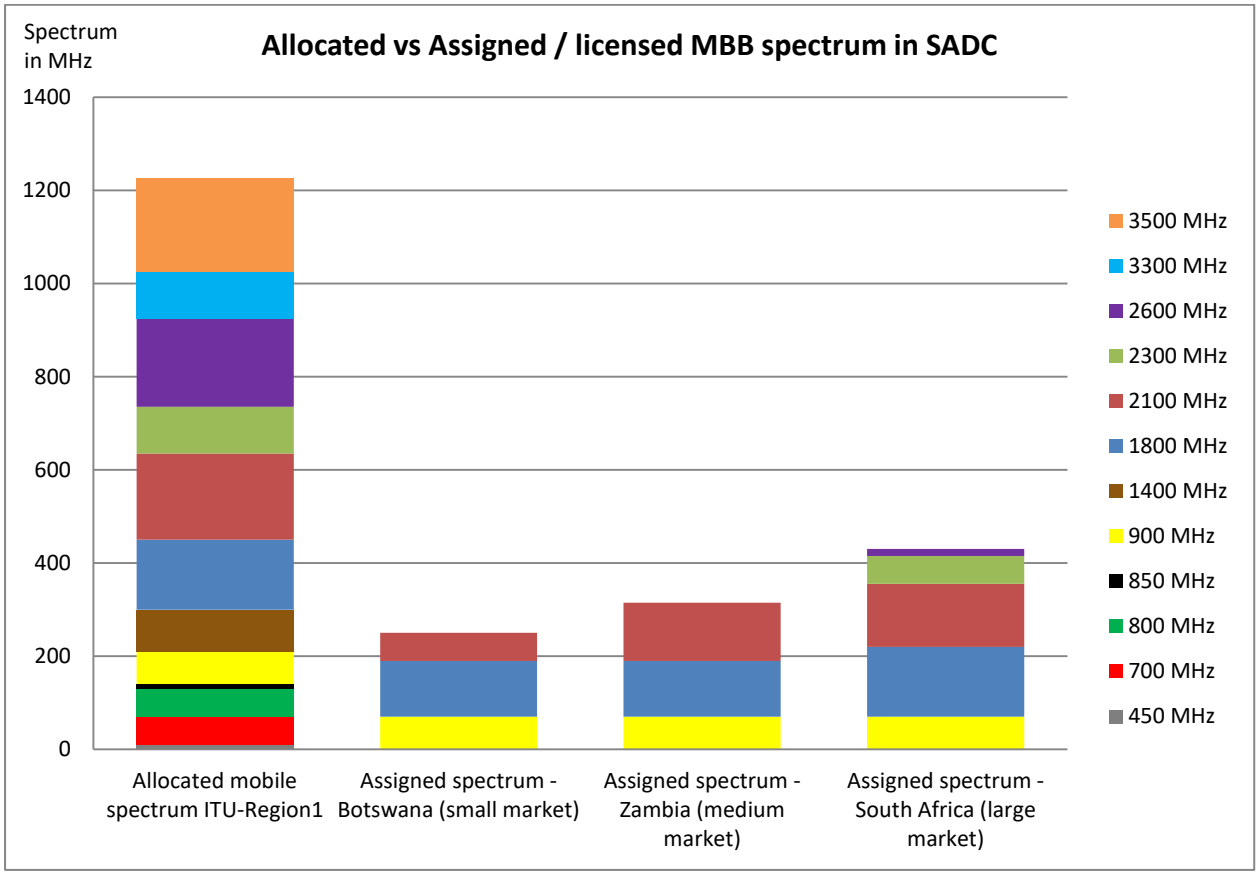
The what, to whom and how analysis of MBB spectrum assignments in SADC, starting with the large market, South Africa, revealed that most of the information on spectrum assignments is readily available from the NRA's website and the officials tasked with spectrum management function were happy to provide answers for clarification. In the case of the medium-sized market, Zambia, although the MBB spectrum assignments information is not published on the NRA's website, it was provided on request during data collection.

Table 8: Spectrum allocated to mobile in ITU Region 1, and SADC by extension

Band	Uplink (MHz)	Downlink (MHz)	Unpaired	Bandwidth	Total Bandwidth	ITU Allocation & IMT Identification	ITU Channel Plan (Assignment)
450 MHz	450 – 455	465 – 470		2 x 5.475 MHz	10.95 MHz	Resolution 224 (WRC-07)	D4 – Rec. ITU-R M.1036-5
700 MHz	703 – 733	758 – 788		2 x 30 MHz	60 MHz	Resolution 232 (WRC-12)	A7 – Rec. ITU-R M.1036-5
800 MHz	832 – 862	791 – 821		2 x 30 MHz	60 MHz	Resolution 749 (WRC-07)	A3 – Rec. ITU-R M.1036-5
850 MHz	824 – 849	869 – 894		~ 2 x 5 MHz	~ 10 MHz	Resolution 224 (WRC-2000)	A1 – Rec. ITU-R M.1036-5
900 MHz	880 – 915	925 – 960		2 x 35 MHz	70 MHz	Resolution 224 (WRC-2000)	A2 – Rec. ITU-R M.1036-5
1400 MHz[7]					~ 90 MHz	Resolution 223 (WRC-15)	Channel Plan TBD by ITU-R Working Party (WP) 5D
1800 MHz	1710 – 1785	1805 – 1880		2 x 75 MHz	150 MHz	Resolution 223 (WRC-2000)	B2 – Rec. ITU-R M.1036-5
2100 MHz (FDD)	1920 – 1980	2110 – 2170		2 x 60 MHz	120 MHz	Resolution 223 (WRC-2000)	B1 – Rec. ITU-R M.1036-5
2100 MHz (TDD)			1880 – 1920[8] 2010 – 2025	1 x 40 MHz 1 x 15 MHz	65 MHz	Resolution 223 (WRC-2000)	B1 – Rec. ITU-R M.1036-5
2300 MHz			2300 – 2400	1 x 100 MHz	100 MHz	Resolution 223 (WRC-2000)	E1 – Rec. ITU-R M.1036-5
2600 MHz (FDD)	2500 – 2570	2620 – 2690		2 x 70 MHz	140 MHz	Resolution 223 (WRC-2000)	C1 – Rec. ITU-R M.1036-5
2600 MHz (TDD)			2570 – 2620	1 x 50 MHz	50 MHz	Resolution 223 (WRC-2000)	C1 – Rec. ITU-R M.1036-5
3300 MHz[9] (TDD)			3300 - 3400	1 x 100 MHz	100 MHz	Res. 223 (REC.WRC-15) Footnote 5.429B (WRC-15)	Channel Plan TBD by ITU-R WP-5D
3500 MHz (TDD)			3400 – 3600	1 x 200 MHz	200 MHz	Resolution 154 (WRC-15)	F1 – Rec. ITU-R M.1036-5
			Total available bandwidth		~1225 MHz		

[7] 1427 – 1518 MHz band has been allocated for mobile use and identified for IMT in ITU Region 1 at the WRC-15. Channel plans are still being finalised by ITU-R Working Party 5D.
[8] Whereas the band 1880-1920 MHz is included in Recommendation M.1036, the IMT identification starts only at 1885 MHz
[9] 3300 - 3400 MHz band has been allocated for mobile use and identified for IMT in ITU Region 1 at the WRC-15. Channel plans are still being finalised by ITU-R Working Party 5D.

Figure 3: Mobile assignments in SADC compared to allocations



Source: Author (2017)

However, when it came to the small-sized market, Botswana, firstly, it took several weeks to secure an interview with relevant officials from the NRA. Spectrum assignments information is regarded as confidential in Botswana and thus some details could not be shared with the researcher. Botswana MNOs passively declined to participate after being furnished with all the information pertaining to the study whilst Zambia MNOs failed to participate after having confirmed in writing to do so. Table 9 summarises the IMT spectrum assignments in SADC, thus answering the "what and who" question of this study. The information on Botswana is generally estimated in the absence of spectrum assignment data from the NRA.

It would seem therefore that the smaller the market, the less transparent it is, and vice versa. Stiglitz (2002) argues that because economic processes entail information asymmetry (IA), individuals get incentivised for not revealing information, for lacking transparency. Players in the market want to know more about their competitors' strengths and weaknesses; they want to know more about opportunities and threats in the market than their counterparts and even the regulator. This IA exists between market players and between market players and government. In a market where the industry arguably knows more than the regulator, it is however not clear what the incentives are there for the NRA to withhold the kind of information that is supposedly public, unless of cause the NRA might have been led by the market to believe that doing so will compromise the latter.

Table 9: IMT spectrum assignments in SADC[10]

		900 MHz	1800 MHz	2100 MHz	2300 MHz	850 MHz	2100 MHz	2600 MHz	3500 MHz	Total
		Paired	*Paired*	*Paired*	*Unpaired*	*Paired*	*Unpaired*	*Unpaired*	*Paired*	
Botswana[11]	beMobile	20	30	20						70
	Mascom	20	30	20						70
	Orange	20	30	20						70
	TOTAL – Botswana	***60***	***90***	***60***						**210**
Zambia	Africonnect							*40*		40
	Airtel	20	40	40						100
	CC Liquid				20					20
	Lamasat				20					20
	Microlink							*60*		60
	MTN	16	40	40						96
	Radicas							*20*		20
	Viva Broadband							*40*		40
	Vodafone				30					30
	Zamtel	16	40	40	30		5	30		161
	TOTAL – Zambia	**52**	**120**	**120**	**100**		**5**	**190**		**587**
South Africa	Cell C	22	24	30						76
	Neotel / Liquid		24			10			56	90
	MTN	22	24	30			10			86
	Telkom		24	30	60				56	170
	Vodacom	22	24	30			5			81
	WBS / Rain		24					20		44
	TOTAL – SA	**66**	**144**	**120**	**60**	**10**	**15**	**20**	**112**	**547**

Source: Author's compilation (2018)

[10] It is worth noting that some of the IMT designated bands in this table are currently utilised for FWA applications not MBB and some of the incumbent licensees are WISP, not MBB networks. Details of spectrum assignments are barely available in small market Botswana, with the NRO also not publishing or disclosing spectrum information.
[11] Estimate assignments for Botswana.

Stiglitz (2013) refers to this as "cognitive capture," a phenomenon where the regulator's outlook is strongly influenced by players in the market it is supposed to regulate. BOCRA conducted a spectrum management reform consultation in 2008 and submissions were received from operators. However, the researcher was informed these submissions are confidential, not only certain part thereof as it's customary in developed markets, but whole submissions. This IA between market players is further exacerbated by the government authority acting in reticence with the industry. Genuinely reformed markets are characterised by openness and transparency, this is quite the opposite in the small market in Botswana. It can then be deduced that small markets are generally lagging on market-driven spectrum management reforms.

5.3 Flexibility of spectrum utilisation as a reform objective

Some scholars (Wellenius & Neto, 2006; Faulhaber, 2006) have identified granting greater flexibility of spectrum use as one of spectrum management reforms that may be implemented with relative ease. The flexibility of spectrum use has allowed MNOs to innovate and invest in technologies that are more spectrally efficient such as HSPA and LTE. Participants generally shared a similar view that spectrum refarming, which has been facilitated by technology and service neutral licensing frameworks, has brought about a measure of flexibility to the MBB industry. Most participants welcomed the flexibility for an MNO to evolve technologies without necessarily having to go through a lengthy bureaucratic process that is sometimes slow and tedious. However, while there seems to be a general consensus for technology neutrality – refarming spectrum between 2G, 3G and 4G technologies – service neutrality is conversely frowned upon by those operators who found themselves at the receiving end of it and some regulators expressly forbid it.

One of the key issues that were highlighted during data collection, flagged in Section 4.2 of this study, is the fact that prior to the era of telecommunications sector reform and the establishment of independent regulators, spectrum management function, including allocation and assignment, was performed by PTOs. Some of these SOEs like BTC in Botswana, Telkom in South Africa and Zamtel in Zambia have since been either partially privatised or governments have indicated their intentions to privatise them in due course and they are now generally competing for spectrum with other MNOs. Some of the legacy spectrum that had been historically self-assigned to these SOEs for fixed service, for example, has since been allocated to mobile by the ITU and identified for IMT. In some instances, NRAs migrated fixed links to other suitable bands and re-farmed this spectrum for MBB, in pursuit of harmonised spectrum for MBB. However, in other instances, the former SOEs re-farmed spectrum on their own from a fixed service to a mobile one.

5.3.1 Government-led flexibility – a top-down approach

BTC, a former PTO monopoly in Botswana, relinquished the 3500 MHz spectrum band which it had been using for FWA. This spectrum has since been re-farmed by the NRA and the latter has initiated licensing through a tender process. Interested parties were invited to submit their proposals and the winners would be licensed through a beauty contest. At the time of compiling this report, BOCRA was busy with the evaluation process for proposals and as a result, bidders could not be disclosed to the researcher. However, the indication was that interest in this spectrum was relatively high. According to industry sources, the 3500 MHz spectrum band is now the second-most popular LTE TDD band globally after the 2300 MHz band (GSA, July 2017). The 2600 MHz band in Botswana, which was the launching pad for most Wi-Max deployments globally, was licensed using a similar process in 2008. BOCRA's predecessor, BTA, resorted to a beauty contest after demand

apparently exceeded supply during the first-come-first-served stage and successful applicants were subsequently adjudicated on the strength of their business cases.

The IMT core band (2100 MHz) was historically used for fixed links in Zambia by the electricity utility, Zambia Electricity Supply Corporation (ZESCO). The initial WCDMA or 3G deployments in SADC and the rest of the ITU Region-1 (EMEA) were rolled out using the 2100 MHz band. As a result, ZICTA's predecessor, CAZ, had to move ZESCO out of the 2100 MHz band to an appropriate frequency for fixed links and make room for MBB. The NRA faced multiple challenges as there was no precedence in Zambia for a similar case, the regulatory framework lacked frequency migration guidelines and most importantly, the SOE didn't have the financial means to bear the migration cost without external funding. ZICTA licensed 3G in this band, funded the migration of the SOE to a suitable band using the proceeds of 3G licensing and cleared this spectrum for MBB licensees. However, MNOs were not directly requested to fund the migration and at the end all stakeholders benefited. The SOE was migrated to a higher frequency with superior capacity and benefited from advanced microwave technology; the MBB industry inherited a globally harmonised band for 3G with a wide ecosystem. This marked the genesis of internet access for Zambians from the palms of their hands, and lastly, the regulator achieved its objective of improving the socio-economic development through diffusion of internet access.

The 1800 MHz band's status as the spectrum of choice for LTE networks began to surge as MNO's across the SADC region intensified their focus on this technology. Under market pressure to release more frequency spectrum for LTE in 2014, BOCRA opted to assign additional 2 x 10 MHz spectrum to operators in the 1800 band MHz band, the band which had been historically utilised for 2G GSM technology (BOCRA, 2015a, p.20). Obviously, this exercise would involve band re-planning to afford operators contiguous assignments in the band, this allowed operators to deploy both 2G and 4G adjacently within their dedicated spectrum. Flexibility to deploy a technology of choice in the assigned spectrum was enacted in a top-down approach from the NRA to the market.

5.3.2 Market-driven flexibility – a bottom-up approach

South Africa presents a different case whereby the 2300 MHz band was initially licensed to Telkom for point-to-point fixed links during the period when the entity had exclusivity to fixed line business. Telkom has since managed to refarm a 60 MHz chunk of spectrum which was used to aggregate and backhaul Digital Enhanced Cordless Telephone (DECT) system base stations and is now using the same spectrum for last mile access with LTE technology. During the exclusivity period, Telkom deployed DECT systems across the country in fulfilment of its mandate to extend the network to historically disadvantaged communities. Telkom's competitors frowned upon this operator's ability to simply refarm spectrum initially assigned for fixed service to mobile. They argued that this granted Telkom "instant access to 60 MHz of high demand spectrum" without going through any competitive process. As far as competitors are concerned, this has given Telkom an unfair advantage because overnight, when 2300 MHz band became one of the leading LTE bands, Telkom was already an incumbent in this band. Interestingly, when it comes to technology neutrality, all operators were all in agreement and none harboured any misgivings about the concept.

Zambia spectrum licensing framework clearly allows spectrum refarming from one mobile technology to another and not across services. Operators don't have to apply to the regulator; they can simply inform ZICTA as to what they are using the spectrum for. In the case of South Africa, Telkom seems to have been allowed to refarm from fixed service to mobile service. South African

MNOs utilised their technology-neutral spectrum licenses to refarm part of their 1800 MHz band assignments with a view to utilising one part for LTE and another to keep alive millions of their subscribers who are still dependent on legacy 2G-only devices. It would seem that the adoption rate of devices capable of the latest technologies such as LTE and LTE-A within developing regions such as in the SADC countries may not be as quick as in developed countries in Western Europe and North America. This presents a limitation on the MNO's flexibility to evolve from an older technology to the latest, more advanced and more efficient technology.

5.4 Appropriateness of reforms

MNOs and some NRAs in SADC expressed their disappointment about the extent and pace of spectrum management reforms in the region. According to Wellenius and Neto (2008), the degree and speed with which spectrum management reforms can be implemented depends on a number of factors including governance, capability of institutions, vested interests and political will. These factors have had an impact on the reforms process across SADC countries and many other developing countries. It must be pointed out though that what succeeded in developed countries may not necessarily produce similar outcomes in developing countries. For instance, there has not been a single successful spectrum auction transaction in the SADC region to date; this failure can essentially be ascribed to some of the factors mentioned above. Although spectrum management is a globally harmonised function, there is no one size fits all when it comes to the licensing details, individual country's context is crucial.

NRAs in SADC have failed to execute successful spectrum auctions not only because their auctions were ill-designed and the bodies were ill-equipped to manage the exercise but auctions have clearly been effective in markets that have significant downstream competition and high levels of maturity. Market maturity and level of competition are beyond the scope of this study, however, it would suffice to say these conditions are generally lacking in SADC countries. Large disparities exist between operators within the region and as a result, outright auctions, without due consideration of local dynamics risks regulatory and market failure. Spectrum trading is prohibited by law in Botswana and Zambia respectively, whilst the law in South Africa does not explicitly specify spectrum trading but elements thereof can actually be implemented through the ECA of 2005 (as amended) and FSR of 2011. Some of these factors that have had an impact on the extent and pace of spectrum management reforms in SADC are ventilated in this study in the context of how these have affected the MBB market.

5.4.1 Spectrum governance

Good governance in management of a country's resources, including spectrum, is characterised by transparency and certainty in policymaking and regulation (World Bank, 1994, p.85). Industry participants in this study had doubts about the existence of these qualities in the way some government institutions in the region manage spectrum. As it was stated in Chapter 2 and 4 of this study, spectrum management has been largely a collaborative effort between the policymaker and the NRA within the respective countries in SADC, the extent of the role played by each has varied across the different member states. Further efforts to liberalise the sector brought about light-touch regulation which in spectrum management reform terms meant ceding some spectrum management responsibilities to the market and or technology. As a result, the role of the state (both as policymaker and NRA) becomes diminished as it gets disintermediated by the market and or technology in the spectrum management process. While some NRAs loosen their grip on spectrum,

it has now become necessary for the state to find the means to ensure promotion of public interest and that government objectives can still be met under the neoliberal regime where its role in spectrum management is becoming significantly reduced.

Some researchers have looked at this issue with the focus on the "what" and "how" but very little or no emphasis has been put on the "why." Zimri (2013) recommended a role clarification in legislation for both the policymaker and the NRA, and he further proposed that the role of spectrum assignment in a country such as South Africa should be "entrusted to an independent agency of government." Questions abound, for example, is there indeed a lack of clarity in the roles of the policymaker and NRA with regards to spectrum management, does the problem lie in the purported lack of clarity, and how will the creation of another agency resolve this challenge. Institutions entrusted with functions such as spectrum management require an institutional memory, which exists not only in the paper trail, but also in the human capital. The proposed agency would, by all means, inherit human resources from the NRA and the policymaker, and the *modus operandi* of these officials would simply not change by operating under a different institution.

5.4.2 Institutional capability

It emerged during data collection that government-led administrative licensing is still prevalent in SADC countries; however, some Member States are trying to move to market-driven mechanisms. Between 2015 and 2016, CRASA in partnership with organisations such as the GSMA, Coleago Consulting and others arranged spectrum auction workshops with a view to enlighten NRAs in the region and enhance their capacity around this concept. NRAs capability to fully implement market-driven spectrum management reforms such as auctions and secondary trading is dependent on clear and focused legislation, unambiguous policy and effective regulation. Market-driven reforms cannot be successfully implemented if these conditions are not met, however noble their intent. Although some spectrum licensing frameworks in SADC recommend licensing via market-driven mechanisms some NRAs indicated incapacity to deal with the dynamics of this licensing method. Some feel that the concept is a bit more complex and NRAs in SADC need to enhance their understanding before they can dive into it. As a result, even in cases where NRAs have indicated in principle an intent to implement more market-driven mechanisms, they are still holding on to most of the administrative command and control practices. At the opposite end of the spectrum, the NRA in a large market, ICASA, has arguably gone through an extensive preparatory process to prepare itself for spectrum auction, barring the disagreements with the policymaker. ICASA embarked on a spectrum management reform process whereby specific regulations were put in place since 2011 and some reviewed in order to align them with the market approach. Some of these regulations are discussed in detail in Chapter 4. This culminated in the publishing of the ITA in 2016 where interested parties were invited to participate in the spectrum auction that was later scuppered by the Minister's court interdict. As a result, it can be argued that the NRA in the large market seems willing and capable of market-driven reforms applied to the full extent; however, NRAs in medium and small markets do not seem to be capable of these, though some may be willing.

5.4.3 Vested interests

South African television broadcasters still using the Digital Dividend bands for broadcasting seem to be the elephant in the room in all discussions concerning licensing these bands to MBB, not only in South Africa, but also across borders. According to the ITU GE-06 agreement, all broadcasting stations in the band 470 – 862 MHz should have switched off analog terrestrial transmission for

television by 17 June 2015 (ITU, 2006, Article 12). Furthermore, 790 – 862 MHz was allocated to mobile at WRC-07 as the first Digital Dividend (ITU, 2008, Resolution 224), and 694 – 790 MHz was also allocated to mobile at WRC-12 as the second Digital Dividend (ITU, 2012b, Resolution 232). The Digital Dividend spectrum has globally been allocated and assigned to mobile and within ITU Region 1 sub-regions such as the EU have already licensed this spectrum for MBB. This spectrum should be utilised mainly for mobile technologies instead of broadcasting in order to maximise the benefits of digital migration (SADC, 2012, p.68). However, data reveals that broadcasters in South Africa are still using this spectrum for both analog and digital television transmission (DTT) and this is not only delaying the release of this spectrum to mobile in South Africa but might potentially be affecting the process in 6 neighbouring states.[12] It emerged during data collection that besides lack of sufficient pressure from the market in the neighbouring countries to release the 800 MHz and 700 MHz spectrum bands for MBB, these countries also have to consider the reality in their neighbouring country, South Africa, as the latter is still using this spectrum for broadcasting. Broadcasters face no opportunity cost to vacate this spectrum and switch-over to a digital platform that is more spectrally efficient. Whilst MNOs might be itching to get their hands on the Digital Dividend spectrum, it is seemingly not in the broadcasters' interests to relinquish this spectrum to MBB anytime soon. This is not only delaying the licensing of the DD spectrum but it is also denying the NRAs an opportunity to unleash market-driven spectrum management reforms where it is feasible to do so using this available and coveted spectrum.

5.5 Competition in the scramble for spectrum resources

Economic theory holds that markets are legal constructs – they are created by legislation, regulations and institutions (Stiglitz, 2013, p.66). It has been pointed out early in this research that because spectrum is at the core of the political economy of MBB, this resource has been utilised both as a competitive and anti-competitive tool. Spectrum has been used as a barrier to entry for new entrants and a barrier to growth for incumbents requiring more access to this resource to support their business growth. Spectrum management reform in some instances has had the unintended consequences, some of which include incentivising MNOs to behave anti-competitively in competing for this resource, as lamented by some regulators. As a result, government has had to intervene in the market when this occurs, either by enforcing existing laws or enacting new ones that curtail and outlaw such conduct.

5.5.1 Rent-seeking conduct by MBB players

While MBB penetration is slowly increasing in SADC generally, a number of economically less-viable areas in the region continue to be deprived of access to this essential service mainly because of lack of infrastructure. MNOs are vehement in their argument that access to the lower frequency spectrum such as the digital dividend bands is probably the only means they have to address this infrastructure deficit. NRAs also shared the same view about the propagation characteristics of lower frequencies, to the extent that ICASA included some coverage obligations in their recent failed attempt to license MBB spectrum via an auction (ICASA, 2016b). However, some MNOs were of the view that ICASA's proposed obligations are onerous and would prove to be too costly for the industry to fulfil, signalling an industry's rejection of NRAs proposed intervention. Stiglitz (2013)

[12] South Africa shares its borders with Botswana, Lesotho, Mozambique, Namibia, Swaziland and Zimbabwe.

refers to this practice where industry expects access to resources (including spectrum) at below fair-market prices as "rent-seeking."

Kedama (2014) argued that the opacity of the relationship between the policymaker and the NRA in South Africa is always exploited by industry to benefit the latter's narrow commercial interests. In response to the ICASA 2016 ITA for MBB spectrum, Cell C challenged in court ICASA's mandate to auction the spectrum and the validity of the process (Cell C and others v. ICASA, 2016). The MNO argued that the NRA cannot initiate this process in the absence of a policy directive from the Minister. However, in its submission to ICASA's consultation on DSA, Cell C had directed the NRA to leave opportunistic spectrum sharing and instead focus its energies on licensing high demand spectrum (ICASA, 2016a, p.13). This contradiction from Cell C was not due to ignorance by the latter but it can be a result of exploiting the opacity in the spectrum management framework to advance a rent-seeking agenda of a MNO in its quest to limit competition.

5.5.2 Information asymmetry in MBB markets

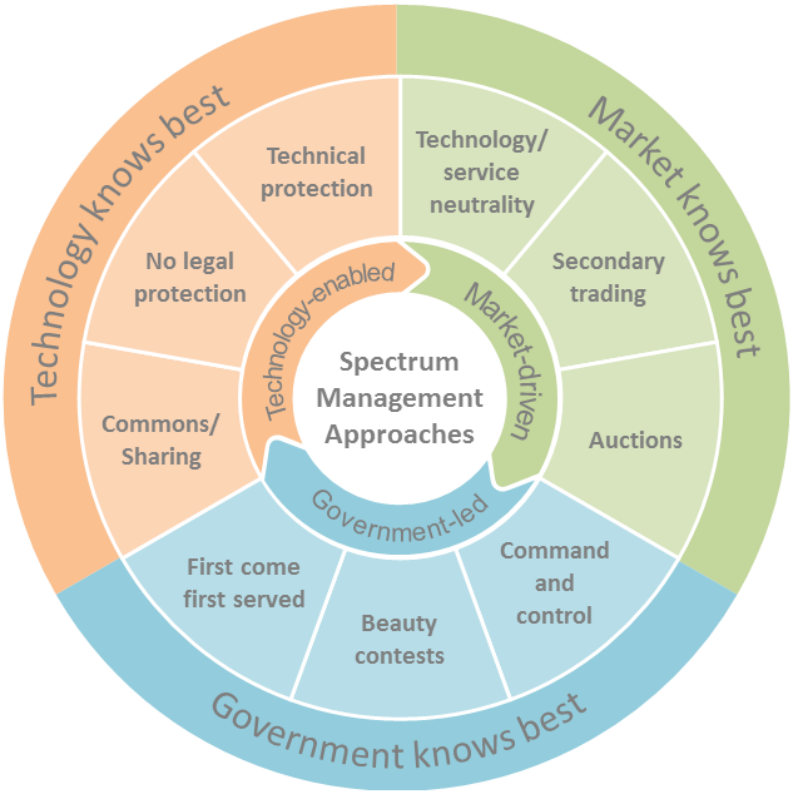
In his study of the political economy of information, Stiglitz (2002) ascertained a phenomenon of imperfect information that exists between government and the market, and between different players in the market; he referred to this as information asymmetry (IA). He argues that the extent of this occurrence is a function of market structure; the firm (in this case the MNO) that gets authorisation (a license) to exploit a resource (spectrum) gets to know more about this resource's potential than government does (Stiglitz, 2002, p.470). In some cases, NRAs expressed doubts about the validity of demands for more frequency spectrum coming from the MBB fraternity, particularly in the small and medium markets. According to these NRAs, MNOs have not fully exhausted infrastructure rollout as one of the options to increase coverage and capacity. It transpired during data collection that much of the information the NRAs in SADC gather about MBB spectrum requirements comes not from empirical studies but from inferences informed by market conduct. These regulators are of the view that industry is seeking the least-expensive alternative to provide MBB service – increasing their spectrum portfolio instead of increasing the base stations. Ironically, these regulators later contradicted themselves, one disclosed that they were indeed making preparations to license additional spectrum to MNOs, while the other was in the middle of evaluating a 2600 MHz spectrum licensing tender to increase licensed MBB spectrum.

5.6 Conclusion

Results suggest that several market-driven reforms such as technology and service neutrality, spectrum re-farming and administrative incentive pricing (AIP), together with technology-enabled reforms such as commons or license-exempt spectrum for MBB technologies are all becoming widespread to varying degrees in SADC countries. However, secondary trading and auctions have been stillborn concepts, partly due to market concentration concerns and appropriateness issues. Most NRAs in SADC do not seem to be adept with the dynamics of advanced market-driven approaches. MNOs conceded, however, that government involvement in the spectrum management cannot be entirely ruled out. The framework in Figure 3 below emerged from the data analysis as it was established that spectrum management reform is not simply a binary process of adopting one approach over the other as it was initially postulated in the original conceptual framework in Chapter 2. However, spectrum management reform can be a continuum on which different elements of administrative, market-driven and technology-driven approaches coexist in varying

degrees. This conceptual framework also allows the NRAs to introduce reforms in gradual manner instead of a "big-bang" approach that lacks room for self-correction.

Figure 4: Spectrum management reform conceptual framework applied to SADC



Source: Author (2017)

The role of administrative spectrum management mechanisms led by government institutions remains critical to spectrum management reforms. Government still has to play a role in allocating spectrum bands, coordinating spectrum internationally and deciding future uses of various spectrum bands. The NRA may still need to intervene in technology-enabled mechanisms were government role may sometimes be limited to facilitation such as equipment type approval, geo-location database authorisation or management and so on. Opponents of technology-enabled mechanisms have cautioned against a possibility of a tragedy of the commons, and in the unlikely event of such, a government institution such as the NRA will be required to arbitrate. The rate of technology evolution demands that the spectrum license should be at least technology-neutral to allow the licensee to migrate to a technology of choice that may be more efficient, within the defined framework. Where demand exceeds supply, depending on the market structure and government policy, an auction may be the best option to apportion spectrum to whoever values it the most. However, government through the NRA still has to define obligations for the licensee. All these scenarios illustrate a coexistence of government-led mechanisms together with market-driven and technology-enabled ones as depicted in the revised conceptual framework.

The pace and extent of reforms has been influenced by several issues such as market structure, competition in the downstream markets and appropriateness of proposed reforms. Whilst industry stakeholders raised concerns around issues of governance and vested interests delaying the

reforms, government institutions are unhappy about the lack of universal coverage of MBB in SADC various countries. The information asymmetry that exists between governments and markets is not helping the situation; instead, it is widening the trust deficit. The artificial scarcity of MBB spectrum supply in SADC has been laid bare against a backdrop of a general scarcity for demand and a discord over how this spectrum should be assigned and to whom. Vast amounts of allocated mobile spectrum in SADC still lie fallow or are encumbered by other services such as broadcasting or at times are historically assigned to FWA applications. It may, therefore, be concluded that effectiveness of spectrum management reforms lies not in lack of frameworks and sufficient spectrum, but in implementing the frameworks through the spectrum licensing details.

Chapter 6: The state of spectrum management reform in SADC and the way forward

The previous chapter presented a thematic analysis of the data collected in this research. This study did not simply document the prevalence of spectrum management reforms and the progress of the same to date in SADC but it has also analysed the effects of these reforms on the MBB industry in the region. The case study methodology has been used to elucidate how we got here and how best we can make advancements in spectrum management reforms broadly within the SADC context can be made. The problem statement as well as the main research question was outlined in Chapter 1, namely:

What is the effect of spectrum management reform in the SADC region on the evolution of MBB industry?

From the findings of the study, the following emerged as the main effects of spectrum management reform in SADC on the evolution of MBB industry: flexibility of spectrum utilisation as a reform objective, appropriateness of reforms and competition in the scramble for spectrum resources. Market-driven reforms in this concern include: technology and service neutrality, refarming, pooling and secondary trading of spectrum. Technology-enabled reforms in the context of MBB include: ASA, LAA, LSA, LTE-U and DSA concepts. AIP is the main reform driven by the administrative authorities with a view to improve spectrum costing. However, the introduction of this concept has an effect on utilisation as it compels users to become more efficient as they now have to pay for the opportunity cost not just the administrative cost of a particular portion of spectrum. This phenomenon has been witnessed in the large market, South Africa, whereby after the introduction of AIP, users surrendered un-utilised and reviewed under-utilised spectrum they were holding at the time.

Countries in the SADC region, like many countries in the developing world, are faced with numerous challenges related to MBB, in particular, a general lack of MBB infrastructure in remote and economically less viable areas, low population densities compared to the developed world and a generally low MBB penetration as highlighted in Chapter 1. For instance, according to the World Bank (2016) the average population density of the European Union is 116 people per square kilometre, almost 30 times that of Botswana and 5 times that of Zambia. This negative demographic impacts negatively on the provision of infrastructure in most SADC countries as it becomes more expensive relatively. Whilst spectrum is recognised as a critical input in the production and supply of MBB services, spectrum management reforms should, for all intents and purposes, be used to enable SADC countries to improve their MBB fortunes by compelling the industry to bridge the identified infrastructure gaps while it provides reasonable incentives to do so. Countries that neglect to exercise these powers do so at their own citizens' peril. A spectrum license is a contract or an agreement between the state and the firm that entitles the latter to provide a MBB service using this resource. This license may specify the conditions and obligations that should be met by the two parties, the firm and the state. Spectrum management, for mobile in particular, defines the role that government plays, not only in defining the MBB market structure and the level of downstream competition as hypothesised by Wellenius and Neto (2008), but this function also endows the state and its institutions with the powers to channel or direct where MBB network infrastructure must be provided using this resource.

This case study concluded that while NRAs in developed markets such as the EU have managed to incorporate government's distributive agenda in their spectrum management reforms, the same cannot be attributed to their counterparts in SADC. For instance, Germany's *Bundesnetzagentur* (BNetza) and *France's Autorité de Régulation des Communications Électroniques et des Postes* (ARCEP) incorporated coverage obligations into their recent spectrum auctions, demonstrating a successful combination of administrative and market-driven approaches. ARCEP highlighted the improvement of MBB data access on France's railway network and in rural areas as a priority in its 700 MHz auction in 2015 (ARCEP, 2015). In spite of these seemingly stringent social obligations, France raised almost €3 billion from this auction. In the same year, BNetza in the Federal Republic of Germany conducted a successful spectrum auction for combined bands, 700 MHz, 900 MHz, 1800 MHz and additional spectrum in the 1500 MHz band (Bundesnetzagentur, 2015). It is worth noting that the 900 MHz and 1800 MHz licenses only expired at the end of 2016 while the auction itself was conducted during the second quarter of 2015, more than a year in advance. The incumbents, whose spectrum licenses were due to expire in 2016, had to reapply like all other interested and qualifying parties. The auction was characterised by openness and transparency, a quality that is missing in most markets in SADC. The new licenses issued by ARCEP will expire in the year 2033 and they come with obligations to provide full coverage for main transport routes such as motorways and railway lines in France – the industry has gladly obliged to these requirements.

Unlike in the above-mentioned examples from the EU countries where at the end of the license period a market-driven approach that imposes social and economic objectives is followed to renew the spectrum license, even if the licenses might have been obtained via administrative command and control or beauty contests, there is no precedence for such in SADC. The duration of a spectrum license is simply linked to the duration of a service license in some countries in SADC, and the spectrum license is renewed annually by payment of the administrative fees. Furthermore, South Africa is the only country in the region that applies AIP, a pricing scheme that closely reflects the economic value of different spectrum bands, thus bringing the large market a step closer to renewal via market-driven mechanisms. The introduction of market-driven approaches such as auctions and secondary trading seems to raise concerns of market concentration, anticompetitive trading and windfall potential in markets where there is a general scarcity for demand.

6.1 Action and inertia in spectrum management reform

From the findings of this qualitative case study research, it can be concluded that spectrum management reform is not just a binary exercise concerned with a departure from a government-led administrative approach to either a market-driven property rights or a technology-enabled commons. The results from the analysis of the individual elements of the conceptual framework and their occurrence in SADC countries suggests that government-led administrative spectrum management remains a critical component of this function, even in mature markets that are advanced with reforms. In instances where flexibility exists in the licensing framework, markets have moved swiftly to refarm spectrum and launch evolved MBB technologies, thus signalling action. Meanwhile, the "SADC regional infrastructure development master plan" aptly describes the inertia over spectrum licensing mechanisms in the region:

> There is a lack of clarity among the policy makers and regulators regarding procedures for awarding 3G/4G licences. The regulators also sometimes have to wait for a long period of time for the ministries of information and communication technology to approve spectrum for 3G/4G networks (SADC, 2012, p.63).

This inertia makes it even more imperative for policymakers and NRAs to find the right balance for business interests and government's developmental objectives and infrastructure distribution agenda.

6.1.1 Implications for command and control by government

Government-led administrative spectrum management mechanisms, commonly known as command and control enjoy a high prevalence in the SADC region. This has led to spectrum licensing delays in some markets as some bands remain idle while the authorities try to figure how to proceed, a case in point is 700 MHz and 800 MHz throughout the region. NRAs in the region have either been hamstrung by dissenting views from the policymaker or the former has caught in a state of inertia, uncertain and insecure of how best to proceed. The findings of this study indicate that there is generally no scarcity for spectrum supply in the SADC region instead there is an artificial scarcity for spectrum demand. Most attempts to introduce advanced market-driven spectrum management reforms such secondary trading and auctions have generally occurred in an advanced market such as South Africa and to a lesser extent in small markets such as Mozambique. Those NRAs who have attempted, with no luck, to license spectrum through auctions in SADC have ended up on a collision course with their policymakers disagreeing with the auction method or market players not happy with the terms and conditions of this licensing mechanism. Small and medium size markets are characterised by a higher degree of command and control practices and a general lack of transparency. This breeds uncertainty in the market, prompting MNOs to return the favour, intensifying the asymmetries of information and encouraging anti-competitive behaviour. Effective spectrum management reforms can only be implemented through open consultations that are conducted regularly in the market as posited by Wellenius and Neto (2008).

The industry expectation when it comes to access to new IMT bands seems to be at an all-time low, especially in the large market, South Africa, where the 2016 ICT white paper declared sweeping adjustments to how spectrum is managed in South Africa. These fundamental changes seek to reclaim back the entire licensed spectrum from the MNOs and license this resource exclusively to a WOAN that operates at wholesale level. As a result, the industry is so busy just trying to hold on to what it has currently to the extent that it cannot be bothered about future IMT bands. In the meantime, NRAs in smaller markets have pacified MNOs demands for more spectrum by enlarging their assignments in the current bands such as the 1800 MHz where there was still ample capacity for expansion.

6.1.2 Implications for market-driven spectrum management reforms

Considering the analysis of allocated mobile spectrum in ITU Region 1 (and SADC by extension) vs the assigned MBB spectrum that was conducted in Chapter 5, this study concludes that there is no scarcity of MBB spectrum supply in SADC, instead there is a general scarcity for demand. A mature and large market such as South Africa is a rare exception to this rule. MBB markets are faced with a general discord over how current and future spectrum should be assigned and to whom. In the meantime, technology is evolving and demands for spectrum are not about to evaporate. It is evident that most markets in SADC have implemented some market-driven reforms with relative ease. Technology neutrality and spectrum refarming have emerged as "low-hanging" fruits of the reforms process. However, the findings indicated that most markets in the region have a limited number of players that can afford to participate in a spectrum auction whilst secondary trading transactions have been thwarted by sector regulators and or competition authorities due to market

concentration concerns and a conflict with national policies. As a result, spectrum auctions in SADC markets that possess a general lack of significant downstream competition pose a risk of regulatory and market failure.

Small and medium sized markets in SADC are characterised by a general lack of transparency and a systematic IA between governments and markets, and between markets themselves. MNOs are using this IA to weaken competition and further entrench themselves in markets where significant downstream competition is lacking. Most regulators in the region fail to cover themselves in glory in terms of conducting empirical studies to plan and estimate future spectrum requirements for MBB, instead, the majority of them either borrow from studies conducted elsewhere in developed markets or they simply bow to pressure from market forces. NRAs in large markets have bowed to pressure from one side of the market that demands the application of advanced spectrum management reforms such as auctions and secondary trading. However, policymakers have bowed to pressure from the opposite end of the market that is obviously not in favour of these mechanisms and have thus scuppered any progress to that effect.

6.1.3 Implications for technology-enabled spectrum management reforms

The basic tenet of technology-enabled reforms is spectrum sharing and the quest to maximise efficient utilisation of spectrum. On the contrary, the findings of this case study indicate that MNOs have a preference for dedicated, exclusive spectrum use, even when some of this spectrum may lie idle due to a lack of utilisation on their networks in time or space, resulting in inefficiencies. There is a strong resistance from MNOs to open up mobile spectrum that is not utilised temporally or geographically to secondary users for sharing, using principles such as DSA as applied to TVWS. Mobile industry players cite issues such as spectrum fees they have to pay as licensed users while secondary users might potentially be granted a free access. Other reasons cited against sharing include potential interference that may be caused by introducing secondary users to share mobile bands and also the apparent lack of maturity of the new technologies that are reliant on technology-enabled commons. Sadly, MNOs are not even prepared to share their assigned mobile spectrum amongst themselves, whether by pooling their spectrum resources to create wider bandwidths or just complementing each other's spectrum assignments through active network sharing to allow different parties access to different bands. However, the same operators are advocating for pseudo-sharing techniques such as LAA and LSA. These techniques were presented in Chapter 2 of this study; LAA seeks to complement licensed spectrum used for a mobile technology like LTE with license-exempt spectrum in bands such as 5800 MHz, and hence it is also referred to as LTE-Unlicensed or LTE-U. Meanwhile, LSA creates a binary sharing with mobile as a single secondary user and the primary user can be a government service such as the military, radar or satellite communication systems operating in globally harmonised but nationally encumbered bands like the 2300 MHz in Europe or 3500 MHz in the US.

It is evident that MNOs are displaying a *"not in my backyard"* syndrome, willing to share spectrum as long as it is not spectrum allocated to mobile and identified for IMT. LSA as a spectrum sharing technique is still an unorthodox concept in the SADC region to the extent that some NRAs were not even familiar with it but MNOs welcomed the idea due to its potential to increase MBB spectrum. Although LAA or LTE-U has been piloted by some MNOs in the region, widespread adoption for it will be adversely impacted by lack of capable devices. Notwithstanding the MBB industry's pessimistic disposition towards technology-enabled spectrum management reforms, evolved MBB technologies will be underpinned by shared spectrum. NRAs will therefore need to

enhance their involvement in research for future spectrum requirements in order to enlighten themselves as to the future of spectrum for MBB.

6.2 Research limitations and further research

A number of potential respondents in small and medium markets were reluctant to participate in the study, exhibiting a general apprehension to research and uneasiness to share data. As a result, the sample group for this qualitative case study research would have been slightly larger. The researcher also experienced some delays in securing an appropriate participant from the NRA of a small market and this consequently delayed the research to a certain extent.

During data collection, it became apparent that most participants and even spectrum management instruments that includes policies, legislation and regulations across SADC loosely refer to efficiency as another reform objective that must be pursued in the utilisation and management of this resource. However, upon further enquiry to establish what type or form of efficiency is being referred to, whether technical, economic, social, or otherwise, the instruments were silent and there was no consensus among research participants. The researcher was unable to further explore this question of types or forms of efficiency.

As a result, further research could consider exploring efficiency as a spectrum management reform objective – determining what form is being referred to in the current efficiency narrative and whether a balance of technical, economic, social, or otherwise needs to be struck, or whether society can be best served by prioritising one form over the rest, and if there should be a packing order of some sort.

6.3 Conclusion and recommendations

This study explored spectrum management reforms that have been undertaken in the last decade, between 2006 and 2016, in the Southern African Development Community (SADC) region, with specific focus on the mobile broadband (MBB) industry. The findings have revealed that several market-driven reforms such as technology and service neutrality, spectrum re-farming and administrative incentive pricing (AIP), together with technology-enabled reforms such as commons or license-exempt spectrum for MBB technologies are all becoming widespread in the region. However, secondary trading and auctions have been stillborn concepts, partly due to market concentration concerns and appropriateness issues. The artificial scarcity of MBB spectrum supply in SADC has been laid bare against a backdrop of general scarcity for demand and a discord over how this spectrum should be assigned and to whom. Vast amounts of allocated mobile spectrum in SADC lie fallow or are encumbered by other services such as broadcasting or at times are historically assigned to Fixed Wireless Access (FWA) applications.

The study concludes that spectrum management reform is not just a binary exercise concerned with a departure from a government-led administrative approach to either a market-driven property rights or a technology-enabled commons. The revised conceptual framework in Chapter 5 depicts that spectrum management reform can be a continuum on which different elements of administrative, market-driven and technology-driven approaches can be applied to varying degrees, depending on the respective country's context. This study recommends that spectrum management reforms should be nuanced as the latter can impact, positively or negatively, on the distributive agenda of government.

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Annexure A – Interview Participant Information Sheet

THE STATE OF RADIO FREQUENCY SPECTRUM MANAGEMENT REFORMS AND THE MOBILE BROADBAND INDUSTRY IN THE SADC REGION.

Dear Prospective Participant,

My name is Thabiso Thukani, a student at the University of the Witwatersrand (Wits), doing a Masters of Arts in the field of ICT Policy and Regulation (MA ICTPR). As part of my studies, I am conducting research on the state of radio frequency spectrum management reforms and the mobile broadband industry in the SADC region.

I hereby invite you to participate in the interviews for this study. Your inputs will be valuable in mapping the data relevant to understanding the advances of spectrum management reform and how these have affected the mobile broadband industry. The responses you provide will be used exclusively for the purposes of the research report, and for related scholarly publishing and capacity building. I therefore request your permission to audio record this 45-60 minute interview, and possibly consult with you in future should I need to clarify any issues.

Anonymity and confidentiality

Your words, input and personal details will be kept anonymous by utilising a naming convention rather than your actual name or other identifiers, unless you expressly require that your name or position be published. Confidentiality will be observed with respect to any matters discussed in the interview that you do not wish to be reported.

Research ethics

Participation is entirely voluntary. Should you wish to withdraw from the interview at any time during or after, you are free to do so without giving reasons and any responses provided will not be reported. Should you have any concerns about this research, please do not hesitate to contact my supervisor, Dr Lucienne Abrahams at the LINK Centre, University of Witwatersrand.

Researcher: Thabiso Thukani

LINK Centre, University of the Witwatersrand (Wits), Johannesburg, South Africa

Email: 769232@students.wits.ac.za / thabiso.thukani@gmail.com

Cell: +27 83 212 0152

Research Supervisor: Dr Lucienne Abrahams

LINK Centre, University of the Witwatersrand (Wits), Johannesburg, South Africa

Email: Lucienne.Abrahams@wits.ac.za / luciennesa@gmail.com

Annexure B – Informed Consent Form

I hereby agree to participate in the research study title: The state of radio frequency spectrum management reforms and the mobile broadband industry in the SADC region.

I will participate in a recorded interview of approximately one hour in length, in which I will give my views on spectrum management reforms and the effect thereof on mobile broadband. The research has been explained to me and I understand the study. I have been informed of (i) the names and affiliations of the researcher; (ii) the purpose, content, objectives and potential benefits of the study; (iii) the fact that the content of my responses may be reported, anonymously, in the study's published outputs (e.g., conference paper, research report, journal article, book chapter); (iv) the study's procedures for storage and use of the data collected from the interview in a manner that ensures anonymity and confidentiality of the data; and (v) the steps I can take if I have questions or concerns or feel that I have been harmed by the research. I understand that this is a research project whose purpose is not to benefit me personally.

Please initial box

1. I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason. ☐
3. I understand that the researcher will not identify me by name in any publications using information obtained from this interview and that any views I express will remain confidential where such confidentiality is required; or ☐
4. I understand that my name will not be explicitly stated in the reporting of data and that any views I express will remain confidential where such confidentiality is required. ☐
5. I agree to a 45-60 minutes interview being audio recorded. I may be contacted post the interview for clarification on any points I made. ☐
6. I agree to the use of anonymised quotes in any publications. ☐
7. I agree that data gathered from me in this study may be stored (after it has been anonymised) and may be used for future research. ☐

Name of Research Participant	**Date**	**Signature**
_____	_____	_____
Name of Research Participant	**Date**	**Signature**
_____	_____	_____

Annexure C – Interview Guide

The state of radio-frequency spectrum management reforms and the mobile broadband industry in the SADC region.

THABISO KENNETH THUKANI

MA in ICT Policy and Regulation at the University of Witwatersrand, South Africa.

The interview questions explore the prevalence of three major radio-frequency spectrum management models:

1. Administrative spectrum management:
    a. Which IMT bands are currently utilised for mobile broadband, by which entities (operators) and for how long (license period)?
    b. Have the licenses in question 1(a) above been renewed recently, if so what process was followed? Administrative, market or combination.
    c. Is there a long-term spectrum policy that addresses all services, including mobile broadband? If so, how is this policy currently being implemented by the regulator?
    d. Which new IMT bands are due to be available for mobile broadband in your country in the short to medium term, how will these be assigned or licensed?
    e. How is the pace of spectrum regulatory reform in your country affecting the mobile broadband industry?
    f. Do you anticipate a spectrum crunch for mobile broadband? Please elaborate on your answer.

2. Market-enabled property rights:
    a. Are concepts such as technology-neutrality, spectrum refarming, spectrum trading and spectrum auctions used in your market? If so, how are they part of the regulatory framework currently in place?
    b. What challenges (if any) are encountered with market-driven spectrum reforms?
    c. Does your national regulator have the regulatory framework to facilitate the introduction of these new regulatory approaches? Please elaborate.
    d. How is the mobile broadband industry affected by these market-driven spectrum management reforms?

3. Technology-enabled spectrum commons:
    a. What is your view of the application of regulatory approaches such as Dynamic Spectrum Access (DSA), Licensed Assisted Access (LAA), Licensed Shared Access (LSA), LTE-Unlicensed (LTE-U) and TV White Space (TVWS)?
    b. What challenges (if any) are encountered with technology-enabled spectrum reforms?
    c. Does your national regulator have the regulatory framework to facilitate the introduction of these new regulatory approaches? Please elaborate.
    d. How is the mobile broadband industry affected by these technology-enabled spectrum management reforms?

Annexure D – List of Potential Respondents

Botswana	
Government	1. Regulator-BW
Mobile Broadband Network Operators	2. Telco-BW1
	3. Telco-BW2
South Africa	
Government	4. Policymaker-SA
	5. Regulator-SA
Mobile Broadband Network Operators	6. Telco-SA1
	7. Telco-SA2
	8. Telco-SA3
Research Institutions	9. Researcher-SA
Network Equipment Vendors	10. Vendor-1
	11. Vendor-2
Zambia	
	12. Regulator-ZM
Mobile Broadband Network Operators	13. Telco-ZM1
	14. Telco-ZM2
SADC	
Regional Regulatory & Development Bodies	15. SADC-1 (Policymaking)
	16. SADC-2 (Regulation)

Annexure E – Ethics Clearance Certificate

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Thukani

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H17/02/28**
PROJECT TITLE	The state of radio frequency spectrum management reforms and the mobile broadband industry in SADC
INVESTIGATOR(S)	Mr T Thukani
SCHOOL/DEPARTMENT	Literature, Languages and Media Studies/
DATE CONSIDERED	17 February 2017
DECISION OF THE COMMITTEE	Approved
EXPIRY DATE	09 March 2020

DATE 10 March 2017 **CHAIRPERSON** _____
(Professor J Knight)

cc: Supervisor : Ms L Abrahams

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

_____ _____/_____/_____
Signature **Date**

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES