

Business Models for Next-generation Communication Networks and Mobile Operators in Africa



By

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Doctor of Philosophy (PhD)

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Abstract

This thesis uses an exploratory, sequential, mixed-methods research approach to: (1) identify and investigate the factors that limit existing business models for mobile network operators (MNOs) in facilitating next-generation communication networks (NGCNs); (2) develop a conceptual business model framework for NGCNs by addressing the shortcomings of existing business models and theoretical concepts in the strategic management and technological innovation literatures; and (3) evaluate the proposed conceptual business model framework for improving the business viability of MNOs. The study was conducted in four successive phases. Phases 1, 2 and 3 achieved the preceding three research aims. Phase 4 presented and interpreted the research findings.

This study linked three main concepts in developing the business model framework: 5G network technologies, mobile network operators and theoretical concepts of management science. For the qualitative part of the study, semi-structured interviews were conducted using a case study approach and snowball sampling. Interview participants included top executives and senior managers from established mobile operators in Africa. The qualitative data analysis was conducted using reflexive thematic analysis and was implemented using the MAXQDA 24 software. The emerging themes and sub-themes as well as the proposed research prepositions were used in developing a conceptual framework and associated research hypotheses. The conceptual framework was quantitatively surveyed among employees of mobile operators in Africa that have commercialised 5G network services. Quantitative data analysis was performed using partial least squares structural equation modelling (PLS-SEM) and implemented using SPSS and SmartPLS software. Based on the quantitative findings, four of the six research hypotheses formulated were significant and clearly supported, while two were insignificant and therefore rejected.

The main contribution of this thesis is the development of a business model framework for African MNOs deploying 5G and beyond networks. Theoretically, the study contributes by designing and examining business models for 5G networks and MNOs in Africa. Methodologically, the study contributes by combining inductive and deductive approaches in theory development, reflexive thematic analysis, PLS-SEM, and the use of MAXQDA24, SPSS and SmartPLS software in a single study. Empirically, the study contributes by highlighting practical implications and recommendations for practitioners, regulators, policy makers, and researchers.

Declaration

I, **Laurence Banda**, declare that this research study on business models for next-generation communication networks and mobile operators in Africa is my own unaided work. It is submitted in the fulfilment of the requirements for the degree of Doctor of Philosophy in Technology and Operations Management (TOM) at the Wits Business School, University of the Witwatersrand, Johannesburg, South Africa. It has never been submitted for any other degree or examination at this or any other university. I further declare that I have duly acknowledged all sources of information used in this study.

Laurence Banda



Signed at Johannesburg, South Africa

On the 13th..... day of February..... 2025

Dedication

To my late parents and to my son, Laurence (Junior)

Peer-Reviewed Publications Emanating from the Study

Journal Articles

Banda, L., Mzyece, M., & Mekuria, F. (2022). 5G Business Models for Mobile Network Operators - A Survey. *IEEE Access*, 10 (3), 94851-94886.

Conference Papers

Banda, L., Mzyece, M., & Mekuria, F. (2022). Business Models for 5G and Future Mobile Network Operators. In *2022 IEEE Future Networks World Forum (FNWF)* (pp. 215-219), 12-14 Oct 2022, Montreal, Canada.

Banda, L., Mzyece, M., & Mekuria, F. (2023). Business Models for 5G-IoT Private Networks. In *2023 IEEE AFRICON* (pp. 1-6), 20-22 Sep 2023, Nairobi, Kenya.

Banda, L., Mzyece, M., & Mekuria, F. (2024). 5G-IoT and Sustainability: Smart City Use Case. In *2024 IEEE Vehicular Technology Conference (VTC)*, 7-10 Oct 2024, Washington DC, USA.

Banda, L., Mzyece, M., & Mekuria, F. (2024). Green Mobile Operator Business Model for 5G and Beyond Networks. In *2024 IEEE Future Networks World Forum (FNWF)*, 15-17 Oct 2024, Dubai, UAE.

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Acronyms and Abbreviations

2G	2 nd Generation (Mobile Communications Networks)
3G	3 rd Generation (Mobile Communications Networks)
3GPP	3 rd Generation Partnership Project
4Cs	Connection, Content, Context, Commerce
4G	4 th Generation (Mobile Communications Networks)
5G	5 th Generation (Mobile Communications Networks)
5G-PPP	5G Infrastructure Public Private Partnership
6G	6 th Generation (Mobile Communications Networks)
AI	Artificial Intelligence
AR	Augmented Reality
AVE	Average Variance Extracted
BM	Business Model
BMI	Business Model Innovation
BMO	Business Model Ontology
CAPEX	Capital Expenditure
eMBB	enhanced Mobile Broadband
FWA	Fixed Wireless Access
HTMT	Heterotrait-Monotrait Ratio
IoT	Internet of Things
ITU	International Telecommunications Union
mMTC	massive Machine Type Communication
ML	Machine Learning
MNO	Mobile Network Operator
MVNO	Mobile Virtual Network Operator
NFV	Network Function Virtualisation
NGCN	Next Generation Communications Network
OPEX	Operational Expenditure
OTT	Over The Top
PLS-SEM	Partial Least Squares SEM
QDA	Qualitative Data Analysis
QoS	Quality of Service
SDGs	Sustainable Development Goals
SDN	Software Defined Networking
SEM	Structural Equation Model
SME	Small to Medium Enterprises
SPSS	Statistical Package for Social Sciences
UHD	Ultra-High Definition
uRLLC	ultra-Reliable and Low Latency Communication
VIF	Variance Inflation Factor
VR	Virtual Reality
WTTx	Wireless to the x

CHAPTER 1: RESEARCH INTRODUCTION AND RATIONALE

1.1 Research Purpose Statement

The purpose of this research study was to use a mixed-methods research design to: (1) Identify and investigate the factors that limit existing business models for mobile network operators (MNOs) in facilitating next-generation communication networks (NGCNs) (i.e., 5G and beyond networks), (2) develop a conceptual business model framework for NGCNs by addressing the shortcomings of existing business models and theoretical concepts in the areas of strategic management and technological innovation, and (3) evaluate the conceptual business model framework for business viability and sustainability of MNOs.

1.2 Background to Next-generation Communication Networks

5G networks are part of next-generation communication networks and were defined under the umbrella name International Mobile Telecommunication - 2020 (IMT-2020) by the International Telecommunication Union - Radiocommunication Sector (ITU-R) to support multi-service wireless applications: higher data rates (20 gigabits/second - peak data rate), reduced communication latency (1 millisecond air interface delay), a large number of wireless device connections (1 million connections per square kilometre), higher spectral-efficiency (three times higher than 4G networks) and improved energy-efficiency (100 times higher than 4G networks) (ITU-R, 2015).

The improvement of eight key performance capabilities from 4G (IMT-Advanced) to 5G (IMT-2020) is shown in Figure 1.1. Some of the capability parameters in Figure 1.1 are targets for IMT-2020 research and are expected to be expanded in future release versions of the ITU-R Recommendations (ITU-R, 2015).

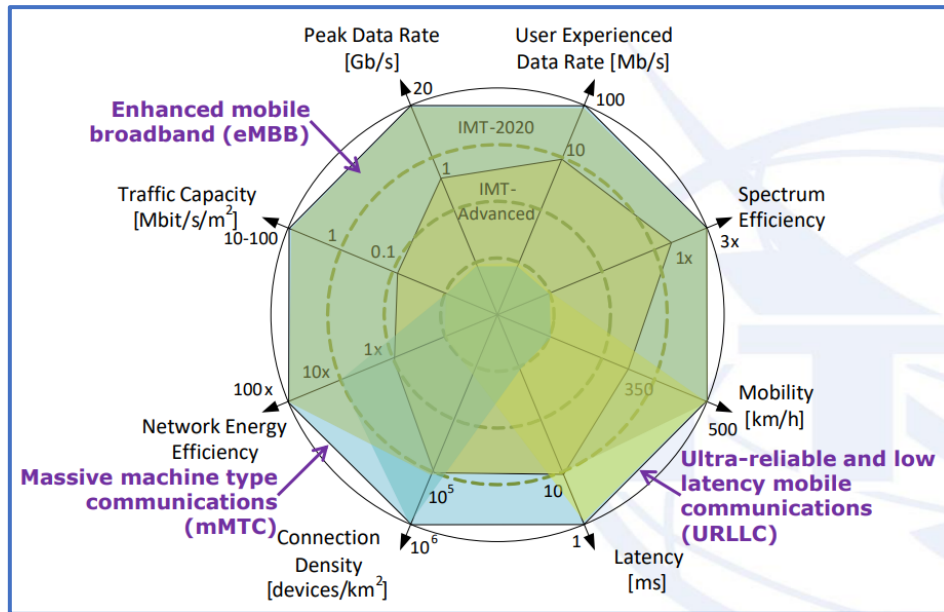


Figure 1.1: Improvement of key capabilities from IMT-Advanced to IMT-2020 (ITU-R, 2015)

1.3 Research Concepts

The emerging 5G and beyond networks are required to enable new business models that can rapidly generate new revenue opportunities for mobile operators in Africa (Coetzee, Mekuria, & du Toit, 2018). As the 5G era becomes a reality, ecosystem players in Africa need to reflect on 5G business cases based on both the supply and demand sides. In particular, careful assessment is required to optimise the transition to 5G in the broader context of next-generation connectivity (K Okeleke, George, & Obiodu, 2019).

This research study designed and investigated the conceptual business model framework based on use cases and services for 5G networks deployed by mobile operators in Africa. In particular, the study integrated three concepts: (1) 5G wireless technologies with a particular focus on 5G networks in Africa; (2) existing business models for mobile operators; and (3) theoretical concepts consisting of strategic management theories that focus on the economic value activities of the business model and theories of technological management that focus on innovation and adoption processes of 5G technologies in Africa. Figure 1.2 illustrates the main research concepts of the study.

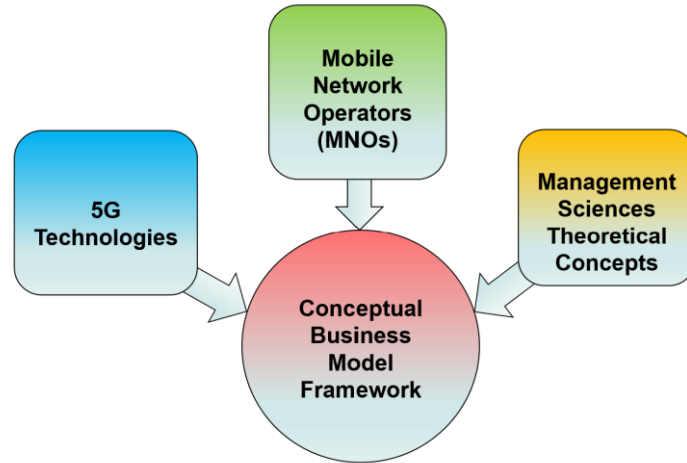


Figure 1.2: Main research concepts

1.4 Knowledge Gap

Research on business models for emerging 5G and beyond networks in the African context has received little attention in the scholarly community. However, there is still limited research that integrates the business model and technological innovations that have resulted from the emergence of 5G and beyond networks, particularly for emerging markets. 5G business models for rural communications have been explored by Skouby (2021) with the aim of closing the urban-rural digital divide and ensuring that the United Nations' 17 Sustainable Development Goals (SDGs) are achieved. Furthermore, Cavalcante, Marquezini, Mendes, and Moreno (2021) analysed the challenges and opportunities of 5G deployment and business modelling in remote areas of Brazil through the collaboration of mobile network operators (MNOs) and rural mobile infrastructure operators (RMIOs). The profit and loss analysis of the developed model shows that a fair distribution of the generated value between the MNOs and RMIO can be achieved. In addition, the problem of deploying 5G services in rural and low-income areas has been studied (Chiaraviglio et al., 2017). The authors considered the possibility of deploying drone-based 5G nodes on large mobile networks in two rural scenarios in the Cook Islands and Zimbabwe, and in a low-income area in Italy. The results show that the 5G nodes can efficiently use renewable energy. Furthermore, the authors claim that end users' monthly subscription fees could be kept significantly low while providing them with adequate and reliable 5G services.

According to Chesbrough (2010), organisations may have substantial investments and processes in place to adopt new technologies, but they often lack the ability to develop new viable business models to drive the new technologies. Although Teece (2010) acknowledges that there is a critical connection between business models and technological innovation, there is still limited research that integrates the business model concept and technological innovation that have emerged from the introduction of 5G and beyond networks. Furthermore, the connection between the 5G business model concept, mobile operators' business strategy and technological innovation has not been sufficiently studied, especially for developing markets such as Africa. Therefore, this research study seeks to fill the gap in the literature in linking theoretically existing concepts: business model, strategic management, technological innovation management and 5G technologies by focusing on mobile operators in Africa.

1.5 Research Problem

Although the emerging 5G and beyond networks are being rapidly deployed in developed markets, Africa appears to be lagging behind in this regard. 5G technologies require huge investments to cover deployment and operational costs, and mobile operators' current business models with subscription as a core element are unlikely to generate enough revenue and profits to cover these costs (Skouby, 2021). Conventional subscription-based business models cannot adequately support the emerging 5G and beyond network technologies that are expected to deliver new, diverse services. In addition, most of these traditional mobile operator business models are simple two-dimensional business-to-business (B2B) models (e.g. mobile operators provide access services to enterprises) or business-to-consumer (B2C) models (e.g. mobile operators offering voice or data to end users) (Iankova, Davies, Archer-Brown, Marder, & Yau, 2019). However, the 5G value chain also involves other industry players, resulting in complex business ecosystems that traditional B2B or B2C models cannot enable. To this end, African mobile operators should adopt multi-dimensional business models such as business-to-business-consumer (B2B2C) models that can support new and diversified services within the complex 5G value networks (Iankova et al., 2019).

The combined challenge of high network investments and untested business models is significant, but appears to be accepted by investors in developed countries with the ongoing rollout of 5G. However, this is unlikely to happen in some African markets where no or very poor communications infrastructure is available (Skouby, 2021). Findings from some African mobile operators that have rolled out 5G networks appear to be leveraging traditional mobile network business models. This could be because mobile operators do not have documented business models and the literature does not provide structured guidelines for the development and implementation of business models for 5G networks and mobile operators. This issue should be addressed as disruptive technologies such as 5G networks often alter the existing value chain, thereby impacting the current ecosystem for mobile operators, making traditional business models unsuitable (Peppard & Rylander, 2006).

1.6 Research Questions

Based on the research problem outlined above, the key research question is:

How can a viable business model framework for next-generation communication networks be designed to achieve increased economic value for mobile operators in Africa?

1.6.1 Sub-questions

The following sub-questions were identified to address the main research question under study.

SQ1: What factors limit existing business models in enabling next-generation communication networks?

SQ2: How can a business model for next-generation communication networks be conceptualised and developed?

SQ3: How can the designed business model framework have a positive impact on the business viability and sustainability of mobile operators?

1.7 Research Objectives

The primary objective of this research study was to design a viable and sustainable business model framework that mobile operators in Africa can adopt when deploying next-generation networks.

1.7.1 Specific Objectives

Corresponding specific objectives are:

- To review literature on business models and next-generation communication networks.
- To study the current and future deployment status of 5G and beyond next-generation communication networks in Africa.
- To determine the optimal strategy with respect to business models that mobile operators in Africa can implement when deploying next-generation communication networks.
- To identify key factors that limit current and future business models in supporting the emerging next-generation communication networks deployed by African mobile operators.
- To understand how theoretical concepts in strategic management and technological innovation can be employed in formulating the business model framework.
- To determine the role and impact of the business model concept on mobile operators' profitability, long-term sustainability and new use cases for technological advancement.
- To examine the relationship between the integration of 5G technologies, mobile network operators and theoretical concepts in designing the business model framework.

1.8 Contributions and Outputs of the Study

This research study contributes significantly to the development of business models for the emerging 5G and beyond networks that can be adopted by African mobile operators. The theoretical and practical contributions as well as the outputs of the present research study are highlighted below:

- **Theoretical Contribution**

This research will lead to a better understanding of the underlying theoretical constructs on business models and next-generation networks. The development of a conceptual business model framework using theoretical concepts from the fields of strategic management and technological innovation management will contribute to the current literature in management sciences. In addition, the research outcome will form the basis for future research on business models, business model innovations and next-generation communication networks.

- **Practical Contribution**

From an industry perspective, mobile operators in Africa will be able to identify business models that are most cost-effective when deploying the emerging 5G and beyond wireless networks. This ensures that appropriate customer value propositions (5G services), customer interface, infrastructure management and financial goals are achieved (Zott, Amit, & Massa, 2011). Established mobile operators in developed markets such as the United Kingdom have recognised that the next development path for mobile services is next-generation wireless services (Jones & Comfort, 2020). Accordingly, operators in these markets have already invested in upgrading their current networks to the latest technologies to gain a first-mover advantage. However, due to the wide range of options available, finding the best and most cost-effective technological path seems to be a challenge.

Furthermore, most operators are still unsure about the optimal business model to implement since the business landscape of next-generation networks is new (Patwary et al., 2020). Therefore, this study will help demystify the implementation strategies of next-generation networks' business models and the technological path to be taken when deploying these cutting-edge communication networks. Additionally, the significance of the study is that it highlights the importance of developing innovative business models that address the potentially disruptive impact of next-generation networks in an African environment. This will enable mobile network operators to increase their market value, gain competitive advantages and improve the business environment within the framework of existing and future laws and regulatory policies (Manenti & Scialà, 2013).

● Research Outputs

The list below presents the research outputs in terms of international journal articles and conference proceedings publications:

Journal Articles

Banda, L., Mzyece, M., & Mekuria, F. (2022). 5G Business Models for Mobile Network Operators - A Survey. *IEEE Access*, 10 (3), 94851-94886.

Banda, L., Mzyece, M., & Mekuria, F. (2024). Business Models for 5G Mobile Network Operators in Sub-Saharan Africa: Policy Perspectives. Submitted to *Telecommunications Policy*.

Conference Proceedings

Banda, L., Mzyece, M., & Mekuria, F. (2022). Business Models for 5G and Future Mobile Network Operators. In *2022 IEEE Future Networks World Forum (FNWF'22)* (pp. 215-219), 12-14 Oct 2022, Montreal, Canada.

Banda, L., Mzyece, M., & Mekuria, F. (2023). Business Models for 5G-IoT Private Networks. In *2023 IEEE AFRICON* (pp. 1-6), 20-22 Sep 2023, Nairobi, Kenya.

Banda, L., Mzyece, M., & Mekuria, F. (2024). 5G-IoT and Sustainability: Smart City Use Case. (Accepted) *2024 IEEE Vehicular Technology Conference (VTC)*, 7-10 Oct 2024, Washington DC, USA.

Banda, L., Mzyece, M., & Mekuria, F. (2024). Green Mobile Operator Business Models for 5G and Beyond. Submitted to *2024 IEEE Future Networks World Forum (FNWF'24)* 22-24 Oct 2024, Dubai, UAE.

1.9 Delimitations and Scope of the Study

The following are the delimitations and scope of the study.

- The study focuses exclusively on the design of business models for mobile cellular network operators. Business models for over-the-top (OTT) content providers, social media networks, equipment vendors or device manufacturers are not investigated. However, the impact of the role of OTT actors and other stakeholders on the business model of mobile operators is taken into account.

- Business models for previous mobile generations networks (2G, 3G and 4G) are not considered. However, the technology part of the study will cover both 4G and 5G networks to identify the best options for upgrading from 4G to 5G networks.
- The research study focuses primarily on mobile operators that are established in the mobile network market in the sense that they are not considered start-ups or similar entrepreneurial ventures.
- Business models are studied from both the perspective of strategic management and technological innovation management. The strategic management perspective focuses on economic value activities, while the technological innovation management perspective examines next-generation networks as technology enablers for mobile operators' business models. The study does not consider business models from organisational theory, e-business, entrepreneurial, marketing or accounting perspectives.

1.10 Assumptions of the Study

The present research study assumes the following:

- The mobile operators are established in the existing mobile network markets and operate within the relevant government policies, guidelines and regulations.
- The 5G network is deployed in either 5G non-standalone (NSA) or 5G Standalone (SA) configuration mode (Teral, 2019). In the NSA configuration, the 5G radio access network is anchored on the 4G core network, while in the SA configuration, the 5G core network is deployed to support end-to-end 5G services.
- The technical aspects such as network design, network configuration, hardware installation and software commissioning are successfully implemented in the introduction of next-generation communication networks. However, as de Vasconcelos Gomes, Lopez-Vega, and Facin (2021) noted, the mobile operator should assess the potential technological uncertainties it may face when introducing new technologies such as 5G with its alliance

partners such as network vendors, technical consultants and contracted hardware installers, so that the adverse effects of such uncertainties are mitigated.

- During the data collection phase of the research study, survey questionnaire respondents are honest and accurately reflect actual experiences in the mobile communications industry.

1.11 Definitions of Key Concepts

This section provides brief definitions of all concepts and constructs examined in the present research. A comprehensive discussion is provided in Chapters 2 and 3. For the current research study, concepts are defined as follows:

1. Next-generation Communication Networks

Next-generation communication networks (i.e., 5G and beyond networks) refer to future generations of mobile wireless communication systems consisting of the emerging 5G network standards (ITU-R, 2015) and the wireless communication networks of 2030 (i.e., 6G and beyond) (Alsharif et al., 2020). These intelligent and advanced wireless networks are intended to serve not only consumer-based smartphone applications, but also the needs of various vertical industrial markets (e.g. public service, education, energy, healthcare, transportation, manufacturing, mining, agriculture, etc.). 5G networks are designed to meet the needs of a fully connected world and provide ubiquitous wireless connectivity for all (ITU-R, 2015).

2. Ecosystem and 5G Ecosystem

In the discipline of management science and operations research, an ecosystem can be described as an alignment structure of the multilateral group of partners that must interact through both competition and cooperation within their business environment to achieve a core value proposition (Adner, 2017). The 5G ecosystem will bring together various industry partners to enable the convergence of wireless infrastructure, connectivity and devices in a holistic manner (DotEcon & Axon, 2018). Recently, the mobile industry witnessed a rapid expansion of the 5G ecosystem with the addition of key industry players such as consumer and enterprise customers, original equipment manufacturers (OEMs), device manufacturers, infrastructure

providers, network maintenance partners, system integration partners, testing and validation partners, independent technology consultants, and so forth (Banda, Mzyece, & Mekuria, 2022a).

3. Business Model, Disruptive Business Model, and Business Model Innovation

A business model is the rationale of how an organisation creates, delivers, and captures value from its customers (Osterwalder & Pigneur, 2010). Thus, a business model is the underlying economic logic of how a company creates, delivers and captures value by serving the target customer, taking into account key activities, resources and partnerships, as well as the value exchange between the core company and its alliance partners (Osterwalder, Pigneur, & Tucci, 2005).

A disruptive business model occurs when new technologies and innovations become crucial in relation to an existing business model (Schiavi & Behr, 2018). In such cases, disruptive business models emerge that replace existing business models, either by modifying them or by developing completely new business models that target a specific value proposition of new technologies (Schiavi & Behr, 2018).

Business model innovation (BMI) occurs when one or more components of an existing business model are altered or modified to create, deliver and capture value in new ways. Business model innovation is therefore a process of modifying a company's existing business model by establishing new value propositions, designing new value creation and value delivery channels, and developing innovative value capture mechanisms (H. Guo, Zhao, & Tang, 2013).

4. Mobile Network Operator

A mobile network operator (MNO) is a licenced telecommunications company that owns and operates the network spectrum and infrastructure, provides voice and data services to subscribers, supplies devices, and controls the billing systems for customers use (Bormann, Flake, & Tacken, 2007). Furthermore, an MNO can be described as either a public (primary carrier) or a private MNO (Banda et al., 2022a). A public MNO owns and operates the spectrum and network infrastructure. In contrast, a private MNO is a private organization (e.g., an enterprise) that owns, operates, or has priority access to the network's infrastructure or

spectrum. The amount of network infrastructure and spectrum owned and operated by a private MNO can vary widely (S. Guo, Lu, Wen, Dang, & Saeed, 2022).

5. Vertical Markets

A market in which a seller offers products or services specifically tailored to a particular industry or a group of customers with specialised needs. Thus, a vertical market includes all potential buyers or purchasers in a particular profession, industry, or trade (Lv, Chen, & Li, 2021). 5G industry verticals markets include: automotive, transportation and logistics, mining, agriculture, public services, aviation, healthcare, manufacturing, education, and many more (Banda, Mzyece, & Mekuria, 2022b; DotEcon & Axon, 2018).

1.12 Thesis Structure

This doctoral research thesis consists of seven chapters and is structured as follows:

Chapter 1 presents the general background and rationale of the study. It highlights the concepts associated with the present research, the knowledge gap, the research problem, the research questions, the research objectives, and the research contributions and outputs. In addition, the chapter highlights the delimitations, scope and assumptions of the study as well as definitions of key research concepts and constructs.

Chapter 2 provides the context of the research study by highlighting the meaning and significance of 5G from an African perspective. The chapter also discusses progress in 5G deployment, current status and future projections, challenges in deployment on the continent, adoption strategies, and the impact of policies and regulations on 5G deployment in Africa.

Chapter 3 contains a detailed literature review. It provides insights into the extant research and the theoretical elements underpinning the study. The chapter summarises the state of existing knowledge on the theoretical business model concept and the related published work on next-generation communication networks (i.e. 5G and beyond networks).

Chapter 4 describes the research design and methodology used for the study. A sequential exploratory mixed-methods design approach was adopted. The research design and

methodology chapter include research process, research philosophy, research methodology and approach to theory development, research design, population and sampling strategy, data collection and analysis, reliability and validity, and ethical considerations.

Chapter 5 presents the analysis and interpretation of both qualitative and quantitative data collected from the research participants. The process of data analysis and interpretation is guided by the research questions and objectives of the study.

Chapter 6 discusses both qualitative and quantitative research findings to provide insight into the results and demonstrate the achievement of the research objectives. The results are discussed with reference to theory and existing literature.

Chapter 7 concludes the thesis with the main concluding remarks, significance and implications of the study, limitations of the study, reflections on the research process and recommendations for future research.

Figure 1.3 presents the structure of the thesis.

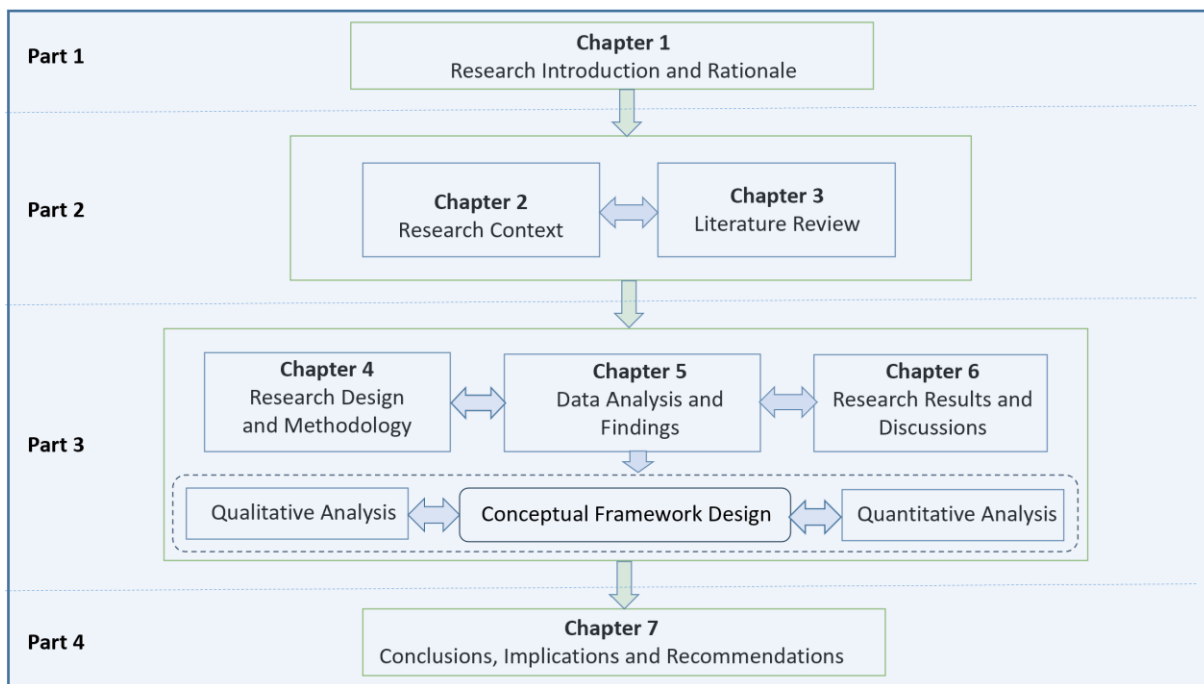


Figure 1.3: Thesis structure

CHAPTER 2: RESEARCH CONTEXT

2.1 Introduction

The present research study focuses on business models for next-generation communications networks (i.e., 5G and beyond) and mobile operators in Africa. To put the research into context, 5G technologies are discussed by highlighting the significance of 5G from an African perspective. Thereafter, 5G deployment in Africa is presented by specifically discussing: progress and current status, future deployment projections, adoption strategies and African challenges in deploying 5G technologies. The chapter concludes with an overview of the impact of policy and regulation on 5G deployment in Africa.

2.2 5G Networks in the African Context

There are about 1.4 billion people living on the African continent (Worldometer, 2023), and the population is expected to increase in the coming years to approximately 1.7 billion people in 2030 (UNICEF, 2017). Information and communications technology (ICT) in Africa has experienced dynamic growth in recent years, particularly driven by the mobile communications sector. According to Coetzee et al. (2018), Sub-Saharan Africa remains the region with the highest growth rate in mobile subscriptions globally. The report by Coetzee et al. (2018) further projects that by 2025, the number of mobile subscriptions in sub-Saharan Africa will exceed 900 million, total mobile data traffic will increase elevenfold (compared to 2019), and there will be around 75 million cellular Internet of Things (IoT) connected devices.

By 2025, there will be 28 million 5G connections in the sub-Saharan Africa region, representing 3% of total mobile connections, with commercial services in at least seven markets, including South Africa, Nigeria and Kenya (K Okeleke et al., 2019). Additionally, with over 200 million connections in sub-Saharan Africa in 2030, 5G is expected to bring US\$11 billion in benefits to the regional economy, accounting for more than 6% of the total economic impact of the mobile industry (GSMA, 2023). The main factors contributing to this unprecedented growth

will be: the widespread rollout of 5G network coverage, the reduction in prices for both 5G-enabled devices and services, and the rapid increase in access to relevant video content provided by new players in the 5G ecosystem (K Okeleke et al., 2019).

2.2.1 The Significance of 5G in Africa

Africa has historically lagged behind in terms of technological advancement. While Europe, North America, and Asia Pacific regions have been technological frontrunners, Africa has always been viewed as a mere consumer market (Garba, Oshiga, & Moriki, 2022). Nevertheless, the emerging 5G and associated technologies provide an opportunity for Africa to actively participate and play a vital role as a key stakeholder in the continued deployment and development of 5G technologies.

The emerging 5G is the first cellular network technology tailored to the specific needs of various industry verticals including: healthcare, automotive, energy, public services and utilities, manufacturing and logistics, agriculture and so forth (Waterfront & Wharf, 2019). In addition, 5G networks have revolutionized the mobile sector by opening the market to new entrants such as micro-operators, content providers and infrastructure owners, expanding the traditional mobile business ecosystem and paving the way for industry-specific requirements in a hyper-connected, intelligent and digital world of the future (Moqaddamerad, Ahokangas, Matinmikko, & Rohrbeck, 2017).

The information and communications technology (ICT) sector is a huge market that can drive digitalisation and the growth of new smart industries through the relevant use of 5G and future wireless technologies (Ericsson, 2019). The continued deployment of 5G opens up the opportunity for mobile operators to go beyond connectivity and collaborate across vertical sectors to deliver new and comprehensive services to residential and business customers (Obiodu, 2019). 5G and future wireless technologies also offer industry, society and individuals the opportunity to advance their digital capabilities and ambitions (Oughton, Comini, Foster, & Hall, 2022).

Africa's investments in 5G network technologies will benefit various key players and stakeholders in the value chain of the mobile market such as: (1) Service providers - consisting of mobile network operators and private service providers, (2) Network vendors - comprising equipment manufacturers, device manufacturers and technology providers, (3) Industry partners - composed of private enterprises, vertical industry markets, and government/public entities

Figure 2.1 shows the expected key investment beneficiaries in the African 5G market.

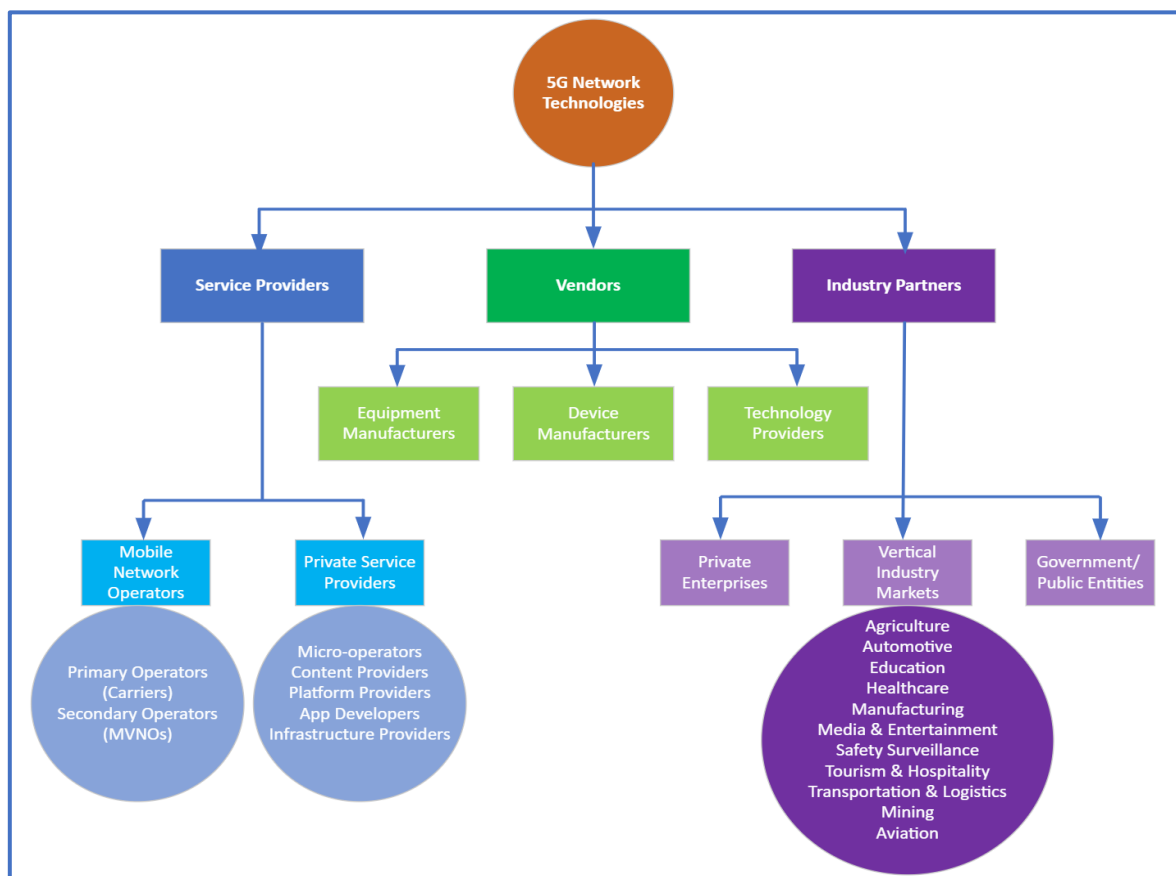


Figure 2.1: 5G key investment beneficiaries within the African market (compiled by researcher)

Within industry verticals, 5G is expected to benefit most sectors of the Sub-Saharan African economy, depending on their ability to integrate 5G use cases into their business. According to GSMA (2023), over the period leading to 2030, 32% of benefits are expected to come from

the manufacturing sector, driven by IoT applications such as smart factories, smart cities and smart grids, and 29% from the services sector, including public administration, finance, healthcare and education, as shown in Figure 2.2 below.

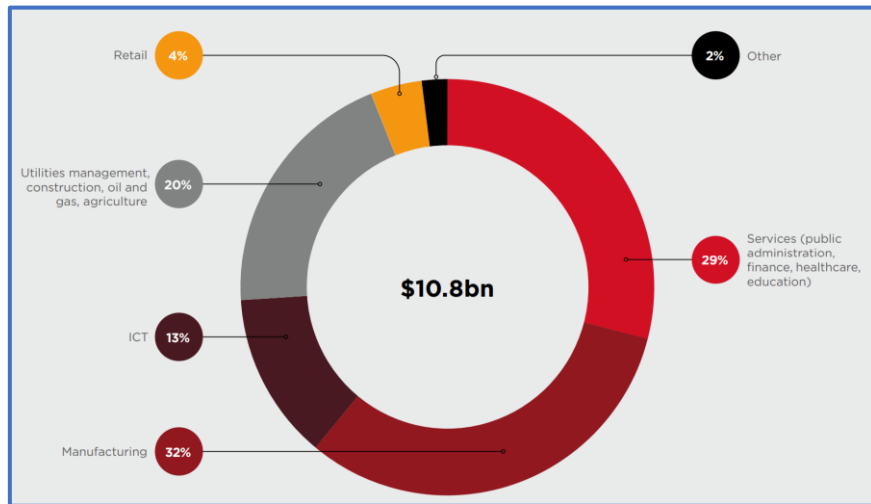


Figure 2.2: Sub-Saharan Africa, 5G contribution by vertical industry market, 2030 (Source: (GSMA, 2023))

2.3 Deployment of 5G Networks in Africa

Despite the negative economic impact of the COVID-19 pandemic, mobile operators continue to expand their 5G networks faster than expected. This has led to fierce competition for market share in the mobile communications sector. Therefore, operators should identify key areas that are a priority for their future market growth. Additionally, 5G investments, deployments and markets are increasingly consumer-focused. This of course has an impact on the potential of the enterprise market, which has not yet been fully exploited (Ericsson, 2019).

2.3.1 Progress and Current Status of 5G Deployment

In preparation for 5G networks, most mobile operators in Africa have upgraded their existing 4G network nodes to 5G-ready baseband and radio antennas that can support multi-band

frequency spectrum. In addition, there is a need to build a suitable transport network infrastructure based primarily on fibre technology. Operators also need to leverage network management virtualisation through the use of cost-effective technologies such as Software-Defined Networking (SDN) and Network Function Virtualization (NFV), both of which are important enablers of network slicing (K Okeleke et al., 2019).

The Global and African 5G network index is defined as the ratio of countries with commercially available 5G network services to the total number of countries in the world and Africa, respectively (Adimula, Idowu, & Ojerheghan, 2020). As of November, 2020, only 34 of the world’s 193 UN-recognised countries had 5G networks and only 2 (South Africa and Lesotho) of 54 African countries had 5G deployed (Likhtman, 2020). These figures correspond to a global 5G network index of 18% and an African 5G network index of 3.7% (Handforth, 2019).

5G continues to gain momentum in Africa. As of September 2023, 27 operators had launched commercial 5G services in 16 markets across the region (Kenechi Okeleke & Joiner, 2023). According to Kenechi Okeleke and Joiner (2023), more markets are expected to follow soon, with operators in another ten countries committing to deploy 5G in the coming years. 5G coverage in the region is still largely limited to major cities, but there is increasing evidence that 5G coverage is increasing in some countries. For example, in South Africa, 5G coverage reached 41% of the population in September 2023 (Kenechi Okeleke & Joiner, 2023). Figure 2.3 shows commercial 5G deployment in Africa for the year ending December 2023.

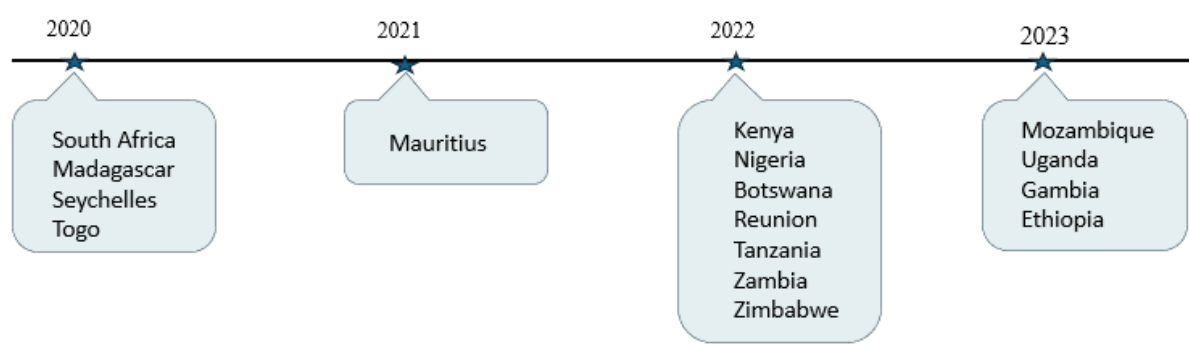


Figure 2.3: Commercial 5G deployments in Africa by year from 2020 to 2023 (source: (Kenechi Okeleke & Joiner, 2023))

As of October 2023, only 10 countries in Africa had allocated spectrum to mobile operators for 5G services (Kenechi Okeleke & Joiner, 2023). While this represents reasonable progress compared to the previous year, 5G spectrum allocation in the region is still underdeveloped compared to Asia Pacific, Europe and North America. Further progress is likely to be made in 2023 and beyond, with several countries set to auction 5G spectrum in the coming years.

2.3.2 Future 5G Deployment Forecast

Despite the global experience with the COVID-19 pandemic and the associated economic constraints, the rollout of 5G networks continued unabated at the beginning of this decade (Hatt & Jarich, 2020). In 2020, three network operators: Vodacom, MTN and RAIN launched the first major 5G networks in Africa, offering mobile and fixed wireless access (FWA) services in South Africa. FWA is a more obvious opportunity in Africa due to the lack of fixed-line infrastructure (Hatt & Jarich, 2020). In Nigeria, 5G technology was not commercially launched until 2021 despite the three-month trial test conducted in 2019 following approval by the national regulator, the Nigerian Communications Commission (Agubor, Chukwuchekwa, & Ezema, 2021). It is unlikely that some African countries will see mass deployment of 5G networks any time soon, as most mobile operators are likely to focus on 4G deployment (GSMA, 2023). This is because the average adoption rate of 4G on the continent is only 12% and more than half of the capacity is still unused, so the return on investment (RoI) has not yet been achieved (Hatt & Jarich, 2020). In addition, 4G technology is sufficient to meet the current needs of subscribers as well as most Internet use cases in the region. Furthermore, the cost of 5G devices will remain exorbitantly high for most African consumers for the foreseeable future (Hatt & Jarich, 2020).

The GSMA (2023) report predicts that there will be 226 million 5G connections in Sub-Saharan Africa in 2030, representing an adoption rate of 17%. The report further indicates that Nigeria and South Africa will account for almost half of these connections. Furthermore, by 2030, there will be over 1.2 billion smartphone connections in Sub-Saharan Africa, accounting for 88% of total mobile connections in the region, compared to the global average of 92% (GSMA, 2023).

With the increase in smartphone connections, mobile data traffic from immersive content and video applications in the Sub-Saharan Africa region will quadruple by 2028 (GSMA, 2023).

Sub-Saharan Africa is experiencing steady growth in mobile subscribers. This will continue over the next seven years, increasing the total number to nearly 700 million by the end of 2030, with Nigeria and Ethiopia accounting for almost a third of the total number of participants over this period (GSMA, 2023). Mobile penetration in Sub-Saharan Africa will reach 50% by 2030. Nevertheless, this figure will be well below the global average of 73% in the same year and within the region, the penetration rate will be highest in Mauritius at 93% of the population (GSMA, 2023).

Despite the ongoing massive deployment of 5G technologies in Sub-Saharan Africa, the GSMA (2020b) predicts that 4G will remain a dominant technology for the foreseeable future and 5G set to gain momentum. Figure 2.4 shows the scope of mobile networks in Africa from 2020 to 2030, as forecast in the GSMA report (Kenechi Okeleke, James Joiner, & Emanuel Kolta, 2022).

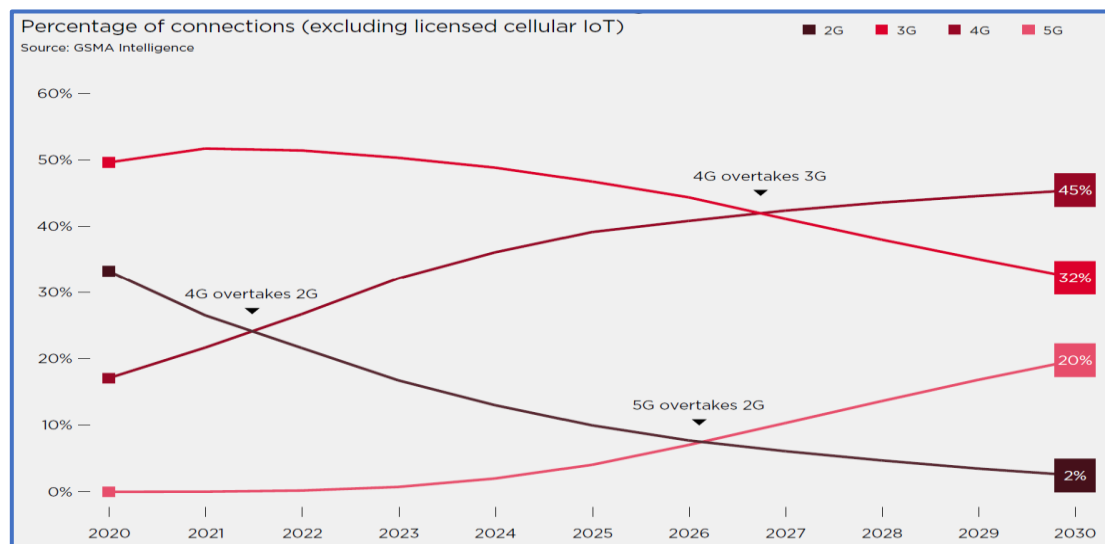


Figure 2.4: Scope of mobile networks in Africa from 2020 to 2030 (Source: (Kenechi Okeleke, Joiner, & Kolta, 2022))

5G is currently at a nascent stage in Africa, with adoption rate at around 1% of total connections and is expected to increase to 8% by 2026 (Kenechi Okeleke et al., 2022). By this point, 5G

adoption will have overtaken 2G adoption and will have reached a double-digit share of total connections in eight countries in the region: South Africa, Morocco, Réunion, Botswana, Zambia, Mauritius, Algeria and Namibia (Kenechi Okeleke & Joiner, 2023). The adoption of 5G will continue to increase in the following years, accounting for 22% of all connections by the end of the decade (GSMA, 2023). Figure 2.5 shows the predicted top 10 markets in Africa by 5G adoption in 2030.

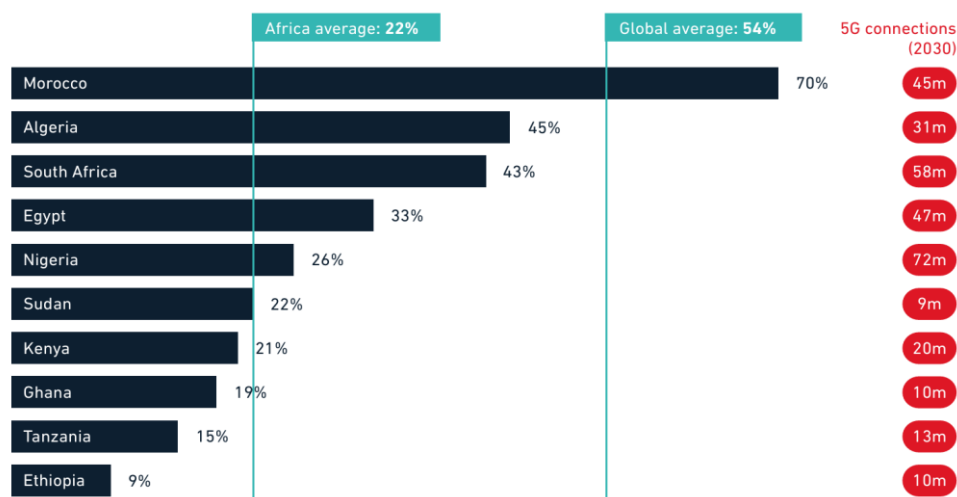


Figure 2.5: Top 10 markets in Africa by 5G adoption, 2030 (source: (Kenechi Okeleke & Joiner, 2023))

2.3.3 African Challenges in 5G Network Deployment

The key challenges underlying the deployment of 5G networks in developing countries, and particularly in Africa, are diverse. These challenges range from the business environment and investment prospects to the political atmosphere and the level of technological progress. The following challenges have been discussed in the literature.

- **4G is capable of meeting the current mobile broadband service demands**

Although 5G deployment is inevitable, it is unlikely to be imminent in some African countries as existing 4G technologies can support current use cases and demand for mobile broadband connectivity (K Okeleke et al., 2019). Therefore, most mobile operators would prefer to explore the untapped markets for 4G and maximise their return on investment (RoI) before implementing the 5G technologies.

- **Exorbitant spectrum pricing**

In developing markets such as Africa, spectrum pricing is dominated by regulations and policies aimed at maximising communications regulators' revenues. Spectrum prices in countries like Nigeria are reportedly much higher than most developed countries (Agubor et al., 2021). The exorbitant spectrum prices are influenced by several factors, usually related to expensive and low-quality mobile broadband services (Coetzee et al., 2018). Consequently, the return on investment for mobile operators will be negatively affected. This can lead to lower investments by mobile operators and thus higher service prices for customers.

- **Unavailability and unaffordability of 5G capable devices**

As with other previous network technologies, the rollout of 5G in Africa should be accompanied by 5G-capable devices. However, the cost of 5G devices will remain exorbitantly high for most African consumers for the foreseeable future (Hatt & Jarich, 2020). Due to the slow rollout of the 5G network on the continent, the maturity level of the 5G device market is also low, as device manufacturers are sceptical about achieving sales and revenue growth in seemingly smaller markets. The biggest challenge for device manufacturers in Africa is to produce devices at a low enough price to gain market share, particularly in the 5G and 4G markets where devices remain extremely expensive for most regional consumers (GSMA, 2023).

- **Inadequate 5G network infrastructure**

Most African countries have weak financial bases, low human resource development per capita, sub-standard network infrastructure and low quality broadband connectivity (Adimula et al., 2020). This may lead to loss of confidence by potential investors seeking to deploy 5G networks in certain countries.

- **Low fibre penetration**

The 5G transport network is mainly supported by fibre infrastructure due to the higher transmission bandwidth and low transmission latency of fibre optic technology (Jaber, Imran, Tafazolli, & Tukmanov, 2016). However, low fibre penetration in Africa is a key challenge in the rollout of 5G networks. The fibre penetration rate in Africa was 10% in 2017 (compared to 30% globally) and will only reach 15% by 2025 (compared to 40% globally) (Handforth, 2019).

- **Unreliable power supply**

The energy consumption of 5G hardware equipment such as baseband units and radio frequency components is relatively higher than that of previous technologies (ITU-R, 2015). Most African countries have experienced power outages due to load-shedding over the years. The power shortage is mainly because of increased demand due to industrialisation and urbanisation (Kaseke & Hosking, 2013). This has resulted in higher OPEX for operators as diesel-powered generators and expensive batteries are used as backup power sources (DotEcon & Axon, 2018).

- **Societal issues**

Most radio base stations are distributed across urban and suburban areas where mobile operators face community challenges. Key challenges include site acquisition during network rollout surveys and site access during network maintenance (Garba et al., 2022). This can be attributed to hostile access policies from landowners, security concerns, equipment vandalism, as well as bureaucratic environmental policies of local authorities in land acquisition and tower construction.

2.3.4 Proposed Adoption Strategy for 5G Technologies in Africa

Commercial 5G networks are now operational in almost every region of the world, making 5G a truly global technology. However, the adoption of 5G is progressing at different rates in different regions of the world. As an emerging state-of-the-art technology, the adoption of 5G should meet the current and future needs of the African continent. This is critical to ensure that Africa does not fall behind in terms of technological advancement and skills. Technologically advanced economies such as Western Europe, North America and North East Asia (i.e., China, Japan and South Korea) were considered early-movers of 5G technology and begun adopting 5G through primary innovation (GSMA, 2021). Conversely, it would be appropriate to consider less advanced adoption levels through secondary innovations for developing and emerging economies such as Africa, which have low 5G deployment rates and face the above-mentioned rollout challenges (Q. Xu & Wu, 1991). Research by X. Wu, Ma, and Shi (2010) has shown how latecomer firms can successfully introduce new and disruptive technologies from advanced

economies to emerging markets through secondary business model innovations, despite their disadvantages in terms of technological capabilities and market resources.

Standards organizations such as the ITU and IEEE are proposing new innovations and a scaled-down version of the 5G standard to accelerate the adoption of 5G. For example, the IEEE has developed a draft standard for a scaled-down version of the 5G standard called P2061, also known as Frugal 5G (IEEE, 2021). Frugal 5G describes a draft 5G standard architecture for an energy-efficient, low-mobility network with affordable broadband access. In addition, Frugal 5G will enable developing countries to start implementing 5G with lower capabilities and describes some of the use cases such as: basic connectivity to ICT infrastructure; economic opportunities for the agricultural sector, small businesses, and financial inclusion; human resource development and access to life-enhancing services such as healthcare, education, entertainment, support for clean water, sanitation and clean energy; and e-governance and electronic citizen service delivery (IEEE, 2021).

In the context of 5G adoption, mobile operators in Africa can be viewed as technological laggards while, operators in developed markets can be viewed as first-movers or pioneers. As latecomers, African mobile operators have two key advantages:

1. Importing 5G implementation strategies - The phenomenon of technological paradigm shifts offers African operators the opportunity to realise technological capabilities by importing 5G technology implementation strategies from developed countries.
2. Competitive position - Initial competitive advantages, such as low adoption costs, that African mobile operators can leverage to strengthen their position within the global 5G ecosystem.

2.4 Impact of Regulatory Policies on 5G Deployment

The expected socio-economic benefits of 5G have already attracted the attention of regulators and policymakers, who are expected to continue playing a critical role in accelerating global 5G deployment. It is worth noting that regulatory measures can either help or hinder the

deployment of 5G networks. With a positive outlook, the significant investments required for 5G deployment are expected to be motivated by a stable, consistent and proportionate regulatory framework for all stakeholders (DotEcon & Axon, 2018).

5G is considered a disruptive innovation of the 21st century because it has created new market values in which new services and applications are emerging in unexpected ways. Therefore, policymakers face major challenges in monitoring 5G deployment in their respective countries (Suryanegara, 2016). Furthermore, since the future development of 5G technologies and associated markets is open, implementation guidelines are being developed with incomplete knowledge and under conditions of uncertainty (Bauer & Bohlin, 2022).

Regulators and policymakers should ensure that suitable spectrum is available in appropriate frequency bands, in sufficient quantities and with favourable licencing conditions (DotEcon & Axon, 2018). Maintaining a stable and predictable regulatory and spectrum management environment is critical to operators' long-term investments in network infrastructure, service quality and spectrum resources. Exclusive allocation methods for licensed mobile spectrum will continue to be important to ensure stability for long-term investments in networks and the underlying spectrum (5G-IA, 2015).

5G technology has triggered the deployment of local 5G networks in various industry vertical sectors (Ahokangas et al., 2019). Ensuring spectrum availability for these local 5G networks should be a priority for regulators in their 5G decision-making as this requires adjustments to existing spectrum valuation approaches that serve as the basis for spectrum allocation decisions (Matinmikko, Latva-aho, Ahokangas, & Seppänen, 2018). In their work, Taheribakhsh, Jafari, Peiro, and Kazemifard (2020) identified spectrum management and spectrum fragmentation as key regulatory issues in 5G implementation. According to Taheribakhsh et al. (2020), regulators face spectrum management challenges, particularly for local and specialised 5G providers such as private 5G networks and 5G micro operators. Micro licensees may have to pay high fees for backhaul or middle-mile connectivity to established competitors in their region. Spectrum fragmentation poses a challenge that can lead to interoperability issues between equipment vendors and mobile operators, thereby reducing the impact of 5G efforts. This should be taken into account in the market approach (e.g. spectrum trading) and controlled by spectrum and

licencing authorities for new 5G spectrum releases in order to achieve a harmonised 5G spectrum (GSM-Association, 2016). A summary of the 5G regulatory components, their role in 5G and the associated challenges in their implementation is given in Table 2.1.

Table 2.1: 5G regulatory components, role in 5G and challenges (compiled by researcher)

Regulatory Component	Description	Role in 5G	Challenges
Spectrum management	• Spectrum authorisation granting of access rights to use frequency bands including rights and obligations (licensing models)	• New local licensing models will be needed to complement existing models to allow different stakeholders to establish local 5G small cell radio access networks with guaranteed quality.	• Spectrum fragmentation causes interoperability issues especially between public and private 5G networks.
Network access regulation	• Interconnection and interoperability requirement to allow access to infrastructure for operators (e.g., MVNO and private 5G operators) who do not own it.	• Network slicing and providing “network as a service” spans across multiple stakeholders and local 5G small cell radio access network deployments need to connect to other operator networks to ensure end-to-end connectivity	• Infrastructure owners may charge higher access fees. • Non-infrastructure owners have limited governance and management of the network.
Coverage and Quality	• Regulatory authorities should ensure that MNOs, enterprise operators, micro-operators and other service providers meet end-users’ coverage requirements with guaranteed quality of service (QoS).	• Network operators are encouraged to deliver more value to their existing customers and potentially new ones by contributing to cross-industry activity that benefit governments, enterprises, and consumers.	• Investment in coverage and capacity dimensioning to meet the target subscriber base can be capital-intensive for most operators. • For most MNOs, QoS guarantee is mostly focused on urban population where return on investment (RoI) is substantially higher than in rural areas.
Pricing regulation	• High quality services should be made available for end users with affordable prices. Retail and wholesale prices between operators need to be non-discriminatory and reasonable.	• Local and private 5G networks need to be allowed to connect to other networks with reasonable prices to ensure affordable prices for end users.	• Dependent local and private 5G operator tend to pay hefty connection fees to access MNOs’ infrastructure. • Higher connection fees give rise to higher service prices for consumers
Competition management	• Holders of significant market power should not be allowed to abuse their dominant positions. • Incumbent and new market entrants should be treated fairly.	• Regulations should promote competition among MNOs, micro-operators and private operators to serve vertical sectors' specific needs in specific areas as well as the consumers.	• Heterogeneity among key stakeholders such as customers and partners pose a challenge for regulators to level the playing field as far as market dominance control is concerned.
Network security and user privacy	• Service providers need to safeguard the security of their services and protect the privacy and data of users as well as confidentiality.	• Role of data collection, analysis and usage will increase in 5G service provisioning which calls for regulatory actions to define rules for data ownership and exploitation.	• The massive device connectivity being championed mainly by industrial IoT is a challenge for both operators and regulators in ensuring network cyber-security and user privacy protection.
Taxation	• Network operators obliged to comply with national tax policy frameworks to avoid revocation of operational licenses.	• Regulatory authorities should ensure MNOs, micro-operators, private networks and other service providers are taxed fairly and at affordable rates to promote investment in 5G deployment	• In some countries, government regulators view taxation of network operators as their main source of revenue. This may lead to a decrease in operators’ investments and an increase in service prices for consumers.

2.5 Chapter Summary

This chapter discussed the research context of this study by providing background information on 5G networks from an African perspective and by highlighting the significance of 5G networks in Africa. The deployment of the 5G forecast in Africa was presented highlighting, progress and current status, future deployment prediction, deployment challenges, and adoption strategies. Finally, the impact of policies and regulation on 5G deployment in Africa was discussed. The next chapter provides a detailed literature review by highlighting theoretical business model concepts and related published work on next-generation communication networks.

CHAPTER 3: LITERATURE REVIEW

3.1 Introduction

The previous chapter presented the context of this study by highlighting the importance and meaning of next-generation communication networks (i.e., 5G and beyond) from an African standpoint. Building on that, this chapter outlines an analysis of the literature which was conducted to position the current study within the existing literature on the business model concept, 5G and beyond networks, and mobile network operators (MNOs). Further, it was observed that limited research evidence has originated on business models for emerging 5G and beyond networks from the MNOs' perspective.

Critical literature review was conducted in four phases consisting of six sections that summarises the state of the knowledge gap to which the current research aims to contribute. *Phase-1* addresses the business model theoretical concepts (*Section 3.2*) and business model innovation (BMI) (*Section 3.3*). *Phase-2* outlines the 5G wireless technologies (*Section 3.4*) and the 5G economic impacts, opportunities and benefits (*Section 3.5*). *Phase-3* outlines the various business models for 5G MNOs (*Section 3.6*) and finally *Phase-4* presents the conceptual framework of the business model design (*Section 3.7*). Figure 3.1 illustrates the literature review process of the current research study.

Peer-reviewed journals were used as major sources of literature as they have a high level of academic acceptance. Further sources were used to a minor degree in the literature review to provide additional information, define topics and concepts, and show current status and development. Amongst other sources were technical reports, conference papers, white papers, and articles from organisational standards.

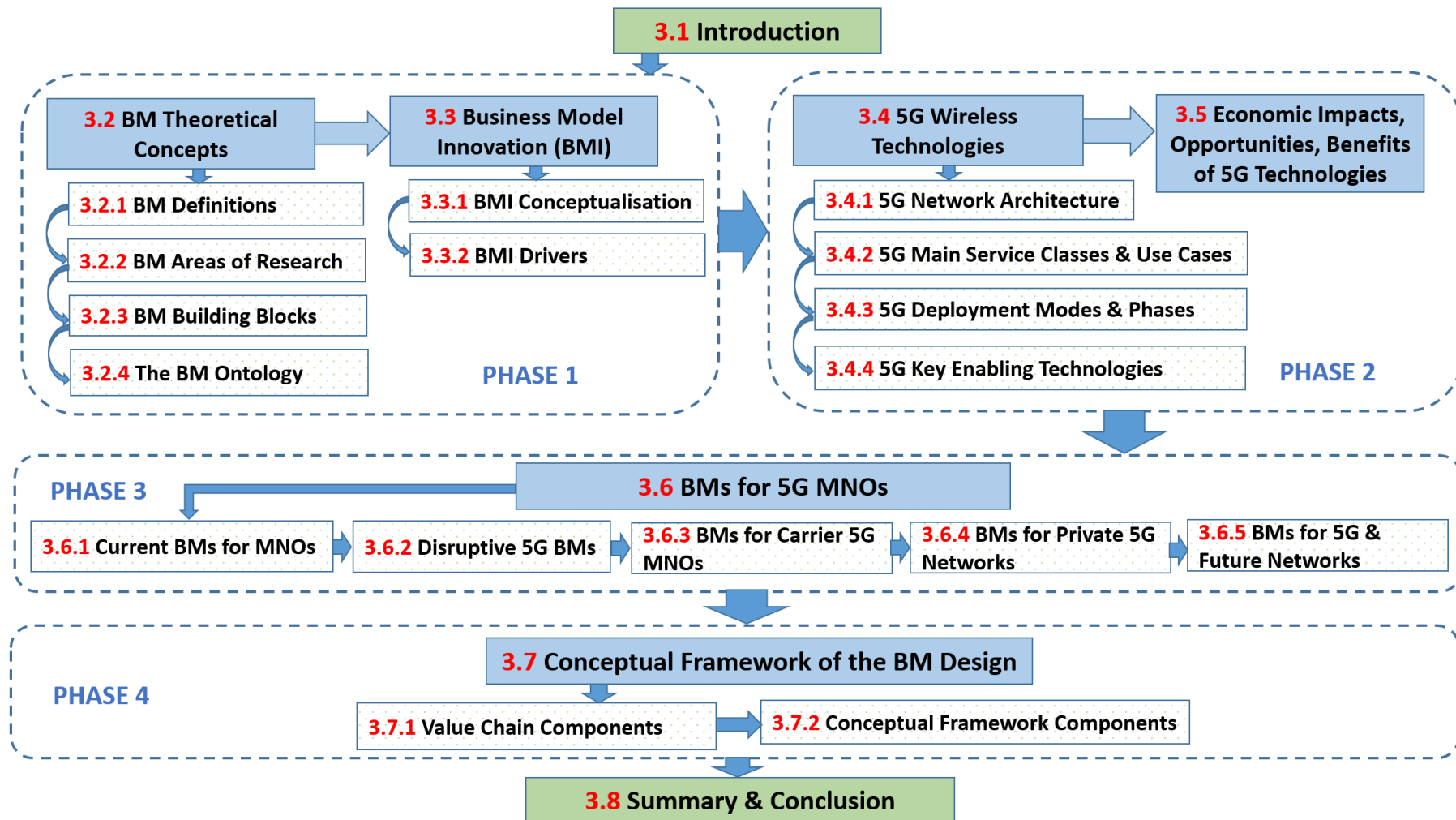


Figure 3.1: Literature review process of the current research study (compiled by researcher)

3.2 Business Model Theoretical Concepts

Business models have been an important research topic in management disciplines over the past three decades. The business model concept gained popularity with the advent of the Internet in the mid-1990s and has become a key area of focus within the research community (Goyal, Kapoor, Esposito, & Sergi, 2017). The significance of business models for companies in the current business environment is well presented in the business model literature (Osterwalder et al., 2005). It is important to note that every company has a business model, whether documented or not, and that the more knowledge there is about the phenomenon of business models, the better positioned the company is to remain sustainable in the market (Saxena, Deodhar, & Ruohonen, 2016).

3.2.1 Business Model Definitions

Despite its wide application in both management practice and academic literature, there is no standardised formal definition of the term “business model” (Teece, 2010; Wirtz, 2019; Zott et al., 2011). This is primarily because different business models are applicable to different industry categories. The notion of value is crucial to the business model concept. Scholars in the field of management science agree that a business model describes how a company creates and delivers value to its customers, and how that value is exploited. This is critical because the performance and viability of organisations depend on both their value creation and their ability to capture value and generate profits (Shafer, Smith, & Linder, 2005).

Since there is no formal standardised definition of a business model and based on the various definitions of the term in the literature reviewed, a business model in the context of this research study is described as follows:

The rationale of how a mobile network operator (MNO) can create, deliver and capture value within the 5G networks' ecosystem by using interconnected elements such as customer relationships, value propositions (services), technology design, financial aspects and infrastructure management.

Table 3.1 shows some selected definitions of a business model across different research domains from the literature.

Table 3.1: Selected definitions of a business model across different domains

Author(s)	Business Model Definition
Al-Debi, El-Haddadeh, and Avison (2008)	An abstract representation of an organization of all core, interrelated architectural, co-operational, and financial arrangements designed and developed by an organization now and in the future, including all core products and services that the organization offers or will offer, based on the arrangements that are needed to achieve its strategic goals and objectives.
Baden-Fuller and Haefliger (2013)	A system that solves the problem of identifying who is (or are) the customer(s), engaging with their needs, delivering satisfaction, and monetizing the value.
Teece (2018)	An architecture that shows how a company creates and delivers value to customers and the associated mechanisms used to capture a share of the value created.
Casadesus-Masanell and Ricart (2010)	The logic of the firm, the way it operates and how it creates value for its stakeholders.
Rao and Prasad (2016)	A company's plan on how it will generate revenues and make profit.
Osterwalder and Pigneur (2010)	The rationale of how an organization can create, deliver and capture value as part of the entire business strategy.
Fielt (2013)	The value logic of an organization in terms of how it creates and captures customer value and can be concisely represented by an interrelated set of elements that address the <i>customer</i>, <i>value proposition</i>, <i>organizational architecture</i> and <i>economics</i> dimensions.
Yunus, Moingeon, and Lehmann-Ortega (2010)	A social business model has four interrelated components: <i>value proposition</i> (stakeholders & products/services); <i>social profit equation</i> (social profit & environmental profit); <i>value constellation</i> (internal value chain & external value chain); and <i>economic profit equation</i> (sales revenues, cost structure & capital employed $\Rightarrow$ no economic loss, i.e., full recovery of capital).
Wirtz, Pistoia, Ullrich, and Götzel (2016)	A simplified aggregated representation of the company's relevant activities indicating how customer value is created to achieve competitive advantage, coupled with business model evolution/innovation to adapt to changing internal and external circumstances.
Amit and Zott (2012)	A system of interconnected and interdependent activities that defines how the company interacts with its customers, partners and vendors. This activity system specifies the activities required to satisfy perceived customer needs, which parties (the company or its partners or its vendors) conduct which activities, and how these activities are interlinked.
DaSilva and Trkman (2014)	A specific combination of resources which through transactions generate value for both customers and the organization.
M. W. Johnson, Christensen, and Kagermann (2008)	A combination of the interlocking elements of <i>customer value proposition</i>, <i>profit formula</i>, <i>key resources</i> and <i>key processes</i> that when taken together create and deliver value.
Chesbrough (2007)	A business model articulates the <i>value proposition</i>, identifies a <i>market segment</i>, defines the <i>value chain structure</i> from raw materials to final customer, specifies <i>revenue generation mechanisms</i> and associated cost structure and profit potential, describes the position of the firm within the <i>value network (ecosystem)</i> and formulates the <i>competitive strategy</i> which gains and sustains an advantage over rivals.
Afuah (2019)	The set of activities that an organization performs to build and use resources to generate, deliver, and monetize benefits (embodied in products and services) to customers.

3.2.2 Business Model Research Areas

In their review article, Zott et al. (2011) pointed out that the business model concept has been used to address three phenomena: (1) e-business and the use of information technology, (2) strategic issues such as value creation, competitive advantage, and firm performance, and (3) innovation and technology management. The e-business area focuses on understanding the composition and structure of new Internet-based firms. Strategic issues consider the following: the interconnected nature of value creation, the relationship between business model and firm performance, and the distinction between business model and other strategy concepts such as product-market strategy. In the field of innovation and technology management, a business model is viewed as a mechanism that connects a company's innovative technology with customer needs (Zott et al., 2011).

On the other hand, Wirtz (2019) states that the three basic research directions on the business model concept are: information technology, organizational theory, and organizational strategy. The information technology context emerged from the field of management information systems (Teece, 2010), and the focus of this branch is on business modelling from which the business model emerges (Wirtz, 2019). Organizational theory views a business model as an abstract representation of the company's structure and architecture (Al-Debi et al., 2008). The strategic management stream considers the relationship between the business model concept and business strategy and therefore considers a business model as a source of information for the implementation of a company's strategy (Wirtz, 2019).

Despite the attempts of Zott et al. (2011) and Wirtz (2019) to objectively analyse the literature on business model research areas, both reviews were based on theoretically under-developed concepts, that make empirical research and theory building uncertain. This research study approaches the business model concept from two research perspectives: (1) strategic management, which focuses on value proposition, value creation, value delivery and value capture activities of mobile operators within the 5G value chain, and (2) technological innovation, which considers 5G networks as technology enablers for innovative business models of mobile operators.

- **Business Model Concept in Strategic Management**

Strategic management is the process of specifying an organisation's objectives, developing policies and plans to achieve the set objectives, and allocating resources so as to implement the policies and plans (Raduan, Jegak, Haslinda, & Alimin, 2009). As a result of increased research activities in strategic management, David (2011) and Hashim (2005) have formulated six strategic management theories which are applicable to 21st century industrial and public organisations: *profit-maximising and competition-based theory*, *resource-based theory*, *survival-based theory*, *human resource-based theory*, *agency theory* and *contingency theory*.

The business model framework for the current study will be conceptualised from the perspectives of the *profit-maximising and competition-based theory* and the *survival-based theory*.

Profit-maximising and competition-based theory: The profit-maximising and competition-based theory indicates that strategic management in organisations is driven by the long-term objective of maximising the organisation's profit. This is crucial to mobile network operators in Africa as they will have to ensure they maximise their profits by minimising the deployment costs and the recurring operational costs. In addition, the mobile operators will have to withstand the fierce competition from their rivals (e.g., OTT content providers, micro-operators and private networks) thereby, developing sustainable competitive advantage over competitors. The profit-maximising and competition-based theory is key to ensuring that a viable business model framework is conceptualised (Breuer & Lüdeke-Freund, 2014). This will result in the following: viable value proposition, value creation, value delivery, value capture, and generation of feasible partnership networks in order to achieve operators' increased economic value in terms of profit maximisation and competitive advantage.

Survival based-theory: The survival based-theory centres on the notion that in order for an organisation to survive in the long term, it needs to adapt to its continuously competitive environment (Sulaiman & Hashim, 2003). According to Magretta (2002), a viable business model is fundamental to the success and long-term survival of an enterprise. Additionally, a

business model should be viable both in terms of technology and in terms of economic value (Derzsi, 2011). The adoption of the survival based-theory will ensure that the conceptualised business model framework is viable thereby, enabling mobile operators in Africa to adapt within the dynamic and continuously competitive 5G market.

- **Business Model Concept in Technological Innovation**

Technological advancement has been identified as a key contributing factor to the long-term productivity and economic growth of an organisation (Greenacre, Gross, & Speirs, 2012). In its broad conceptualisation, innovation is the process of developing and implementing an idea, product, process and behaviours in an organisation (Donbesuur, Ampong, Owusu-Yirenkyi, & Chu, 2020). According to Damanpour and Aravind (2012), innovation covers a wide range of activities including product and process development; managerial and administrative processes; and organisational structures. In relating technological advancement to innovation process, Damanpour and Evan (1984) describe technological innovation as the “implementation of an idea for a new product or a new service or the introduction of new elements in an organisation’s production process or service operation.”

Technological innovation system (TIS) is one of the dominant and well-developed theoretical frameworks in the literature. A TIS is a set of elements, including technologies, actors, networks and institutions, which actively contribute to the development of a particular technology field such as a specific technical knowledge field or product and its applications (Bergek et al., 2015). TIS has been widely applied in the study of emerging technological fields and industries within the context of sustainability transition (Markard, Hekkert, & Jacobsson, 2015). Furthermore, Bergek et al. (2015) have outlined the interaction between a focal TIS and the relevant sectors. However, TIS is more policy-oriented (Markard & Truffer, 2008; Sandén, Hekkert, & Negro, 2017) and its applications tend to either be in the manufacturing sector or with respect to environmental sustainability (Dewald & Truffer, 2011; Markard, 2020), rather than the ICT sector where next-generation networks play a pivotal role. For these reasons, this study will not consider TIS in the conceptualisation of the business model theoretical framework.

Secondary innovation is a typical innovation process in developing countries which starts from introduction and imitation, and focuses on technology catch up (G. Xu, Wang, Wu, & Zhou, 2015). Thus, unlike original innovation which generate and dominate the technological archetype, and usually conducted in developed countries, secondary innovation is done on the basis of acquired technologies, particularly implemented in developing countries (X. Wu, Xu, Ma, & Du, 2008; Xiaobo, 1997). Emerging technologies usually encounter technology paradigm shifting which has often resulted in a trend of technology catch-up for firms in developing countries (G. Xu et al., 2015). Secondary innovation process consists of four phases: imitation, assimilation, exploitation and exploration (X. Wu, Ma, & Xu, 2006). Due to a number of challenges (e.g., lack of sufficient investment capacity, low levels of R&D, poor infrastructure and so forth) being encountered during the deployment of 5G networks, African mobile operators can play a role of latecomers within the global 5G ecosystem and import the 5G deployment strategies from their counterparts in developed countries. From the technological innovation perspective, this study will investigate business models for next-generation networks via the lens of secondary innovation.

Figure 3.2 illustrates the theoretical concepts of the proposed business model framework.

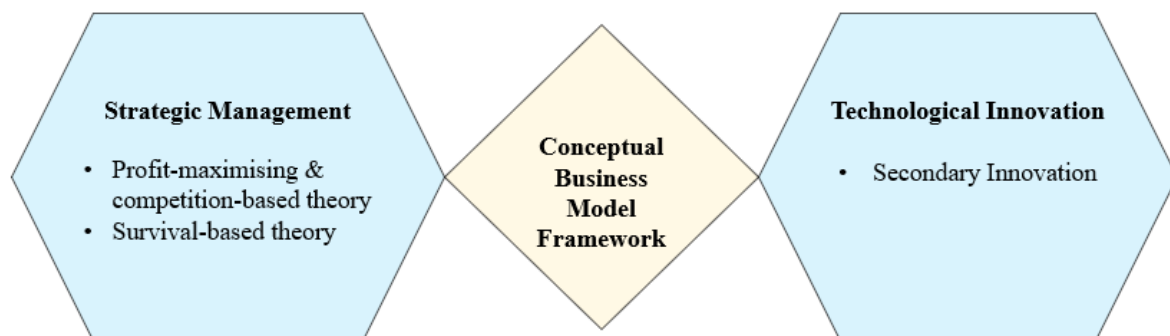


Figure 3.2: Theoretical concepts of the proposed business model framework

3.2.3 Business Model Building Blocks

The purpose of analysing the business model components is to deepen and broaden the knowledge about the basic building blocks of a business model, irrespective of the chosen research stream. Table 3.2 shows some selected business model components from the literature.

Table 3.2: Selected business model components proposed in the literature

No.	Author(s)	BM Components	Analysis
1	Afuah (2004)	• Industry factors • Resources • Cost • Positions	The proposal considers technology, financial aspects & customer relationships. It does not consider value proposition & infrastructure management. It cannot support complex business environments.
2	Watson (2005)	• Competitors • Customers • Company economy • Management • Products • Suppliers	Proposal includes: customer relationships, value proposition (products), partners, organisational management & financial aspects. Exhibits a complex character, however, it ignores the technology and infrastructure management aspects. Competitors are not part of the BM building components (Slavik & Bednár, 2014).
3	M. W. Johnson et al. (2008)	• Customer value proposition • Profit formula • Key resources • Key processes	The BM framework considers value proposition (service), financial & technology aspects. It does not include infrastructure management.
4	Mullins, Mullins, Mullins, and Komisar (2009)	• Revenue model • Gross margin model • Operating model • Working capital model • Investment model	The BM concept focuses only on the financial aspects of a company without considering other factors such as resources and processes, thereby making it inadequate for comprehensive analysis.
5	Adom, Hussein, and Agyem (2018)	• Service design • Technology design • Finance design • Organisation design	The BM concept design is based on four key elements which are critical for any firm. However, no infrastructure design is considered.
6	Afuah (2019)	• Customer value proposition • Market segment • Growth model • Revenue model	The BM framework considers value proposition (service), financial & customer relationships aspects. It does not include technology and infrastructure management.

The reviewed publications in Table 3.2 show that there is no single business model architecture that can meet all the needs of a given firm. For this study, which focuses on value-related strategic management activities and technological innovation, the business model components in (M. W. Johnson et al., 2008) and Adom et al. (2018) are more applicable than the others.

3.2.4 The Business Model Ontology (BMO)

A business model ontology (BMO) can be used to conceptualise, develop, and evaluate a business model (Gordijn, Osterwalder, & Pigneur, 2005). BMOs are considered standardised approaches to business model design and form the theoretical basis on which business models can be developed component by component in various fields. The currently best known and most frequently applied BMO is the business model canvas developed by (Osterwalder & Pigneur, 2010).

Research by Osterwalder and Pigneur (2004) describes a BMO as a conceptual tool that contains a set of elements and their relationships, and allows the expression of the business logic of a particular firm. Further, Osterwalder and Pigneur (2004) translates four simple business pillars into four main business model blocks to make a BMO. These four pillars are: the 'what', the 'who', the 'how' and the 'how much' of a company. Specifically, these pillars allow us to express 'what' a company offers, 'who' it targets with this, 'how' this can be realized and 'how much' can be earned by doing it. The four business model pillars described by Osterwalder and Pigneur (2004) are as follows:

- 1) Product (what?): What business is the company involved, what products/services and what value propositions it offers to the market?
- 2) Customer Interface (who?): Who are the company's target customers, how does it deliver products and services to them, and how does it build strong relationships with them?
- 3) Infrastructure Management (How?): How does the company efficiently deal with infrastructural or logistical issues, with whom and as what kind of network enterprise?
- 4) Financial Aspect (How much?): What is the revenue model, cost structure and financial sustainability of the business model?

In addition, Osterwalder et al. (2005) identified nine building blocks of a business model which were classified based on the four business model pillars discussed above (Osterwalder &

Pigneur, 2004). Table 3.3 shows the nine business model building blocks in relation to the business model pillars.

Table 3.3: Nine business model building blocks (source: (Osterwalder & Pigneur, 2004))

Business Model Pillar	Business Model Building Block
Product	Value Proposition
Customer Interface	Target Customer
	Distribution Channel
	Relationship
Infrastructure Management	Value Configuration
	Core Competency
	Partner Network
Financial Aspects	Cost Structure
	Revenue Model

The nine business model building blocks are further elaborated by (Osterwalder & Pigneur, 2004, 2010):

1. Value Proposition: provides an overall view of a company's product and service package.
2. Target Customer: describes the customer segments to which a company wants to offer value. These are customers who are addressed with the value proposition.
3. Distribution Channel: describes various means that a company can use to connect with its customers and offer them the value proposition.
4. Relationship: explains the type of connections a company builds between itself and its different customer segments.
5. Value Configuration: describes the arrangement of various activities and resources of a company
6. Core Competency: describes the competencies required to implement the company's business model.
7. Partner Network: illustrates the collaborative arrangements with other companies necessary for the efficient delivery and commercialisation of value.

8. Cost Structure: summarises the monetary consequences of the resources used in the business model.
9. Revenue Models: describes ways a firm makes money through a variety of revenue streams.

Figure 3.3 shows the business model ontology developed by (Osterwalder & Pigneur, 2004).

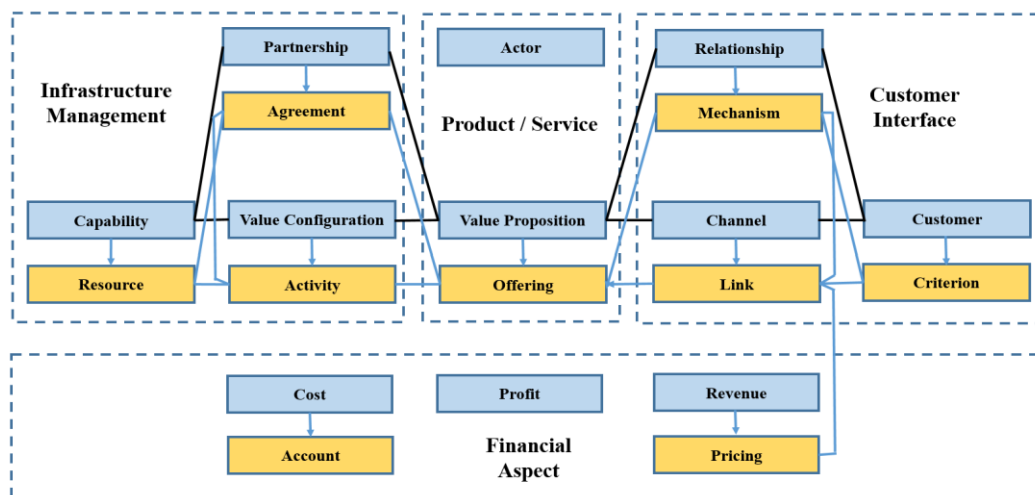


Figure 3.3: Business Model Ontology (Source: (Osterwalder & Pigneur, 2004))

3.3 Business Model Innovation (BMI)

Business model innovation (BMI) has attracted considerable attention in both practice and research community and is emerging as a critical phenomenon within the business model concept. BMI represents a new activity system that includes innovation, value creation, and the value capture structure of a firm and its partners (Hossain, 2017). Cucculelli and Bettinelli (2015) regard BMI as a process of modifying the firm's existing activity system and renewing its core business logic, to enact and exploit opportunities. Ramdani, Binsaif, and Boukrami (2019) suggest that firms pursue BMI by exploring new ways to define value proposition, create and capture value for customers, suppliers and partners. Besides, Geissdoerfer, Vladimirova, and Evans (2018) have defined a BMI as the conceptualisation and implementation of new business models.

Companies commercialise new ideas and technologies through their business models. However, Chesbrough (2010) argues that companies with large-scale investment and process for exploring new technological ideas, may often have little if any ability to innovate their existing business models. Like the business model concept, BMI is not only about products and services, but also about producing value-creating outcomes for customers (Gujral, 2016). Therefore, BMI ensues when a company increases customer value, while simultaneously creating a new value and revenue model that allows the company to capture this value in a new way (Matzler, Bailom, von den Eichen, & Kohler, 2013). An extensive body of the literature asserts that business model innovation plays a vital role to a firm survival, business performance and as a basis of competitive advantage (Amit & Zott, 2012; Baden-Fuller & Haefliger, 2013; Chesbrough, 2010; Geissdoerfer et al., 2018; Ramdani et al., 2019).

3.3.1. Business Model Innovation Conceptualisation

As the business model concept is still undergoing development in management sciences, business model innovation (BMI) has recently attracted substantial interest as a growing subfield of business model research. Business model has been recognised widely as a formidable and essential tool to appropriate value from technological innovation and therefore, is regarded as an object of innovation with the aim of allowing firms have advantages in market competition (Chesbrough, 2010). Additionally, as business models are concerned with company-level value proposition, creation and capture, BMI introduces complexity about the company's creativity in value offerings to its customer.

Business model innovation (BMI) can be conceptualised from the strategic entrepreneurial or resource-based perspectives (Baden-Fuller & Morgan, 2010; Hossain, 2017; Wirtz, Göttel, & Daiser, 2016).

Strategic entrepreneurial BMI: This view considers BMI as an action of modifying the firm's existing business activities and renewing its core business logic in order to validate and exploit opportunities (Cucculelli & Bettinelli, 2015). Strategic and entrepreneurial BMI examines the

importance of entrepreneurial opportunity-seeking and strategic advantage-seeking from a particular firm's viewpoint (Schneider & Spieth, 2013; Schröder, Tiberius, Bouncken, & Kraus, 2021).

Resource-based BMI: This perspective emphasizes on the effective exploitation of resource-capability combinations that enhance competitive advantage and ultimate profitability (Bouncken & Fredrich, 2016; Foss & Saebi, 2017; Visnjic, Wiengarten, & Neely, 2016). Thus, the resource-based view focuses on how firms employ extant resources and competencies to gain competitive advantage and maximise profitability.

According to Giesen, Berman, Bell, and Blitz (2007), business model innovation in incumbent firms can be classified into three groups, which are:

Industry BMI - innovation of the industry value chain by reconfiguring an existing business model or establishing an entirely new one.

Revenue BMI - innovation of the revenue model by redesigning the revenue generation streams. This may involve reconfiguring or designing new pricing models.

Enterprise BMI - innovation of the incumbent firm's role within the value chain by modifying extended enterprise and networks with employees, suppliers, customer and other stake holders.

Based on their analysis of BMI as a change in the configuration of either the entire business model or individual elements of it, Geissdoerfer et al. (2018) have established four distinct generic configuration of BMI. These are:

Start-up business model - there is no current business model, and a new business model is created.

Business model transformation - there is a current business model that is changed into another business model.

Business model diversification - the current business model is maintained, and an additional business model is created.

Business model acquisition - An additional business model is identified, acquired, and integrated.

3.3.2. Business Model Innovation Drivers

Business model innovation (BMI) in a firm can be triggered by either internal or external factors which are referred to as BMI drivers (Bucherer, Eisert, & Gassmann, 2012). Additionally, Bucherer et al. (2012) elucidate that these internal or external drivers can be categorised into threats and opportunities which could also be either internal or external. Internal or organisational drivers have been identified as growth aspirations (Morris, Schindehutte, & Allen, 2005) and resource allocation (Bucherer et al., 2012) as well as performance in terms of time management challenges, highly skilled experts and joy in producing high quality products (Marolt, Lenart, Maletič, Borštnar, & Pucihar, 2016). On the other hand, recognised external drivers include; technological advancement (Bucherer et al., 2012; Casadesus-Masanell & Ricart, 2010; Marolt et al., 2016; Teece, 2010; Wirtz; et al., 2016); market forces (Bucherer et al., 2012; Wirtz; et al., 2016) and regulatory policies (Bucherer et al., 2012; Faloye, Owoeye, & Jayeola; Motjoloane & Ruhode, 2022; Wirtz; et al., 2016).

The business model innovation drivers are illustrated in Figure 3.4, indicating that business model innovation is triggered by either by external or internal (organisational) factors.

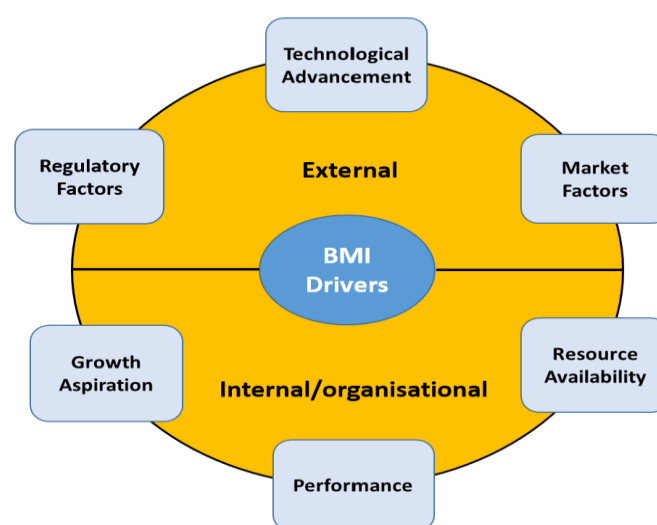


Figure 3.4: Business model innovation drivers (compiled by researcher)

3.4 5G Wireless Technologies

Wireless cellular networks have been evolving since the 1980s and continue to introduce new network technologies in each subsequent decade, covering new use cases, including: First-generation (1G) analogue-based systems (e.g. Advanced Mobile Phone System (AMPS) and Total Access Communication System (TACS)), Second-generation (2G) digital systems (e.g. Global System for Mobile Communication (GSM)), Third-generation (3G) digital systems (e.g. Universal Mobile Telecommunication System (UMTS)); Fourth-generation (4G) digital systems (e.g. Long Term Evolution (LTE) - IMT-Advanced), and 5G digital systems (e.g. New Radio) (Alsharif et al., 2020). Figure 3.5 shows the evolution from 1G to 5G networks.

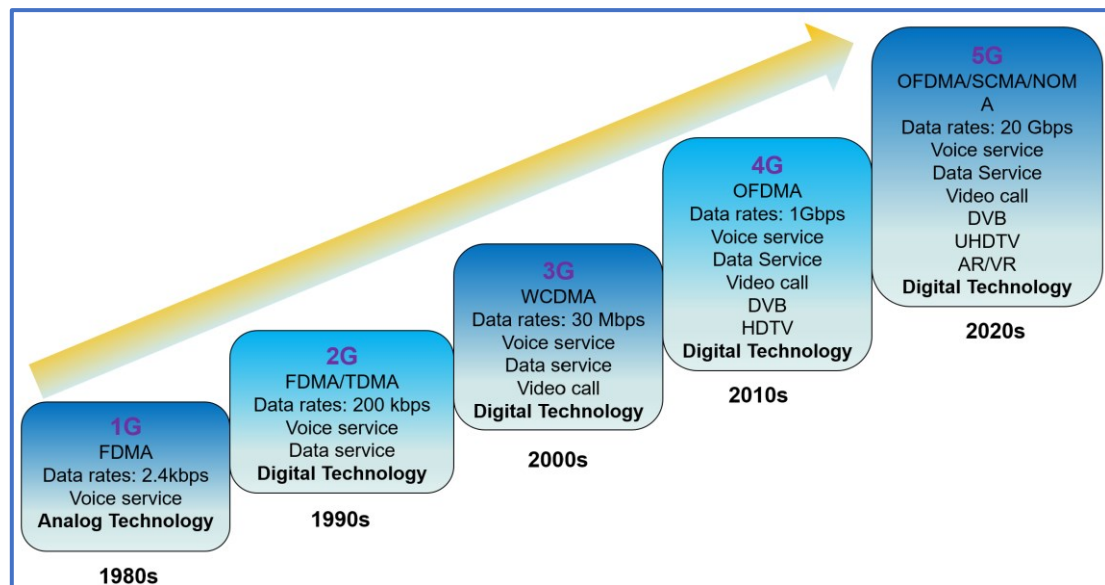


Figure 3.5: Wireless cellular networks evolution (1G to 5G) (source: (Banda et al., 2022a))

The emerging 5G networks are more than just an extension of the 4G networks. The 5G network is designed to meet the unique service requirements of specific vertical industrial markets. Furthermore, 5G network services should be accessible through various techniques such as: simultaneous use of licensed and unlicensed bands, intelligent spectrum management, and 5G New Radio (NR) air interface to enable a range of different intelligent applications (Agiwal, Roy, & Saxena, 2016; A. Gupta & Jha, 2015; Khan, Yaqoob, Tran, Han, & Hong, 2020).

3.4.1 5G Network Architecture

Given 5G's sub-millisecond latency requirements and bandwidth limitations in traditional wireless spectrum, mobile networks in the 5G era face a shift toward cloud and edge computing technologies (Agiwal et al., 2016). This can be achieved by adding applications that can be implemented at the basic network level to meet user needs. Therefore, to meet end-user demands and overcome the challenges of 5G systems, a drastic change in the design strategy for 5G wireless networks is required (A. Gupta & Jha, 2015). The emerging 5G and 5G-Advanced networks will consist of heterogeneous radio cells that include high-powered large cells (e.g. macro cells and micro cells) for outdoor coverage extension as well as low-powered small cells (e.g. pico cells and femto cells) for capacity enhancement of outdoor and indoor hotspots (Gures, Shayea, Alhammadi, Ergen, & Mohamad, 2020).

Figure 3.6 shows the 5G radio network architecture.

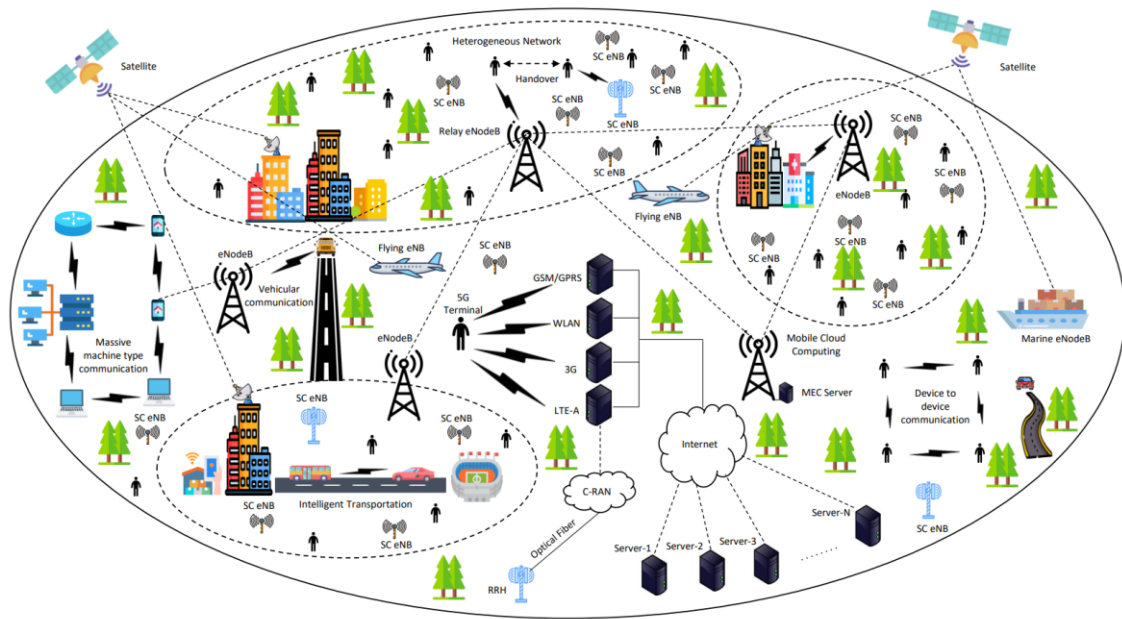


Figure 3.6: 5G NR communication system (source: (Tanveer, Haider, Ali, & Kim, 2022))

3.4.2 5G Main Service Classes and Use Cases

Mobile networks were originally designed for human-to-human (H2H) communication for voice and data transmission (Erunkulu, Zungeru, Lebekwe, Mosalaosi, & Chuma, 2021). However, in the 5G era, a variety of new and unique vertical industrial markets have emerged (Waterfront & Wharf, 2019). To meet the technical requirements of various vertical industries for 5G wireless networks, the IMT 2020 vision defined three main use cases for 5G: (1) enhanced mobile broadband (eMBB) to support ultra-high throughput applications), (2) massive machine type communication (mMTC) to support ultra-large connection applications, and (3) ultra-reliable and low latency communication (uRLLC) to support ultra-low latency applications) (ITU-R, 2015). Figure 3.7 shows the main 5G use cases and sample applications.

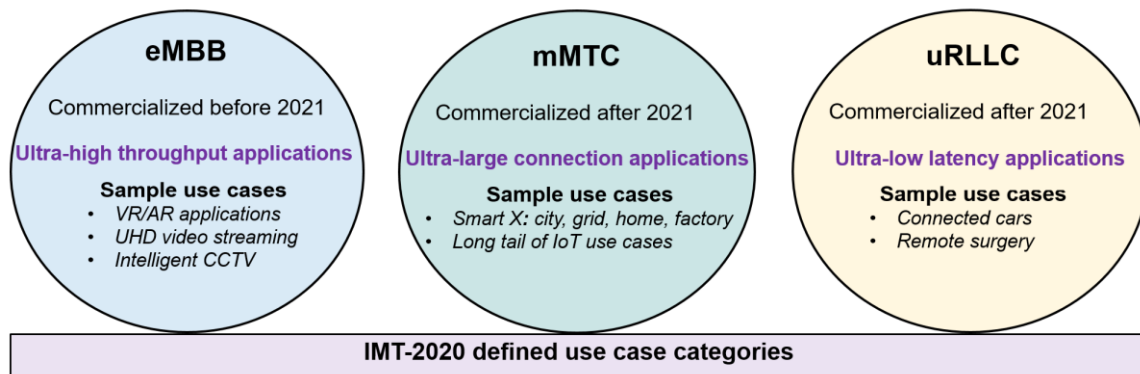


Figure 3.7: 5G main use cases and sample applications

eMBB: The need to support the explosion in mobile data traffic is arguably one of the key drivers for 5G development (Andrews et al., 2014). eMBB traffic can be viewed as a direct extension of 4G mobile broadband service and the main goal of eMBB use cases is to meet the need for ultra-high data rate transmissions (Popovski, Trillingsgaard, Simeone, & Durisi, 2018). This is critical for many human-centric applications such as ultra-high definition (UHD) video streaming, virtual/augmented reality (VR/AR), video surveillance, virtual presence and online gaming. The growing need for higher data rates was the primary motivation for the development of earlier 3G and 4G mobile broadband cellular systems. As the need for mobile data to support new applications such as extended reality (XR) continues to grow, 5G networks aim to deliver

peak data rates of 20 Gbps, cell edge user experience data rates of 50-100 Mbps and traffic density of 10 Mbps/m² (ITU-R, 2015).

mMTC: This class of service is intended to support the connection of large numbers of low-rate, low-power devices, commonly known as machine-type devices (MTDs), within 5G cellular networks (3GPP, 2020a, 2020b; Bockelmann et al., 2018). According to the IMT-2020 vision, mMTC is expected to support 1 million wireless devices per km² and a battery life of 10 years (ITU-R, 2015). This service will promote the realisation of the mobile Internet of Things (IoT) by providing efficient Internet connectivity. mMTC applications include: smart cities in the public sector, smart grids in the energy sector, smart factories in the manufacturing sector, and smart irrigation in the agricultural sector (Pokhrel, Ding, Park, Park, & Choi, 2020).

uRLLC: Also referred to as mission-critical communications, this class of services requires extremely low communication latency in the range of 0.25–0.3 millisecond/packet with a very high network reliability of approximately 99.999% (3GPP, 2020a, 2020b; Anand, De Veciana, & Shakkottai, 2020). The uRLLC use cases are critical to supporting many emerging mission-critical applications, such as remote surgery, industrial automation and robotics, applications for unmanned aerial vehicles (UAVs) and vehicle safety communications (Anand et al., 2020).

Table 3.4 summarises the performance requirements of the IMT-2020 service class.

Table 3.4: IMT-2020 service class performance requirements

eMBB	mMTC	uRLLC
Peak data rate: 10 to 20 Gbps Minimum data rate: 100 Mbps	Supports high density of device connectivity(10 ⁶ devices/km ²)	Provides ultra-responsive connections
Increases traffic capacity by 100 times	Supports long range and low data rate (1-100 Kbps)	Offers less than 1 millisecond air interface latency
Supports macro and small cells	Leverages benefits of ultra-low cost of M2M communication	Ultra-reliable and available 99.999% of the time
Supports high mobility of about 500 km/h	Ensures a battery life of 10 years for IoT	Provides low to medium data rates (50 Kbps - 10 Mbps)
Improves network energy savings by 100 times	Provides asynchronous access	Offers high speed mobility

3.4.3 5G Deployment Modes and Phases

- **5G Deployment modes**

As with the previous cellular network generations, 3GPP has defined both 5G core network and the radio access network. However, unlike the preceding generations that required that both radio access and core network of the same generation to be deployed simultaneously (e.g., E-UTRAN (radio access) and EPC (Core network) in 4G), with 5G it is possible to integrate elements of different generations in different configurations. Accordingly, the 3GPP (3GPP, 2020a, 2020b) has defined two main deployment configuration modes for 5G networks: Non-Standalone (NSA) solution, which combines LTE and 5G New Radio (5G NR) access networks with the 4G evolved packet core (EPC), and Standalone (SA) solution based on 5G NR access and the new 5G core network (5GC) running in parallel with the existing LTE network (El Rhayour & Mazri, 2019; G. Liu et al., 2020; Zaame, Mazri, & Elrhayour, 2020). Figure 3.8 shows the configuration modes for NSA and SA 5G network deployment.

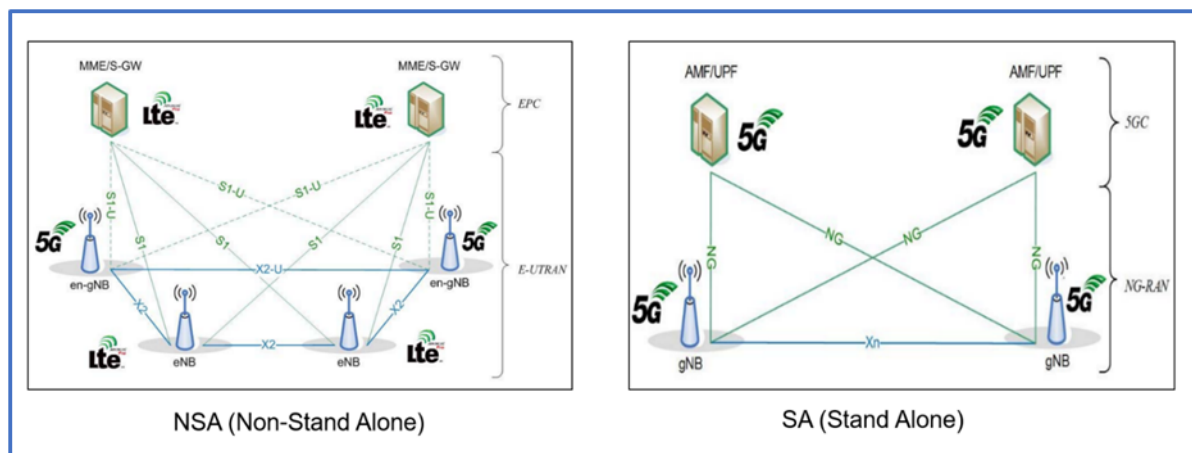


Figure 3.8: NSA and SA 5G network deployment modes (3GPP, 2019)

5G Non-Standalone (NSA): In this mode, the existing LTE radio access network node (eNodeB) is used as an anchor for the 4G core network (EPC) to support the mobility management of the 5G NR access network. This solution focuses primarily on eMBB services and enables operators to deliver 5G services within short deployment periods and at lower deployment costs.

5G Standalone (SA): This is an end-to-end (E2E) 5G network configuration consisting of the 5G NR access and the 5GC. Network slicing, virtualization, ultra-high data rates, ultra-low

latency and the ability to compute large amounts of data are natively integrated into the 5G architecture. The SA solution supports eMBB, mMTC and uRLLC service applications.

● 5G Deployment phases

As previously highlighted, 5G networks are not just the next incremental update to current 4G communication standards. The services and network quality of service (QoS) expected from 5G and future networks are based on the seamless integration of many different elements such as 5G ecosystem partners, use cases, key technologies and performance measurement metrics (Xie et al., 2022). Accordingly Femminella, Pergolesi, and Reali (2020) insist that innovative and rigorous testing at every phase of 5G deployment is critical if mobile operators want to ensure the delivery of consistent performance that both applications and users demand. However, the inherent complexity of 5G networks presents a number of challenges in the deployment process.

The 5G Alliance for Connected Industries and Automation (5G-ACIA) ensures that the interests and peculiarities of the industry are sufficiently considered in the standardisation and regulation of 5G technologies. 5G-ACIA has been actively involved in promoting and publishing white papers on several industrial business applications for 5G (5G-ACIA, 2022). Figure 3.9 illustrates the possible 5G deployment phases using the examples of 5G connected, automated and smart industries outlined by (5G-ACIA, 2022; Banda et al., 2022a).

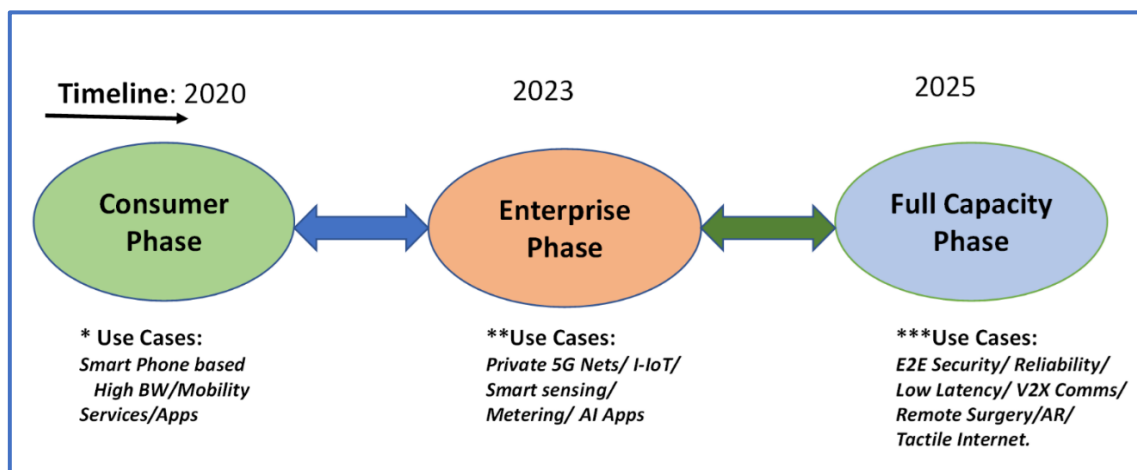


Figure 3.9: Possible 5G deployment phases (source: (Banda et al., 2022a))

Consumer Phase: The first phase of 5G deployment took place in 2020 and focused more on the throughput-sensitive smartphone-based eMBB applications of individual end users.

Enterprise Phase: The second phase of 5G deployment took place in 2023. It focused on small and medium-sized 5G enterprises. Example use cases include: private 5G networks, industrial IoT, intelligent sensors such as smart grids, AI-based applications, etc.

Full capacity phase: The final deployment phase is expected to be realised by 2025 and include eMBB, mMTC and uRLLC use cases. Additionally, end-to-end network security guarantees for 5G networks will be critical in this final phase of deployment. In this phase, all vertical industrial markets will be fully supported. These range from mining, manufacturing, financial institutions, educational institutions and many others.

3.4.4 5G Key Enabling Technologies

According to El Hassani, Haidine, and Jebbar (2019), 5G, being a multi-service network technology, must be precisely designed to offer sufficient flexibility to satisfy the various needs of the anticipated applications in a cost-effective way. 5G and future networks are expected to be primarily enabled by a range of emerging technologies. The development and standardization of 5G key enabling technologies are supported by novel air interface access techniques, novel radio frequency (RF) spectrums, complex channel coding algorithms, and higher-order modulation/demodulation schemes. (Kaur & Garg, 2021). 5G mobile networks are technologically more advanced than predecessor 3G and 4G networks (3GPP, 2020a, 2020b; ITU-R, 2015). The capacity of these next-generation mobile networks is much higher, and they can accommodate various emerging applications with strict requirements for end-user quality of experience (QoE) and network quality of service (QoS) (D. Jiang & Liu, 2017; Kaur & Garg, 2021). Table 3.10 summarizes the 5G key enabling technologies.

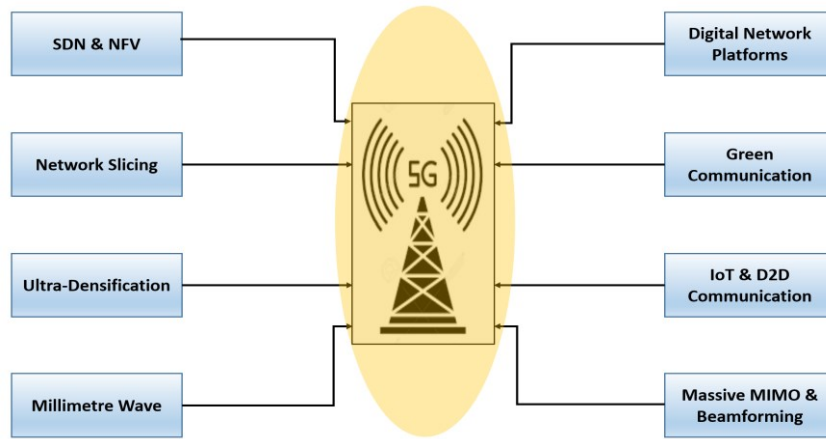


Figure 3.10: 5G key enabling technologies

1. Software Defined Networking (SDN) and Network Function Virtualisation (NFV)

Previous 3G and 4G mobile broadband networks were based on closed, rigid network architectures and were inherently hardware-based (Akyildiz, Wang, & Lin, 2015). By separating the control plane (signalling messages) from the user plane (data/traffic messages), software defined networking (SDN), provides effective and adaptive resource management (Bektas, Monhof, Kurtz, & Wietfeld, 2018). It enables the control and optimization cloud networks and ensures that mobile operators have the flexibility to manage and control their networks through programmable software interfaces referred to application programming interfaces (APIs).

Network function virtualization (NFV) is a key technology that is enabling the development of 5G and future networks. It provides users and network providers with an effective platform to maximize resource utilization (Sridharan, 2020). As stated by Bektas et al. (2018), virtual network functions (VNFs) are software components that replace integrated generic hardware for functions such as load balancing and intrusion detection. Simplified network functions, effective installation, and automatic upgrades are some of the key advantages of NFV. Additionally, by pooling resources for VNFs that operate on a centralized server pool, NFV saves operational expenditure (OPEX) and significantly lowers capital expenditure (CAPEX) associated with purchasing hardware (Akyildiz, Nie, Lin, & Chandrasekaran, 2016).

The complementary concepts of SDN and NFV allow for the virtualization of all network functions that were previously hardware-dependent in order to run them effectively on cloud

infrastructure. The drawback of this kind of network scenario is that it leaves the network functions vulnerable to security breaches. Therefore, a key element of many vital network applications is 5G network security (Hasneen & Sadique, 2022).

2. Network Slicing

According to Khan et al. (2020) network slicing is a critical technology that will enable 5G and future networks to support composite services by transiting from “network-as-an-infrastructure” to “network-as-a-service” platforms. Foukas, Patounas, Elmokashfi, and Marina (2017), define network slicing as the process of dividing a physical network into several separate logical networks (slices), each with its own service characteristics and performance requirements. Each network slice requires a unique business model to achieve its objectives in terms of economic value and profitability as the service class requirements are different (Barakabitze, Ahmad, Mijumbi, & Hines, 2020). The concept of 5G network slicing is considered a critical catalyst for accelerating the emergence of innovative digital enterprises, and the corresponding service level agreements (SLAs) are intended to support and facilitate the development of these digital enterprises while also promoting digital inclusion (Noll et al., 2018).

3. Ultra-densification

In the 5G era, ultra-densification of the radio access network (RAN) is essential to effectively handle the rapidly increasing mobile data traffic. According to Fumiyuki Adachi (2020), ultra-densification is the combination of several low transmit power radio site types with different coverage radii, such as femtocells (10–50 m radius), picocells (100–300 m), and microcells (250 m–1 km). Therefore, ultra-densification enables a multi-layer network with multi-radio access technologies (multi-RAT), in which dense, low-power small cells are multi-RAT capable. As a result, the distance between the device and the base station becomes shorter, spectrum reuse increases, and transmission power decreases. Three primary gains of ultra-densification are: improved link quality, energy efficiency and capacity improvement (Kazi & Wainer, 2019). To increase the coverage and capacity of the 5G network, small cells should be deployed in partial areas such as indoor environments and outdoor hotspots (Ge, Tu, Mao, Wang, & Han, 2016).

4. Millimetre Wave (mmWave)

The radio access network (RAN) can sustain the rapid growth of mobile broadband traffic in the 5G era by allocating more radio frequency (RF) spectrum resources. Two primary RF spectrum resources for 5G networks have been defined by the 3GPP (3GPP, 2020a, 2020b): *Frequency Range 1 (FR1)*, which is made up of sub-6 GHz frequencies (i.e., sub-3 GHz (e.g., 900 MHz, 1800 MHz and 2100 MHz) and C-band (e.g., 3.5 GHz and 3.7 GHz)), and *Frequency Range 2 (FR2)* consisting of millimetre wave (mmWave) spectrum (e.g., 26 GHz, 28 GHz, 39 GHz and 60 GHz) (El Hassani et al., 2019). The mmWave spectrum has thousands of times more capacity than the sub-6 GHz spectrum due to the abundance of available radio frequency resources (Asha, 2021). Applications for the mmWave spectrum typically include radar, automotive, medical (e.g. body scanning), VR headsets, UHD video, 5G small cell concept, and satellite transmission. (Chittimoju & Yalavarthi, 2021). Although mmWave spectrum has a limited coverage range and may pose potential radiation risks, it is still suitable for use cases that require high bandwidth and short-distance communication.

5. Digital Network Platforms

It is predicted that current “network-for-connectivity” applications will give way to “network-of-services” applications with 5G networks. These applications will be developed on digital network platforms with massive data stocks and flows as well as sophisticated algorithms (Yrjola, 2020). The application of big data and machine/deep learning techniques will therefore be necessary for digital network platforms (Nuccio & Guerzoni, 2019). In addition, new players in the mobile market such as micro-operators, content providers, and app developers will need to share resources as 5G and beyond networks are expected to completely upend the mobile ecosystem through the introduction of “as-a-service” platforms and a shared economy model (Coetzee et al., 2018). Digital network platforms will undoubtedly be crucial in advancing the concept of a digital economy in a society that is intelligent, inclusive, and highly connected.

6. Green Communication

The increase in applications for 5G network services is being accompanied by an increase in network energy consumption. Increased energy consumption can lead to an increase in carbon dioxide (CO₂) emissions into the atmosphere, which can have harmful effects on humans and other living beings through radiation. Green communications is an essential 5G technology that must be considered to address the health and environmental issues associated with rising CO₂ levels (Gandotra & Jha, 2017). Energy harvesting technologies that enable mobile devices and base stations to harvest energy from renewable energy sources (e.g., solar and wind) can provide environmentally friendly energy supply options for the operation of 5G networks (Q. Wu, Li, Chen, Ng, & Schober, 2017). In addition, mMTC is the specific use case of the 5G pillar that will benefit most applications, including industrial IoT-based applications that require network nodes to operate with green energy and energy efficiency technologies for years (Kalalas & Alonso-Zarate, 2020; Yan, Zhang, & Meng, 2021). Additional energy-efficient methods to achieve green communication have been proposed by (Akyildiz et al., 2016). These include improvements in battery technology, energy-efficient hardware, energy-efficient network architecture, and power control and optimization in green communications.

7. Internet of Things (IoT) and Device-to-Device (D2D) Communication

According to Agiwal et al. (2016), IoT technology is expected to support millions of simultaneous connections to various devices related to automated factories, connected homes, smart grids, and intelligent transportation systems. IoT enables smart objects and applications to intelligently exchange data and connect to the Internet (G. Kumar, Lydia, & Levron, 2022). The base station and the user device are the primary points of wireless communication in conventional cellular networks. However, new technologies such as device-to-device (D2D) communication (Tehrani, Uysal, & Yanikomeroglu, 2014) and machine-to-machine (M2M) communication (Kim, Lee, Kim, & Yun, 2013) have spurred the use of IoT in 5G networks. In developing smart cities, D2D communications can be leveraged for 5G-enabled IoT applications for waste management, traffic management, water supply management, crime tracking, and pollution monitoring (Gaba, Kumar, Kim, Monga, & Kumar, 2021).

8. Massive MIMO and Beamforming

One of the key technologies that the 3GPP has standardised with the aim of improving spectral efficiency and increasing data throughput (especially for cell edge users) is massive multiple-input multiple-output (MIMO), also known as full-dimension MIMO (Kammoun & Alouini, 2019). Massive MIMO is a technology feature in which base stations are outfitted with arrays of many antenna elements (López-Pérez et al., 2022). Massive MIMO always involves a trade-off between technologies as it increases the cost and energy consumption of 5G networks and end-user devices (Chataut & Akl, 2020). On the other hand, the use of massive MIMO in conjunction with beamforming (i.e., directionality of the propagation beams) guarantees improved capacity and coverage at the cell edge. Furthermore, because narrow beamwidths are formed, beamforming also improves the energy efficiency of signals (Mohamed, Alias, Roslee, & Raji, 2021).

Table 3.5 provides an overview of the 5G key enabling technologies in terms of service classes, performance targets and example application scenarios. This is based on the previously described 5G key enabling technologies and 5G service classes.

Table 3.5: 5G key technologies, service classes, performance targets and sample application scenarios (compiled by researcher)

5G Key Technologies	5G Service Classes	Performance Targets	Sample Application Scenarios
SDN & NFV	eMBB, mMTC, uRLLC	- Efficient and flexible resource management. - Reduced CAPEX & OPEX	- VR/AR for public service - Autonomous vehicles
Network slicing	eMBB, mMTC, uRLLC	Improved resource utilization	- Ultra-high definition (UHD) video streaming - Real-time online gaming - Intelligent transportation system (ITS)
Ultra-densification	eMBB	- Higher data rates - Higher spectral efficiency	- Indoor and outdoor hotspots - Sport arenas - Dense urban areas
Millimetre Wave	eMBB	Higher data rates	- Indoor and outdoor hotspots - Ultra-high definition (UHD) video streaming
Digital network platforms	eMBB, mMTC	- Massive data computation - Big data computation	- Smart meters - Smart grids - Traffic monitoring
Green communication	eMBB, mMTC, uRLLC	- Low CO₂ emission - Improved network efficiency	- e-health - Remote surgery - Smart factories
IoT & D2D communication	mMTC	Large number of device connectivity	- Smart cities - Smart grids
Massive MIMO & Beamforming	eMBB	- Higher data rates - Coverage enhancement - Capacity maximization	- High rise building - Rural and sub-urban areas

3.4.5 Private 5G Networks

A 5G network owned and operated by a primary carrier mobile network operator (MNO) is called a public 5G network. All customers of the public 5G network generally have the same access rights to the network, with the exception of emergency or public safety organisations. (He, Chang, Zhao, Qin, & Qin, 2008). Furthermore, within a public 5G network, the MNO is

responsible for managing the technologies, infrastructure, value-added services (VAS), and subscription charges. An MNO is a licensed telecommunications company that supplies devices, provides voice and data services to subscribers, owns and manages the network infrastructure and spectrum, and oversees the billing systems for customer's network usage (Bormann, Flake, & Tacke, 2008).

A private 5G network, on the other hand, is a local area network aimed at serving a specific area and characterised by improved communication capabilities, unified connectivity, optimized services, and tailored security (Wen et al., 2021). In the context of private 5G networks, private organisations own or operate the network's infrastructure or spectrum and have some priority access to the network. The amount of spectrum and network infrastructure owned and operated by private organisations can vary substantially (S. Guo et al., 2022).

In addition to providing flexible solutions for deploying and operating services under strict and varied constraints regarding latency, availability, reliability, and re-configurability of network resources, private 5G networks are also expected to address concerns regarding ownership and governance of 5G network components and elements (Maman et al., 2021). Non-public 5G networks are private 5G networks that are specifically set up for a particular business-to-business (B2B) customer, such as a vertical industry (X. Li et al., 2021). Non-public 5G networks can be deployed in a variety of ways, depending on the existing regulatory framework and the intended vertical use cases to be supported (GSMA, 2020a).

- **Private 5G network deployment modes**

Private 5G networks can be deployed in either public network integrated (dependent) mode or stand-alone (independent) mode, depending on spectrum and infrastructure availability and the level of network management and access control.

Stand-alone: A private 5G network is deployed as an isolated and independent system without relying on a public 5G network (Wen et al., 2021). In the stand-alone deployment mode, the 5G private network has the following features according to Ordonez-Lucena, Chavarria, Contreras, and Pastor (2019): It is assigned its own spectrum resources, it possesses its own

unique identifier that is independent of the public network, and it logically has a complete deployment of the end-to-end 5G system (radio access, transport, and core network domains).

Public network integrated: A public network integrated private 5G network is one that is anchored on the public network. It generally has limited customised features and low levels of security compared to stand-alone mode (Wen et al., 2021). The public network integration mode is further subdivided into the following three categories (5GACIA, 2019). (1) *Shared radio access network (RAN)*: In this scenario, the private 5G network and the public network share the RAN, while other network domains such as the core network remain separate and all data flows of the private 5G network are restricted to a specific local area. (2) *Shared RAN and Control Plane*: In this configuration, part of the RAN is shared between the public and private 5G networks, and the public network handles network control functions such as signalling management. (3) *Hosted by the Public Network*: In this set up, the private network is entirely hosted and managed by the public network, although the two parts are considered as totally distinct networks to ensure the isolation and independence of both networks.

- **Private 5G network spectrum options**

When deploying private 5G networks, spectrum availability is one of the key aspects to consider. Three spectrum options are available for private 5G networks (Poe, Ordonez-Lucena, & Mahmood, 2020).

Licensed spectrum: A non-public 5G network is granted private use of a portion of the public MNO's own spectrum.

Dedicated private spectrum: A private 5G network can operate independently of the public MNO by purchasing its own spectrum directly from the regulator. Therefore, the operation of the private 5G network does not rely on the spectrum resources of the public MNO.

Unlicensed spectrum: Unlicensed spectrum has the potential to enable rapid growth of private 5G networks as it is a free spectrum option. However, if left unchecked, hostile jamming and

outside interference may prevent certain vertical industries' services from operating as intended (Wen et al., 2021).

Table 3.6 provides as general summary of the comparisons between public 5G networks and private 5G networks.

Table 3.6: Comparisons between public 5G and private 5G networks (compiled by researcher)

Comparison Item	Public 5G Network	Private 5G Network
Network accessibility and usage	Everyone (i.e., consumers and businesses)	Customized for specific organizations / enterprises
Coverage area	Wide area network coverage (e.g., city, state, province or country)	Limited to one specific locale (e.g., university campus, factory or hospital)
Spectrum options	- Licensed spectrum - Unlicensed spectrum	- Leased/rented spectrum - Dedicated private spectrum - Unlicensed spectrum
Service offering	Diversified	Specific
Network accessibility	Less restricted	Highly restricted and fully controlled
Deployment and operational costs	High	- Independent private 5G: High - Dependent private 5G: Low
Network management and Maintenance	Carrier MNO	- Independent private 5G: Organization/enterprise - Dependent private 5G: Carrier MNO

3.5 Economic Impacts, Opportunities and Benefits of 5G Technologies

The information and communications technology (ICT) sector is a sizeable market that can promote digitalization and the growth of new smart industries through the strategic use of 5G and other emerging technologies (Ericsson, 2019). The introduction of 5G networks is creating

windows of opportunities for MNOs to move beyond connectivity and collaborate across vertical sectors to offer comprehensive services to consumers and businesses (Obiodu, 2019). Additionally, 5G and related technologies are creating a myriad of opportunities for industries, society and individuals to advance their digital skills and aspirations (Oughton et al., 2022).

Despite the economic challenges post-COVID-19, the rollout of 5G networks has intensified, globally. Therefore, it is crucial for mobile operators to identify areas they need to prioritise for future market growth. Additionally, the report by Ericsson (2019) noted that 5G investments, deployment targets and market share growth efforts in most markets have been more consumer-focused, which has naturally impacted the 5G enterprise market potential, which has not yet been fully exploited.

- **Mobile Industry Goals for 5G Networks**

With the advent of 5G technologies, the telecom sector is anticipated to transition from a “horizontal” service delivery model, in which services are defined independently of their customers, to a “vertical” delivery model, where the services are vertically and industry-specific (Banchs, Gutierrez-Estevez, Fuentes, Boldi, & Provvedi, 2019). Furthermore, 5G and future networks will revolutionise the mobile sector by allowing new players to enter the market, including content providers, infrastructure owners, and micro-operators. This will be accomplished by expanding the traditional mobile business ecosystem to meet vertical industry needs in a digital, intelligent, and hyper-connected world (Moqaddamerad et al., 2017).

The introduction of 5G technologies has opened a new approach to increasing economic growth in developing nations. Developing countries can benefit from 5G technologies by focusing on the application layer within sectors of their existing economies. (Campbell et al., 2017b; Najjuuko, Ayebare, Lukanga, Mugume, & Okello, 2021). Higher education institutions are also collaborating with communication companies to provide graduates with entrepreneurial skills and technical knowledge about 5G technology standards and use cases (F. Liu, Gong, & Zhou, 2021). Therefore, 5G has the potential to significantly impact the education sector, including:

5G-enabled AR/VR applications in education (Baratè, Haus, Ludovico, Pagani, & Scarabottolo, 2019), development VR-based mobile apps for educational purposes (Virmani et al., 2022), and sharing of 5G and IoT-based online learning materials (Luo & Yee, 2022). In fact, some universities, such as Obuda University in Hungary, have already incorporated 5G technology into their undergraduate and graduate curricula (Kún et al., 2021).

As outlined in the GSMA reports by Obiodu (2019) and K Okeleke et al. (2019) and as illustrated in Figure 3.11, the mobile industry has five primary goals for the 5G era. These goals, which are in line with the mobile industry's purpose "intelligently connect everyone and everything to a better future" were established after surveys of 750 operator CEOs during the 2016-2017 period (Obiodu, 2019) and are as follows:

- (1) Boundless connectivity for all: To provide consumers with fast, reliable, and secure wireless services that support a variety of use cases, emerging 5G and future networks will coexist with existing 4G networks and other alternative wireless technologies.
- (2) Vertical/industrial transformation: By providing network platforms for the digitalisation and automation of industrial processes, 5G and future technologies will accelerate the digital transformation of industry verticals.
- (3) Massive IoT & critical communication: In the 5G era, the mobile industry expects networks to facilitate the extensive deployment of intelligent IoT connections for a range of scenarios that will ultimately lead to the widespread adoption of critical communication services.
- (4) Enhanced broadband: 5G networks promise to revolutionize mobile broadband for end users, providing up to 1 gigabit per second of data transfer and less than 1 millisecond of latency, and providing platforms for AI and cloud services.
- (5) Network economics and innovation: In the 5G era, the mobile industry is committed to providing higher-quality networks at a reasonable cost, independently or through joint ventures. To achieve this goal, new technologies and the use of both licenced and unlicensed spectrum will be required.

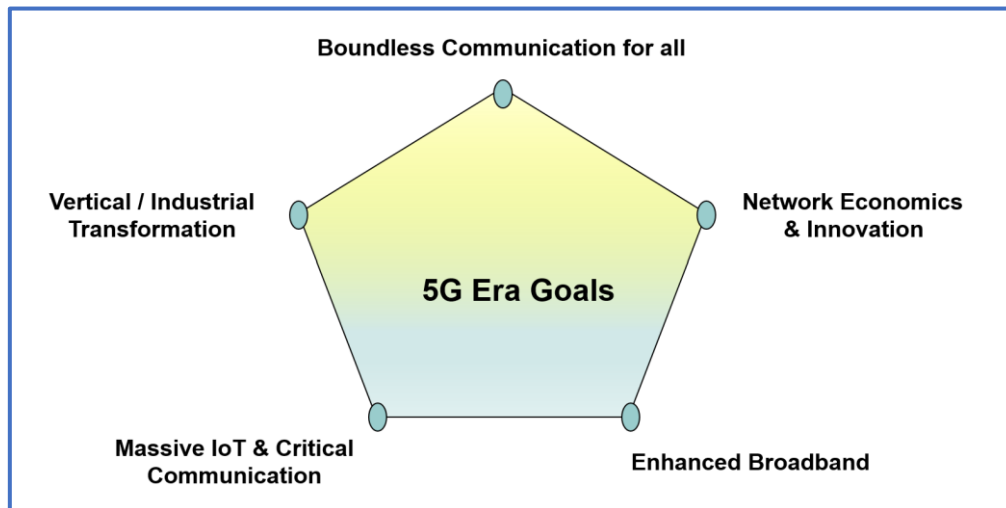


Figure 3.11: Mobile industry goals for the 5G era (source (K Okeleke et al., 2019))

● **5G Market Readiness**

Mobile operators are under intense pressure to quickly transition to 5G platforms and services. However, market maturity, which varies by geographic market, has a significant impact on when 5G will be deployed (Obiodu, 2019). Deployment of fixed wireless access (FWA), rollout of private industrial 5G networks, and maximisation of return on investment (RoI) on 4G networks are some of the major factors influencing mobile network operators' readiness for the 5G market in developing economies (Aijaz, 2020; K Okeleke et al., 2019; Oughton et al., 2022). In many global markets, the competitive landscape heading into the 5G era is still difficult to navigate. MNO competition will continue to be a significant factor in the 5G market for the foreseeable future. In addition, a growing number of operators are facing competition from non-operator businesses in areas such as TV and content services, where operators have acquired businesses (e.g., AT&T's acquisition of Time Warner), as well as the in IoT area that some operators intend to enter beyond connectivity and offer vertical solutions (B. R. Kumar, 2019).

Furthermore, given that the telecommunications sector is capital-intensive, sufficiently large markets have the opportunity to both lower the unit costs of network rollout and better influence the global trajectory of 5G development. Such markets tend to create significant incentives for 5G deployment (Obiodu, 2019). For example, as outlined in the 2021 GSMA Intelligence

Report (GSMA, 2021), mobile operators in China and the US exhibit a greater scale compared to those in the European Union. Therefore, operators in the US and China have the financial capacity to support the rollout of 5G technology and have a significant subscriber base, which consequently reduces the cost per connection for 5G (Obiodu, 2019).

- **5G Economic Benefits and Investment Opportunities**

The global economic value of 5G is expected to be enormous. This is supported by previous World Bank research that found a direct link between economic growth and broadband penetration (Minges, 2015). Additionally, according to the GSMA and TMG (2018) report, 5G is expected to generate \$588 billion in global tax revenue and \$22.2 trillion in global GDP during 2020-2034. A study by Ericsson (2017) shows that mobile operators will generate \$619 billion in revenue from 5G by 2026 in ten industries: manufacturing, financial services, energy and utilities, healthcare, public transportation, media and entertainment, automotive, public safety, retail, and agriculture. Another study by A. Wang et al. (2017) examined the potential of their top ten 5G use cases; For example, they found that the operator addressable market opportunity for cloud AR/VR is \$93 billion. Further research from Markit (Campbell et al., 2017b) estimates that 5G will enable \$12 trillion in global economic activity by 2035.

- i. 5G key investment beneficiaries

The deployment of 5G networks will benefit a number of key players in the 5G market value chain, including: *industry partners* such as public/government institutions, private enterprises, and vertical markets, *network vendors* such as equipment manufacturers, device manufacturers, and technology providers and *service providers* consisting of traditional MNOs (primary carriers and secondary carriers like mobile virtual network operators, or MVNOs) and private service providers such as micro-operators, content providers, platform providers, app developers, and infrastructure providers.

- ii. Share and growth rate for 5G opportunities for service providers

The 5G era is expected to accelerate digital transformation across a wide range of sectors and industries. The estimated global digitalisation revenue for ICT players across all industries is

expected to be approximately \$38 trillion by 2030, while the estimated value of investment opportunities arising from 5G in key industries is approximately \$10.5 trillion (Ericsson, 2017). Additionally, according to estimates by (Ericsson, 2019), the global addressable 5G-enabled market is expected to reach \$700 billion in 2030 for service providers in ten industries: manufacturing, energy and utilities, public safety, healthcare, public transportation, media and entertainment, automotive, financial services, retail, and agriculture. Figure 3.12 shows the 5G-enabled revenue potential in the ten industries from a study by (Ericsson, 2019).

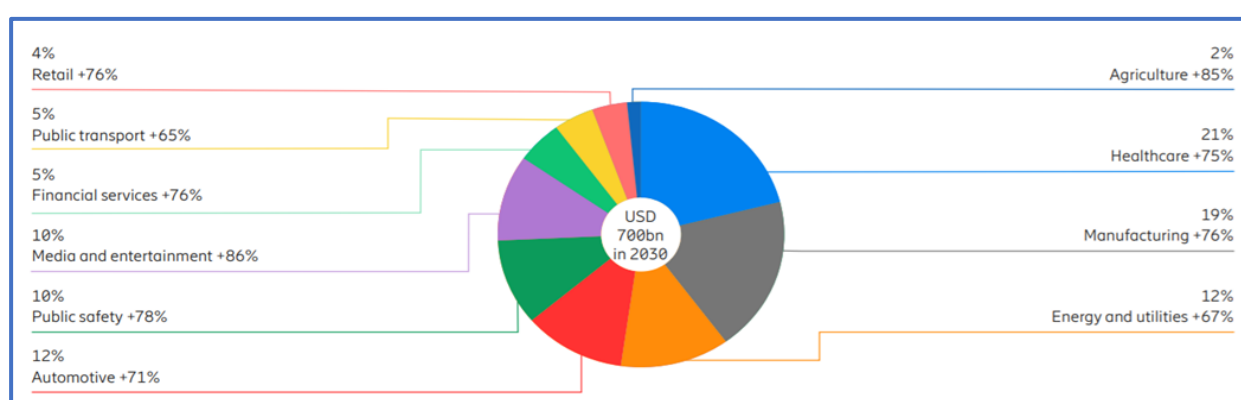


Figure 3.12: 5G-enabled revenue potential across 10 industries (Source: (Ericsson, 2019))

As illustrated in Figure 3.13, the report by Ericsson (2019) also included the expected market opportunities of 5G technology for the ten industries in nine geographical regions. Due to their enormous economies of scale, North America, North-East Asia, and Western Europe will offer the most opportunities for service providers, as Figure 3.13 shows. Service providers will have the least opportunities in developing and emerging markets such as Africa and India due to implementation barriers such as inadequate 5G network infrastructure, a lack of readily available and affordable 5G-capable devices, unstable power supply, immature 5G markets, unfavourable business and political atmosphere, and so on.

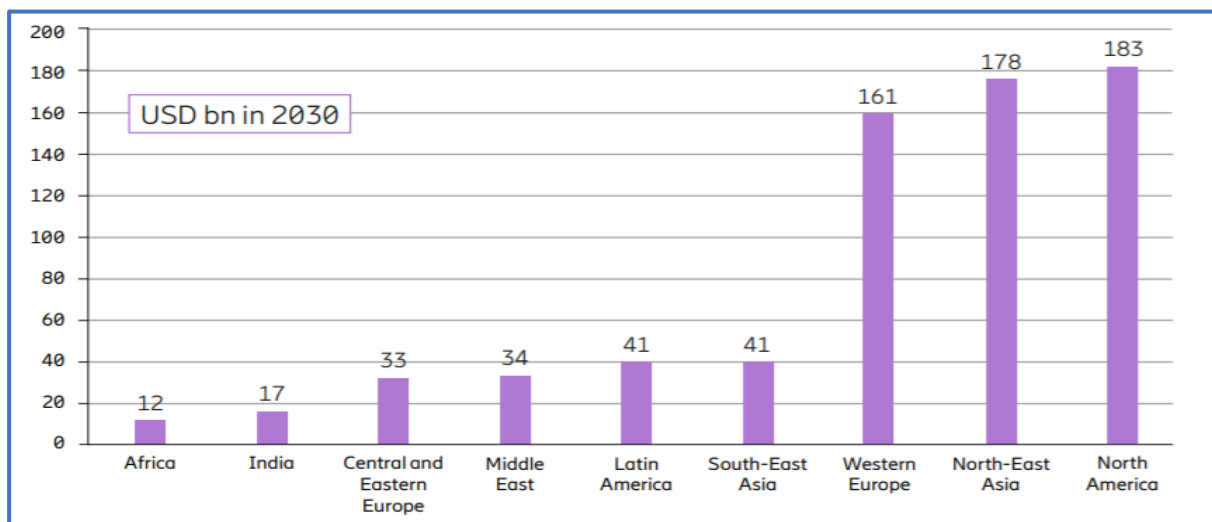


Figure 3.13: Regional distribution of the total service provider 5G-enabled opportunities across 10 industries (Source: (Ericsson, 2019))

3.6 Business Models for 5G Mobile Network Operators

Until the advent of 3G and 4G technologies, when multimedia services (voice, data and video) could be provided to end-users, mobile operators were pure voice and short message services (SMS) providers. In order to thrive in the new business ecosystem created by the disruptive 5G technologies, mobile operators will need to rethink their current business models (Rao & Prasad, 2016).

3.6.1 Current Business Models for Mobile Network Operators and their Limitations

- **Current business models**

Mobile operators' business models have been market-driven rather than technology-driven over the past two decades. The reason for this could be that the evolution of mobile communications from 2G/3G to 4G was more of an evolutionary improvement than a technological disruption. For mobile operators, the traditional business model approach has been to monetise mobile connectivity for consumer and corporate customers - bundled with dealership of digital content and/or equipment, also installed - and differentiated by quality of service, coverage, or data rates/quotas, based on exclusive use of spectrum resources (Ahokangas, Aagaard, Atkova,

Yrjölä, & Matinmikko-Blue, 2023). Prior to the development of 5G networks, mobile operators used the following business models.

A. Outsourced and managed services business model

Rapid technological advancements lead to frequent adjustments in mobile networks such as software updates and hardware upgrades. These network changes present mobile network operators with challenges in managing the technology and maintaining the network with minimal errors and outages. Consequently, several operators have moved to outsourcing the network maintenance or technology portion to specialised equipment or technology providers who manage the outsourced portion of the network through strict outcome-based service level agreements (SLAs) (Rao & Prasad, 2016). In such a model, operators focus on customer experience management (CEM), market acquisition and creating multiple revenue streams through additional value-added services (VASs). This is a form of partnership in the network element described by (Rao & Prasad, 2016) where the equipment suppliers take over part of the value chain such as access or core networks through voluntary agreement under an SLA.

B. Mobile virtual network operator (MVNO) business model

In this model, mobile operators have the option to sell, lease or rent their network infrastructure or capacity to secondary operators, also known as mobile virtual network operators (MVNOs), who do not have their own network infrastructure or spectrum resources. The MVNOs design their own platforms for service delivery, billing and VAS delivery to their customers. MVNOs purchase capacity from primary operators and resell it with added value to the MVNOs' specific customer groups (Rao, 2018). Thus, the MVNO can create and capture value through connectivity, content, context and commerce, relying on the network infrastructure and spectrum resources of the primary mobile operator (Obiodu, 2019).

C. New market acquisition business model

The market acquisition business model can be described as a partnership network business model used to establish joint ventures or strategic alliances to penetrate new geographical markets (Rao, 2018; Rao & Prasad, 2016). Large and established mobile operators tend to expand into new markets to target new customer segments and explore new market

opportunities (Rao, 2018). This could be due to market saturation or intense competition in home markets. New markets are created through partnerships or acquisitions to open up new markets. A typical example is the Indian company Bharti Airtel's entry into the African market through the acquisition of Zain's African branches (Dhir, Ongsakul, Ahmed, & Rajan, 2020). The goal of the market acquisition model is to grow into new markets by studying consumer demand for the goods and services to be provided. Key factors to consider include: potential market supply for sales and growth opportunities, an investment-friendly atmosphere, and favourable regulatory and governance policies such as taxes.

D. Mobile broadband service business model

For the majority of telco subscribers, mobile broadband and mobile Internet connectivity are primarily provided by current 3G and 4G technologies, which are still in use in most developing regions. Apps such as Instagram, Facebook, Twitter, and WhatsApp available over mobile broadband networks, are becoming increasingly popular among end-users. According to (Rao, 2018), the mobile broadband business model was originally a “flat-rate model” with set periodic rates. However, mobile operators are implementing a variety of data usage plans due to increased service consumption by end-users in recent years. Consequently, demand-based models have replaced the flat-rate models (Rao & Prasad, 2016). Simple pricing strategies ultimately benefit end users, while stable revenue streams benefit mobile operators.

E. Integrated WLAN-Cellular business model

The aim of this business model is to provide wireless Internet access to mobile operators' subscribers through a possible evolution of the wireless local area network (WLAN) hotspot concept (Ballon, 2004). Based on the IEEE 802.11 standard, this model positions WLANs as an alternative to expensive cellular base stations and as a complement to 3G/4G networks. This model minimises deployment and operational costs by eliminating the need to upgrade from 3G to 4G. This model is widely used in hotspot areas such as residential complexes, office parks, shopping malls and amusement parks.

- **Challenges facing current business models for mobile network operators**

The deployment and operating costs of 5G technologies require huge investments, and current business models, based primarily on subscriptions, are unlikely to generate sufficient profits and revenue to offset these costs (Skouby, 2021). Current business models for mobile operators often encounter technological and socio-economic challenges. Below are some of the key challenges identified in the literature.

A. Effects of over-the-top (OTT) services on mobile operators' business models

As end-user behaviour continues to change due to increased data demands driven by digitalization, data consumption has increased exponentially, especially for applications with video content. This has led to various over-the-top (OTT) services impacting the business ecosystem of mobile operators as OTT players can offer these services without owning, leasing or operating the network infrastructure (Rao, 2018). OTT services are applications such as social networking applications (e.g. Facebook, Twitter and Instagram), video content applications (e.g. YouTube and TikTok) and messaging applications (e.g. WhatsApp) that are delivered over the Internet using the network infrastructure mobile operators (Stork, Nwana, Esselaar, & Koyabe, 2020). MNOs' business models are affected as their revenues depend primarily on data usage and not OTT applications. Traditional mobile voice calls and SMS businesses are declining, resulting in lower revenues for operators (Rao & Prasad, 2016). Therefore, traditional business models supporting such services prove inadequate to meet the needs of end-users.

B. Limitations of business-to-business (B2B) and business-to-consumer (B2C) models

According to Iankova et al. (2019), traditional business models of MNOs are easy to implement because they are usually two-dimensional business-to-business (B2B) models (e.g. operators providing access services to enterprises) or business-to-consumer (B2C) models (e.g. operators offering data or voice services to consumers). However, complex value chains have been created as a result of the rise in the number of key players in the mobile industry, including private network operators, and private/public enterprises. Therefore, it is unlikely that traditional B2B or B2C models will be successful for MNOs to create and capture value through

the provision of digital services in such complex business environments. Instead, innovative business-to-business-to-any (B2B2X) models are likely to flourish.

C. Effects of disruptive non-cellular technologies on mobile operators' business models

Al-Debei and Avison (2011) found that most mobile network operators expect current 4G services to account for a majority of their revenue growth. However, current business models for cellular technologies are threatened by disruptive non-cellular technologies such as Wi-Fi, which operate using unlicensed spectrum bands. Furthermore, Al-Debei and Avison (2011), claim that disruptive networks using the IEEE 802.11 standard in hotspots enable Internet access in public places and have the potential to cover the entire globe. A key advantage of Wi-Fi is that deployment costs are much lower compared to 3G or 4G cellular and higher data rates are possible, albeit over a comparatively limited coverage area.

Table 3.7 summarises the current business models for MNOs and their respective challenges.

Table 3.7: Current MNOs' business models and their challenges (compiled by researcher)

Business Model	Challenges
Outsourced and Managed Services Model	• MNOs are reduced to service providers as the infrastructure is managed by third party companies which may result in reduced network ownership. • Outsourcing of the technology part of the network may lower investment in research and development leading to reduction in innovation.
Mobile Virtual Network Operator (MVNO) Model	• This is a simple business-to-business (B2B) model which allows secondary operators to provide data and voice services to their subscribers. However, the increase in the number of key players (e.g., vertical market and third-party actors) in the mobile communications industry has resulted in complex value chains. Thus, only business-to-business-to-any (B2B2X) models can support such complex business ecosystems.
New Market Acquisition Model	• May not be successful in mature or saturated markets. • Could lead to low return on investment (RoI) if inaccurate market analysis is conducted.
Mobile Broadband (MBB) Service Model	• Disruptive non-cellular technologies such as WiFi which are cheaper to deploy can offer high data rate broadband services, albeit over a comparatively limited coverage range.
Integrated WLAN-Cellular Model	• Emerging over-the-top (OTT) services are altering the MNOs' business ecosystem as OTT players (e.g., Facebook, YouTube, Twitter, WhatsApp and Instagram) can offer content applications without owning, leasing or operating network infrastructure.

3.6.2 Emerging Disruptive 5G Business Models

In addition to being technologically advanced, 5G wireless communications networks are expected to create, deliver and capture business value for all key players, including mobile operators, device providers, industry verticals and other third parties. The successful deployment of 5G and future networks requires commercially viable and sustainable business models that can support the targeted multi-dimensional vertical markets.

- **Disruptive Business Models**

A successful strategy must include a business model that creates a sustainable competitive advantage in order to increase company value. However, in dynamic business environments, the profitability and sustainability of a business model are always limited, as innovation and progress not only fuel competition but also have the power to make a business model obsolete (Fasnacht, 2020). The current mobile operator ecosystem is being impacted by disruptive technologies such as 5G mobile networks, which can alter value chains and make traditional business models unsustainable (Peppard & Rylander, 2006). Therefore, the business models that can best address the unique characteristics and economic disruptions underlying 5G wireless networks are likely to be viable and feasible (Moqaddamerad, 2020).

When innovation and new technologies become crucial to an established business model, Schiavi and Behr (2018) contend that business models are disrupted. Schiavi and Behr (2018) further claim that disruptive business models emerge to replace established business models through reconfiguration or the creation of new business models that target at a particular value proposition derived from emerging technologies. In the business environment, disruptive business models are characterized by the fact that they offer differentiated added value for customers, gain a competitive advantage, open up new markets and replace established business models (Schiavi & Behr, 2018). Figure 3.14 shows the composition of disruptive business models.

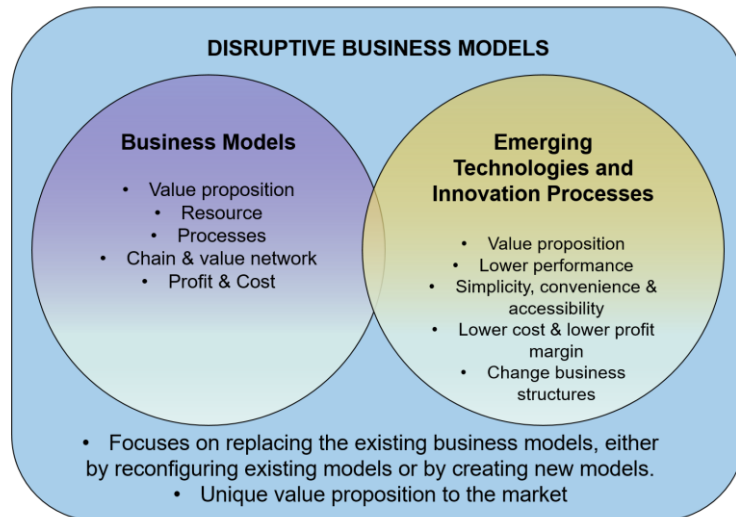


Figure 3.14: Disruptive business models (Schiavi & Behr, 2018)

● **Disruptive 5G Business Models**

In the mobile communications sector, 5G networks are undoubtedly considered cutting-edge and innovative technologies. Mobile operators must therefore develop business models that can cope with the technological and economic disruptions caused by 5G network technologies. If the technological and economic disruptions caused by 5G networks are embraced, it will create sustainable digital business models and increase operator revenues. However, if mobile operators respond too slowly and rigidly to the disruptions of 5G, new competitors such as private 5G networks, 5G content providers, 5G app developers, and others will emerge and disrupt operators' current business models and make them obsolete. The following five categories of disruptive 5G business models can be found in the literature.

i. Partnership business model

The introduction of a new network architecture based on cutting-edge technologies such as SDN, NFV, cloud computing, edge computing, artificial intelligence, and machine learning is one of the key innovations for 5G wireless technologies. In addition to connecting people and objects and enabling access to mobile services that people need, 5G and future networks will also be able to provide competitive, specialised services for public sector organisations, private businesses, and vertical industrial sectors (Kaloxylos, Gavras, & De Peppe, 2020). To serve

vertical industries such as healthcare, smart factories, media and entertainment, energy, and automotive, new business models and related regulatory and policy strategies for 5G networks have been proposed by (Kaloxyllos et al., 2020). In their research, Kaloxyllos et al. (2020) do not go into detail about the components, such as the relationships between industry verticals and mobile operators, but only present high-level business model proposals for different vertical markets.

The following partnership business models have been discussed in the literature.

1. Connectivity provider business model

For telecom operators and service providers, the connectivity provider business model has been laid out by (Rao & Prasad, 2016). Both an enhanced connectivity business model, where connection quality of service (QoS) is guaranteed, and a basic connectivity business model, which addresses best effort Internet Protocol (IP) connectivity for wholesale and retail customers, were described. The article also describes the business models used when primary MNOs form alliances with MVNOs or other service providers. However, the policy and regulatory framework which are crucial, particularly when it comes to revenue sharing are considered in the proposed partnership business models.

2. Digital service provider business model

Rao and Prasad (2016) developed a business model for telecom operators as digital service providers. The authors suggest that telecom operators should expand into digital services such as mobile TV and video content, financial services and smart homes, in addition to their core connectivity offerings. R. Gupta and Parida (2013) add that this transition to non-traditional service offerings is beneficial due to increasing CAPEX and revenue stagnation as revenue is not increasing in proportion to data growth. The two ways MNOs can offer digital services are further described by Rao and Prasad (2016): (1) the operator develops the applications itself and decides whether to serve only subscribers or provide open access to subscribers of other network operators; or (2) the operator works with an OTT provider and the operator commissions the OTT partner to develop the applications. Rao and Prasad (2016) conclude in

their business model framework that it would be beneficial for an operator to create its own applications for digital services and provide open access to subscribers of both paid and free services, thereby expanding the target market. Two revenue streams could arise from this: direct revenue from subscribers of other operators as well as own subscribers (e.g. revenue from advertisements and subscriptions); and indirect revenue from just operator's own subscribers (e.g. enhanced customer analytics, more data users, and better customer retention).

3. Ultra-Low Latency Service Provider Business Model

In their publication, Lema et al. (2017) assert that they have examined the relevant 5G use cases from a technical and business perspectives that require extremely low communication latency. The authors conducted a thorough analysis of the industry verticals that could benefit from low-latency technologies: healthcare, transportation, entertainment, and manufacturing. The study was based on the following research question: "Will it be cost-effective for telecom players to build ultra-low latency in 5G networks?" Interviews, workshops, and collaborative research projects were among the primary sources used in the data collection process, along with a thorough literature review of secondary sources. In response to their inquiry, Lema et al. (2017) concluded that telecom companies can benefit from ultra-low latency 5G applications provided they develop new business strategies and form solid alliances with industry verticals. Therefore, the economic impact of 5G and the revenue of ultra-low latency applications can be determined by the selection of new business models. Although the procedures and guidelines to be followed to generate the revenue are not specified, the article places a strong emphasis on revenue generation for ultra-low latency 5G services. All stakeholders can also benefit from creating an appropriate revenue sharing agreement between mobile operators and the industry verticals.

4. Smart City Business Model

Timeus, Vinaixa, and Pardo-Bosch (2020) proposed the concept of a smart city business model and a practical framework for analysis. The authors present the city model canvas (CMC), which is derived from the typical business model canvas of companies (Osterwalder & Pigneur, 2004). The CMC investigates the research question of how local governments and municipalities can assume responsibility for smart city initiatives to ensure that their citizens

benefit from them. A number of components of the business model canvas have been replaced in the proposed CMC with elements relevant to a public service context. According to Timeus et al. (2020), the city of Bristol in England was selected as an appropriate context for the application of the CMC due to its ongoing smart city strategy. However, only Bristol City Council managers were consulted when implementing the case study. The development of a compelling business case was hampered by limited consultation, which impacted the validity and reliability of the analysis results. Politicians and politically appointed executives as well as other key stakeholders in high-level decision-making roles should have been contacted. To improve the case study results, key stakeholders should have been consulted, including civic organizations, non-governmental organizations, and commercial companies involved in smart city development.

5. 5G Data Communication Business Model

The work by Malolli (2017) focuses on new business models and pricing strategies for data communications in 5G networks. The study examines the significance of data pricing strategies for the 5G network while considering the projected global exponential increase in mobile data traffic (i.e., 49 Exabytes per month and 6.2 billion smartphones and tablets by 2021 (Pepper, 2013)). In addressing the research question, “What business models and what pricing policies will be appropriate for 5G networks?” the article finds that the roles of key players influence the adoption of business models. These roles include: asset provider business models (i.e., network sharing), connectivity provider business model (i.e., basic connectivity through best effort IP and improved connectivity through QoS), and partner service provider business models (i.e., enhanced partner service offerings). Two pricing models are presented: the cost-based pricing model, where pricing is based on the operator’s CAPEX and OPEX, and the SBIFT model, where pricing differentiation is based on the five dimensions of Scope, Base, Influence, Formula and Temporal rights. Malolli (2017) concludes that there is no standard pricing model that should be considered appropriate. Since the study focuses only on data services, the pricing policies examined have limited applicability to the emerging multi-service use case of 5G networks.

ii. Digital platform business model

5G and future wireless technologies are expected to alter the current “network-of-connectivity” business models in the mobile industry towards “network-of-services” business models, that will be based on platforms with intricate algorithms and gigantic amount of data (Cusumano, Yoffie, & Gawer, 2020; Yrjola, 2020). Therefore, the application of data-intensive processing technologies such as big data and machine/deep learning will be necessary. 5G and future networks will promote ecosystemic business models based on digital platforms that integrate technological innovation and economic aspects such as economies of scale and scope (S. Yrjölä, Ahokangas, & Matinmikko-Blue, 2018). In addition, new players in the mobile market, including micro-operators, content providers and app developers, will be able to share the available network resources as 5G and beyond networks are expected to completely disrupt the mobile ecosystem through the introduction of “as-a-service” platforms and a shared economy approach will be used (Coetzee et al., 2018; S. Yrjölä et al., 2018).

The use of scenario-based business modelling in studying the 5G network market is discussed in the article by (Obiodu, 2019). Through the collaboration of various market participants, including Huawei, Ericsson, Nokia and academic institutions, four scenarios were created. A novel method of business model creation has been proposed that improves on more established methods by providing a platform that takes into account evolving value propositions, value chain dynamics, regulatory changes and technological advances. In environments with high complexity and uncertainty, Obiodu (2019) concludes that their approach is useful. However, the analysis of cost structures and revenue models, which are crucial elements in the value capture activities of service providers, was not taken into account in the work.

iii. Network slicing business models

According to (Coetzee et al., 2018), 5G and future wireless technologies will be developed in the form of programmable platforms that offer services on an “as-a-service” basis. A key technological advancement that will enable 5G and beyond networks to support composite services is network slicing, which transforms networks from “network-as-an-infrastructure” platforms into “network-as-a-service” platforms (Khan et al., 2020). Foukas et al. (2017)

describe network slicing as a process of dividing a physical network into several isolated logical networks called slices, each of which has unique performance requirements and service attributes. By using of network slicing, operators can create thousands of virtual, separate networks that are connected from the device through the application within a single physical network infrastructure. Network slicing therefore enables operators to cost-effectively and efficiently package new 5G network capabilities into distinct, guaranteed service level agreement-based (SLA) services (S. Yrjölä, Matinmikko-Blue, & Ahokangas, 2023). For each network slice to achieve its economic value and profitability goals, a unique business model is required as service class requirements vary.

The goal of the work of M. Jiang, Condoluci, and Mahmoodi (2017) was to maximize network revenue by using a novel auction mechanism in network slicing strategy. The study proposed an auction-based model to jointly optimize revenue and network resources. In their results, the authors showed that the proposed auction model can efficiently allocate network resources by providing a higher satisfaction rate per slice along with higher network revenue. Although the work of M. Jiang et al. (2017) addressed the revenue maximisation strategy in great detail, it did not include the pricing policies that are essential to the proposal's successful practical implementation.

Kukliński, Tomaszewski, Kozłowski, and Pietrzyk (2018) examined and analysed business models enabled by network slicing. The single domain business model of network slicing assumes that there is only one virtual and hardware infrastructure provider and that its resources enable the creation of end-to-end slices. These business roles are connected to each other through a series of predefined interfaces. According to the authors, the single-domain model is unrealistic and does not properly exploit network slicing technology. To circumvent these challenges, Kukliński et al. (2018) further proposes a multi-domain business model for network slicing that enables the brokering of slice deployment and the creation of an ecosystem with numerous providers of both virtual and physical infrastructure. Infrastructure broker, slice broker and service broker are three additional broker business roles that are added to the single domain model through the broker mechanism in the multi-domain model. According to the

authors' analysis, the multi-domain concept supports multiple slice providers that can be added as needed if the solution allows for dynamic creation of slice orchestrators. However, the authors note that the standard NFV management and orchestration framework (MANO) as described in (Quittek et al., 2014) is not compatible with the proposed multi-domain model from an implementation standpoint. Mobile network operators may be reluctant to commercially adopt the proposed multi-domain model as it does not conform to the standard MANO framework.

iv. Micro-operator business models

The 5G era has introduced local networks deployed by various stakeholders, which has opened the market for new local entry referred to as micro-operators (S. Yrjölä et al., 2023). Local 5G networks have created local vertical-specific ecosystems around their deployment areas where stakeholders and their roles vary (Matinmikko et al., 2018; S. Yrjölä et al., 2023). Micro-operators are able to provide a range of services tailored to the specific needs of their regional communities and covering different use cases in different 5G market segments. A strategic approach to enable this is the active participation of policymakers and regulators, facilitating the economic procurement of spectrum by local 5G micro-providers (Matinmikko et al., 2018).

Research conducted by Ahokangas et al. (2016) focused on the business models of micro-operators in small cell/indoor 5G environments. According to the article, a micro-operator is a company that integrates mobile connectivity with specific local services in geographically limited areas using appropriate spectrum resources. The authors conclude that through cooperative business relationships (i.e. a partnership that combines cooperation and competition), micro-operators can complement the current offerings of incumbent mobile network operators and play a natural role in small cell/indoor scenarios. Nevertheless, Wi-Fi, based on the IEEE 802.11 standards, is currently the main technology supporting indoor wireless coverage and capacity solutions. Ahokangas et al. (2016) did not address how their proposal would compete economically with current indoor solutions such as WiFi, which are widely available and affordable to the majority of customers.

v. Ecosystemic business models

According to (Moqaddamerad, Ahokangas, Matinmikko, & Seppänen, 2018), ecosystemic business models, of which the 4C model (connection, content, context, and commerce) is a classic example, focus on business models in business ecosystems where multiple companies interact in extremely complex ways, interdependent opportunities for value creation. The structure of a potential 5G business ecosystem was defined using the 4C model as follows (Moqaddamerad et al., 2018): The connection-oriented business model in this ecosystem is centred on charging for connectivity services (e.g. infrastructure provision). The goal of the content-oriented business model is to make money with content services (e.g. audio or video). The context-oriented business model focuses on generating revenue from information already available online (e.g. user profiles, location and time), and putting the content into context. All services related to connection, content, and context are made profitable through the commerce-oriented business model. Possible implementations at each level, including spectrum sharing (connection), industry-specific content (content), contextual and location-based services (context), and network slicing (commerce), are highlighted in the proposed business model framework for the 5G ecosystem. However, the proposal did not address the implementation costs nor the actual methods of achieving the monetization aspects. Furthermore, providing the actual pricing mechanisms to be used would improve the practical application of the proposed framework.

Business models for the vertical smart-grid market in the 5G ecosystem were presented by (Moqaddamerad, Xu, Iivari, & Ahokangas, 2016). The study presented business models based on the logic of highly networked and interconnected business and technology environments. In the context of smart-grid commercialisation in the 5G era, a 4C ecosystemic model was developed. The study used an action-based research methodology for data collection within the framework of two techno-social collective innovation projects: (1) European Union level peer-to-peer (P2P) technical and market design of smart-grids, and (2) Finnish-American research co-operation on 5G networks key sector enablers. The central research question of the study was: “How can business models be applied in a co-opetition based value creation and capture

in the context of a hyper-connected business ecosystem?” As reported by Moqaddamerad et al. (2016), the identification of the four dimensions of hyper-connectivity, namely hyper-connectability, hyper-memorability, hyper-diffusibility, and hyper-scalability represents the main contribution of the study. Furthermore, the empirical study conducted can serve as a basis for creating a more robust theoretical business model for hyper-connectivity. However, the P2P concept was limited as it could only evaluate the potential of 5G in already existing and well-known smart grid applications. Therefore, it is impossible to explore future applications that have yet to be discovered. Apart from that, the study focused only on the technology design component and ignored other components of the business model, such as customer relationships and infrastructure management. Nevertheless, the conclusions of Moqaddamerad et al. (2016) could serve as a basis for further research on the development of the 5G smart-grid vertical market.

3.6.3 Business Models for Carrier 5G Mobile Network Operators

As 5G networks are rapidly being deployed globally, carrier (traditional) mobile network operators (MNOs) are unsure about which business models are best suited to support these networks. Therefore, as MNOs step up the rollout of 5G networks, sustainable and viable business models will be crucial to achieve the desired economic value.

Currently, MNOs are typically responsible for the deployment, operation, and maintenance of mobile communications infrastructure. Considering how capital-intensive this process is, operators typically only deploy mobile networks in areas with high return on investment (RoI), such as urban areas. As a result, rural areas are often overlooked, left behind, or digitally disadvantaged when implementing new mobile technologies (S. K. Kumar, Stewart, Crawford, & Chaudhari, 2020). In some regions such as Sub-Saharan Africa, where approximately 60% of people live in rural areas, this poses a challenge for MNOs to achieve their RoI (K Okeleke et al., 2019). For initial 5G network deployment by mobile operators, the following business models have been proposed in addition to the emerging disruptive 5G business models discussed by (Banda et al., 2022a).

1. Vertical Market Partnership Business Models

5G networks are expected to bring forth novel business models centred on value creation and capture via multiple partnerships with vertical industries within a collective value system (Rejeb & Keogh, 2021). At the same time, 5G will offer various and distinctive operators' value propositions to all clients, including consumers, businesses, verticals, and other partners (Rao & Prasad, 2016). The following business models for vertical market partnerships are suitable for various use cases.

1. Smart Learning Business Model

In this model, MNOs can collaborate with school districts, researchers, regulators, Ministries/Departments of Education, and equipment vendors to offer smart learning through tele-education use cases (Rao & Prasad, 2016). This can be accomplished with minimal visual or auditory delays through eMBB's immersive real-time interaction with VR, AR, and virtual presence applications (Lee & Kim, 2020). Both learners and instructors can greatly benefit from this, particularly in situations where in-person instruction is not possible, such as distance and online learning.

2. e-Health Business Model

In the e-health business model, MNOs have the opportunity to collaborate with key players in the healthcare industry, including departments of health, ministries, private or public health insurance companies, equipment vendors, medical device manufacturers, and researchers. Applications and use cases for 5G-enabled e-health business models include remote surgery, connected care, precision medicine, and remote medical diagnosis (N. Gupta, Juneja, Sharma, & Garg, 2021). The e-health model has become crucial for national and local governments during and after the COVID-19 pandemic. For example, it is now necessary to keep records of vaccinated citizens (Hu, Liang, Hosam, Hsieh, & Su, 2022).

3. Smart Agriculture Business Model

In countries where agriculture is a major economic sector, 5G technologies are expected to provide solutions for intelligent farming systems. According to Khujamatov, Toshtemirov, Lazarev, and Raximjonov (2021), the mMTC service class will enable smart agriculture

through the use of IoT based on 5G. For example, a number of 5G-enabled wireless sensors placed in specific agricultural areas can be used to create tailored applications to optimize soil moisture content and guarantee effective use of water and fertilizers (Tao, Zhao, Wang, & Liang, 2021). In the smart agriculture business model, MNOs have the opportunity to collaborate with government agencies responsible for agriculture, successful farmers in the commercial sector, academic institutions specialising in agriculture, and professionals in agricultural research.

4. Smart Grid Business Model

According to Zheng et al. (2021), the smart grid business model aims to create intelligent, highly efficient power distribution networks that leverage the forecasts and predictions of big data analytics. MNOs have the opportunity to offer wireless sensor connectivity to enable utilities to efficiently monitor and predict energy demand and consumption over 5G networks as the majority of emerging markets struggle with unstable power supplies (Moqaddamerad et al., 2016). In this model, potential key partners for MNOs are regulators and policymakers, energy suppliers, municipalities, research institutes and energy ministries/departments.

5. Smart City Business Model

The increasing complexity of managing cities in developed countries and accelerated urbanisation in developing countries require the application of smart city concepts to improve the well-being and support of urban communities (Rao & Prasad, 2018). MNOs have the opportunity to develop smart city business models by collaborating with various entities such as local governments, non-governmental organisations, citizen groups, legislators, politically appointed leaders, and researchers (Rao & Prasad, 2016). The potential benefits of 5G smart cities include: remote monitoring of roads and infrastructure, waste management systems, smart parking, and water sanitation (Rao & Prasad, 2018; Rusti, Stefanescu, Ghenta, & Patachia, 2018).

6. Smart Transportation Business Model

According to Gohar and Nencioni (2021), smart transportation systems guarantee flexible and adaptive fleet management for public and private companies, including optimised route

planning to reduce traffic congestion and accidents. Ministries/Departments of Transports, local and municipal governments, transport system providers, and researchers are among the potential partners of MNOs for 5G smart transportation system business models. As stated by the World Health Organization and the World Bank (Peden et al., 2004), despite the fact that low- and middle-income countries own approximately half of the world's vehicles, 90% of all road fatalities take place in these countries. The socio-economic potential benefits of 5G-enabled smart transportation business models in low- and middle-income countries are enormous. Additionally, the 5G Automotive Association (5GAA) was founded by key industry players with the aim of promoting collaboration between the telecommunications sector and automobile manufacturers to create comprehensive solutions for upcoming mobility and transportation services (5G-AA, 2021).

2. Mobile Network Operators as OTT/Content Providers' Business Models

One of the biggest challenges for mobile operators is that OTT players and content providers offer video, voice and messaging services for free over the operators' network infrastructure. As a result, OTT players and content providers are in direct competition with mobile operators, but without investing in infrastructure development and maintenance (Rao & Prasad, 2016).

1. Video Streaming Services Business Model

The proliferation of low-cost smartphones and other handheld devices, along with the demand for various video applications, are among the main factors driving the exponential increase in demand for higher data rates. MNOs have an opportunity to enter related digital industries such as video streaming using video-based services, particularly in emerging markets such Brazil, India, Kenya, South Africa, and Nigeria (Coetzee et al., 2018; K Okeleke et al., 2019). According to Rao and Prasad (2016), MNOs can develop business models for 5G video streaming services through the following three options:

MNO develops video streaming services targeting its own customers - where only registered customers generate both direct and indirect revenue for the MNO.

MNO develops video streaming services for open access - where both the direct income from registered and unregistered customers as well as the exclusive indirect income from unregistered customers are generated for the MNO.

MNO partners with the OTT/Content provider for video streaming services - whereby the MNO offers video streaming services that are created by certain content producers or OTT players. The two parties share the revenue generated.

3. Real-time Online Gaming Business Models

The advent of 5G technology and its widespread deployment is undoubtedly causing disruption in the online gaming sector. 5G brings many benefits to the online gaming industry with improved performance characteristics such as lower latency, higher data rates, and increased capacity and reliability for improved player experiences (D. Johnson, 2020). MNOs can benefit from the upcoming opportunities in the 5G real-time online gaming sector, which will be bolstered by high-throughput eMBB applications such as VR/AR (Erunkulu et al., 2021). MNOs may have a choice between the following two business model options.

MNO builds its own real-time online gaming apps: Under this model, MNO develops and manages internal real-time online gaming applications and provides gaming services directly to customers.

MNO partners with real-time online gaming app developers: Under this model, the MNO offers gaming services developed and managed by a third-party app developer under a revenue share agreement.

4. 5G-enabled Internet-of-Things (5G/IoT) Business Models

The Internet of Things (IoT) is based on massive machine communication (MMC) in 5G networks. There are many application areas for IoT, such as automotive, public safety, emergency services, and healthcare, each with its own business model requirements (A. Gupta & Jha, 2015). Consumer IoT (cIoT) and industrial IoT (iIoT) are becoming increasingly different from each other, which has implications for the underlying technologies and business models (Palattella et al., 2016). According to Bandyopadhyay and Sen (2011), consumer IoT

connects consumer electronics to improve people's quality of life by saving time and money and enabling virtual interactions with user environments such as homes, offices and cities. On the other hand, Palattella et al. (2014) claim that industrial IoT focuses on the integration between Operational Technology (OT) and Information Technology (IT). For example, how intelligent machines, connected sensors and data analytics can improve business-to-business (B2B) services in various industries (Palattella et al., 2016).

Research on the connection between real-time sensor networks and IoT-based real-time production logistics in terms of 5G business models for MNOs is gradually gaining importance. In the context of 5G, sustainable business models could add value to system transition, which could lead to the development of IoT-based real-time production logistics, restructuring energy markets and demanding consumer support for sustainable smart energy systems (Kovacova & Lăzăroiu, 2021). In addition, 5G networks will enable smart product innovation and sustainable business models through big data-driven technologies which can help companies achieve better supply chain sustainability outcomes through the application of circular economy standards (Andronie, Lăzăroiu, Iatagan, Hurloiu, & Dijmărescu, 2021). Popescu, Petreanu, Alexandru, and Corpodean (2021), conducted an empirical study to investigate the use of industrial artificial intelligence, cyber-physical process monitoring systems, and IoT-based real-time production logistics in sustainable smart manufacturing. Real-time wireless monitoring of production facilities and networked production or logistics business operations through wireless sensor technologies can be facilitated by cyber-physical production systems (CPPS) (Nica, Stan, Petre, & Geambazi, 2021). CPPSs optimize manufacturing and logistics processes in smart manufacturing environments by auditing, monitoring, and automating business processes (Lăzăroiu, Kliestik, & Novak, 2021).

Additionally, it has been noted that developed countries are not the only ones making creative use of IoT technologies. IoT technologies are being used as a tool for social and economic development in developing regions such as Sub-Saharan Africa, where they are gradually spreading (Kshetri, 2022). However, according to industry forecasts, Sub-Saharan Africa will only account for 1.19% of the global number of IoT connections by 2025 (GSMA, 2018).

Inadequate infrastructure, low investments, and uncertainties regarding return on investment (RoI) could be the reasons for the low adoption rate of IoT-enabled technologies in Sub-Saharan Africa (Najjuuko et al., 2021; K Okeleke et al., 2019).

3.6.4 Business Models for Private 5G Networks

The introduction of 5G mobile network technologies for private 5G network applications can leverage a range of business models. The business model selected depends on a number of factors, including the industry sector, specific use case, capital expenditure (CAPEX), operational expenditure (OPEX), and network scalability (Poe et al., 2020). Private 5G networks can provide reliable voice or data services within buildings or in remote locations. They are quick to deploy, easy to manage, and extremely secure. These networks can support the following use cases and business models from various industries (Wen et al., 2021).

1. Smart Manufacturing Business Model

With a variety of use cases, 5G and IoT integration has gained recognition as one of the key drivers of the vertical manufacturing market (GSMA, 2020a). According to Wen et al. (2021), production line flexibility, machine-to-machine communication, autonomous transport vehicles, connected workers, end-to-end logistics, and multi-client service facilities are some use cases for which manufacturing business models can be developed. Some of the successful applications of 5G smart manufacturing in the private sector include: Ericsson's implemented 5G smart factory in Lewisville, Texas, USA (Ericsson, 2021); The US Department of Defence (DoD) Smart Warehouse developed with technical support from Cisco and other technology companies (GCN, 2020); and factory automation by Mitsubishi Electric Corporation (Mitsubishi, 2020).

2. Smart Mining Business Model

Most mines are located in remote locations, and miners often work underground where it is not always possible to gain access to the public cellular network (Wen et al., 2021). To make mining operations safer and more automated, private 5G technologies are required. In addition, wireless sensor networks based on private 5G can be installed in mines to track operating conditions, detect warning signs of mine disasters, and trigger preventive alerts (Wen et al., 2021). For

example, China Mobile, Yangquan Coal Group and Huawei jointly successfully built China's deepest underground 5G network in the Xinyuan coal mine in Shanxi Province (G. Wang et al., 2022).

3. Smart Seaports Business Model

According to Zhong et al. (2019) smart seaports equipped with private 5G networks are expected to be viable options for port authorities. This is critical as crowded port yards, environmental impacts, worker safety and equipment downtime increasingly become challenges for seaports. Wen et al. (2021) identified four use cases for smart ports supported by private 5G networks. These include remote-controlled and automated cranes, automated guided vehicles (AGVs), condition monitoring, and unmanned aerial vehicles (UAVs). A practical case is when Nokia, the Hamburg Port Authority (HPA) and Deutsche Telekom jointly conducted field tests in the Port of Hamburg in Germany (Fellah, 2019).

4. Smart Airports Business Model

Airports can improve the passenger experience by optimizing ground operations through automated boarding procedures through the implementation of private 5G networks (Wen et al., 2021). In addition, during natural disasters or global pandemics, private 5G networks and other relevant technologies can be used for automatic fever detection, facial recognition, access to passengers' travel documents and passengers' vaccination status. For example, 5G and AI-based boarding technologies can expedite identity checks, baggage drop-off and continuous security monitoring to reduce waiting times for passengers. Beijing's newest and largest airport in Daxing, China, is a prime example of smart airport design, where Huawei has installed a 5G-based automation system operated by China Unicom (B. R. Kumar, 2022).

5. Smart Railways Business Model

Essential and reliable communication services are required for the smooth operation and scheduling of regular and high-speed trains. For example, Wen et al. (2021) observed that train drivers and signallers require secure communication with minimal latency. In addition, rail travellers expect reliable and stable multimedia services when using on-board infotainment applications such as VR/AR apps, video-on-demand (VoD) and UHD video streaming.

Therefore, rail networks can benefit from the characteristics of private 5G networks such as high availability, high reliability, low latency, and tailored QoS network coverage and capacity (Ai, Molisch, Rupp, & Zhong, 2020).

6. Business Models for 5G-IoT Private Networks

The ongoing integration of Internet of Things (IoT) within the 5G ecosystem promises to provide smart and intelligent services meant to foster vertical industry digitalisation. 5G-IoT private networks have become a popular choice of adoption by industry verticals in accelerating digital transformation across various sectors, thereby culminating in Industry 4.0. 5G-IoT private networks are envisaged to offer agile solutions to effectively deploy, own and operate 5G services by non-traditional MNOs (i.e., private organisations and enterprises) for the sole use of a given business-to-business (B2B) customer such as a vertical (Banda et al., 2022a).

5G cellular network technologies can be adopted for private 5G-IoT network applications using a range of business models. Various factors such as industry sector, use case specificity, capital expenditure (CAPEX), operational expenditure (OPEX), and network scalability influence the choice of business model (Banda et al., 2022a). Private 5G networks are secure, fast and easy-to-manage networks that can provide reliable services within buildings or in remote and isolated areas, while delivering business value to key stakeholders. Table 3.8 summarises 5G-IoT private network business models, target vertical markets, key drivers and sample use cases (Banda et al., 2022a; Frank, Colman-Meixner, Assis, Yan, & Simeonidou, 2022; S. Li, Da Xu, & Zhao, 2018).

Table 3.8: Summary of 5G-IoT private network business models, target vertical markets, key drivers and sample use cases (compiled by researcher)

5G-IoT Business Model	Target Vertical Market	Key Drivers	Sample Use Cases
Smart Factory Business Model	Manufacturing	• Proliferation of mobile robotics in process automation.	• Connected workers • Production line flexibility • End-to-end logistics
Smart Mining Business Model	Mining	• Demand for high safety standards in the mining industry. • Rapid transition from human-driven machine control to automated remote controlled applications	• Early warning disaster signalling • Safety signal dissemination • Automated drilling machine communication
Smart Sea Ports Business Model	Maritime	• Surge in seaport activities mainly driven by cargo transportation which cannot be handled by the aviation industry.	• Remote-controlled & automated cranes • Automated guided vehicles (AGVs) • Unmanned aerial vehicles (UAVs) • Sea condition monitoring
Smart Airports Business Model	Aviation	• Rise in air freight activities. • Upsurge of passenger air traffic, post COVID-19 era.	• Automated AI-based boarding procedures for passengers. • Constant security monitoring • Automated fever detection • Optimized luggage handing
Smart Railways Business Model	Transportation & Logistics	• Increase in use of railway systems as a means of inland cargo transportation. • Increased number of train commuters due to road congestion.	• Smooth scheduling & operations of trains. • Secure and low latency communication between drivers and signalling controllers. • Automated AI-based boarding procedures for passengers.
Smart City Business Model	Public service	• Rapid urban/city population explosion • Increase in CO2 emission levels in urban areas	• Remote monitoring of roads and city infrastructure. • Automated water sanitation and waste management systems • Air pollution level detection
Smart Grid Business Model	Energy	• Multiple wireless sensors with uninterrupted 5G connectivity deployed in specific substations.	• Effective monitoring and forecast of energy demand and consumption • Automated adjustment of electric profile via load control.
Smart Agriculture Business Model	Agriculture	• Multiple wireless sensors with uninterrupted 5G connectivity deployed in specific crop fields.	• Optimized soil moisture content • Efficient use of water and fertilizers via customized applications
Smart Education Business Model	Education	• eMBB immersive real-time interaction using VR/AR and virtual presence applications with minimal visual or audio delays.	• Immersive real-time virtual interaction between learners and educators especially during the COVID-19 pandemic • Tele-education for distance-learning.

3.6.5 Business Models for 5G and Future Mobile Network Operators

Emerging 5G and future networks (5GFNs) (i.e., 5G and 6G) will change the mobile communication business ecosystem by introducing multi-service wireless applications with diverse specifications. These smart and future-oriented wireless networks are intended to address not only consumer-based smartphone applications, but also the needs of various vertical industry markets (e.g., education, energy, healthcare, transportation, manufacturing, agriculture, and so forth). 5GFNs are aimed at attaining economic value for all key stakeholders, including customers, mobile network operators (MNOs), equipment vendors, public institutions, private enterprises, digital business start-ups and various third parties. The following business models' options are applicable to 5GFNs from the MNOs' perspective.

1. Adaptive Service-based Business Model

Some of the promising 5G and 6G technologies such as network slicing (Khan et al., 2020) and digital platforms (S. I. Yrjölä, Ahokangas, & Matinmikko-Blue, 2021) will require a wide variety of key players and partners to interact and provide consumers with various smart services. The existing stand-alone and rigid business models cannot support such dynamic service-driven technologies. MNOs and their partners must appropriately adapt to rapid changes within the value chain while providing services to the target customers. Therefore, it is necessary to transition from product-based to adaptive service-based business models. This is crucial since consumer demands may change with time. The design of adaptive service-based business models can increase both the operators' and partners' profits as well as user satisfaction. These adaptive service-based business models will require both dynamic service level agreements (DSLAs) and dynamic pricing strategies (Khan et al., 2020).

2. Security-oriented Business Model

Generally, research on 5G business models has focused more on the economic value aspects of key network performance metrics like data throughput, latency, reliability and device connectivity density with relatively little regard for security objectives such as confidentiality, privacy and data integrity. However, since 5G networks will be enabled to fulfil IMT-2020's mMTC service class (ITU-R, 2015) by technologies like Internet of Things (IoT) and device to

device (D2D) communications, the effects of large-scale wireless connections and related security concerns should be incorporated in the design of business models. The involvement of many role players in the 5G ecosystem, each with different security levels, increases the vulnerability to cyber-attacks. Consequently, existing MNO's business models should become modified security-oriented business models by integrating IoT forensics and various other means of combatting 5GFNs cyber threats (Yaqoob, Hashem, Ahmed, Kazmi, & Hong, 2019). Security-oriented business models should be capable of supporting the complex authentication, authorization and encryption mechanisms of the connected devices as well as users on 5GFNs to guarantee confidentiality, privacy and data integrity.

3. Dynamic and Shared Spectrum-based Business Model

The ultra-densification of the emerging 5GFNs by the introduction of small cells (i.e., microcells, picocells and femtocells) will facilitate the possible entry of local and specialized service providers such as micro-operators who will require their own specific business models (Ahokangas et al., 2019). However, it is still undetermined if the rollout of 5GFNs will create viable business opportunities for micro-operators, especially in rural communities. Micro-operators might have to pay hefty charges to incumbent licensed operators for spectrum resources. Moreover, if the spectrum is auctioned, the incumbent operators' dominance is likely to be perpetuated.

To meet the growing and varying demands of users and achieve an efficient utilization of national spectrum resources, dynamic and shared spectrum allocation mechanisms between traditional mobile operators and micro-operators can be implemented. Regulators and policy makers should vigilantly oversee such a strategy to ensure that fairness, in terms of spectrum utilisation and the associated costs among network operators, is maintained. To motivate and accelerate new network operator entrants and improve inclusive digital businesses, independent communications sector authorities should identify underutilized spectrum bands and allocate them for use by micro-network operators, in a shared spectrum framework and associated toolboxes such as that developed by the CSIR (Somdyala, Rananga, Mfupe, Masonta, & Mekuria, 2017). Therefore, when developing business models, both traditional MNOs and new

micro-operators should carefully consider the details of dynamic and shared spectrum mechanisms before going into partnership for their mutual economic benefits.

4. Three-Dimensional Networks Business Model

Three-dimensional (3D) networks are designed by integrating unmanned aerial vehicles (UAVs) (also known as drones) into 5G and future cellular networks. The introduction of 3D networks is a promising solution to achieve safe UAV operations as well as enabling diversified applications with mission-specific payload delivery (Q. Wu et al., 2021). Such networks are referred to as “moving networks” as they consist of a drone-based user equipment (UE) and a drone-based base station (BS). The study of business models for 3D networks could offer profound opportunities for researchers and practitioners in the era of 5GFNs. This is because the business targets and the network performance metrics requirements for 3D moving networks will be significantly different from the current wireless networks.

5. Green Communication Business Model

To enable sustainable 5GFNs, green and energy efficient communication technologies have been proposed to reduce such systems’ energy consumption. Green energy sources can then be introduced to reduce dependence on traditional fossil fuels to power network devices. 5GFNs are designed with the aim of reducing energy consumption as well as minimizing carbon emission footprints without sacrificing network quality of service (QoS) (Masoudi et al., 2019). Additionally, Eshaghi and Rashidzadeh (2020) have examined energy harvesting technologies, that enable communication devices to harvest energy from various renewable sources. However, research on business models aimed at facilitating green communication within the 5GFNs ecosystem has so far received very little interest from both academia and industry.

6. Business Model for Network Slicing in Digital Platforms

Despite the proliferating literature on 5G developments, hardly any contributions have explored 5G network slicing in conjunction with digital platforms from the business model’s standpoint. Network slicing and digital platforms have been extensively studied by Khan et al. (2020) and S. I. Yrjölä et al. (2021), respectively. The notable feature of network slicing is the ability to

customize the capabilities and functionalities that 5GFNs will be able to offer the business customers. The customized service can consist of a combination of eMBB, mMTC and uRLLC use cases that are logically separated into distinct components: network connection service or network resources service. Platform-based ecosystemic business models will incorporate both the technical (e.g., technological innovation) and economical (e.g., economies of scale and scope) aspects. An ecosystemic platform-based business model, consisting of components, interfaces, data and algorithms, has been studied in (S. I. Yrjölä et al., 2021). Therefore, business models based on network slicing in digital platforms should guarantee performance targets and connectivity as well as resource assignment.

In a network slicing and platform-based business model, the MNO can play key roles in the value proposition such as: ecosystem orchestrator (for partners offering services to their customers); value network orchestrator (for ICT, device OEM manufacturers and OTT providers); and innovation coordinator (for innovative value-sharing mechanisms with other partners) (Psyrris, Kargas, & Varoutas, 2021). Table 3.9 gives a summary of MNOs' business models for 5G and future networks (5GFNs) alongside their implementation targets, drivers and mechanisms.

**Table 3.9: Summary of 5GFN business models, implementation targets, drivers and mechanisms
(compiled by researcher)**

Business Model	Implementation Targets	Drivers	Mechanisms
Adaptive service-based model	Dynamic service-oriented technologies (e.g., network slicing and digital platforms)	Variable and dynamic service demands from customers and consumers	- Dynamic service level agreements (DSLAs) - Dynamic pricing methods
Security-oriented model	- Fulfilment of the IMT-2020 vision of 1 million devices per square kilometre - Increased number of 5GFNs value chain key players	- Massive number of communication devices - Varying security requirement levels of 5G ecosystem players and consumers	Modification and enhancement of current network security schemes (e.g., authentication, authorization and encryption) to fulfil security objectives
Dynamic and shared spectrum model	- Spectrum resource acquisition and utilization - Spectrum associated costs and fees - Growing and varying service demands from customers and consumers	- Ultra-densification of 5G and future access networks - Entry of local micro-operators and other specialized service providers into the 5GFNs market - Efficient Spectrum Resource Utilization	Regulator-driven dynamic and shared spectrum techniques between licensed operators and micro-operators
3D networks model	Integration of the UAVs (drones) within the 5G and Future cellular networks	Drone-based moving networks (i.e., moving base station and moving user equipment)	Modification of the current static networks' business targets and performance metrics
Green Communication model	Incorporating green communication and environmentally friendly technologies in 5GFNs business model design	- Current dependence on traditional fossil fuel as a source of energy - Increase in CO2 emission levels	- Alternative clean sources of energy (e.g., solar and wind) - Energy harvesting technologies for prolonged power conservation
Network slicing and Digital Platforms model	- Network connectivity - Network resource allocation	- Variable service requirements - Variable key performance indicators	- Appropriate platform components, interfaces, data algorithms - Accurate definition of network slice

3.7 Conceptual Framework of the Business Model Design

A conceptual framework is an analytical tool that provides a tentative theory of a phenomenon under investigation (Adom et al., 2018). It establishes the relationship between concepts by showing theories which influence the research study, thereby providing a theoretical basis to design the research and interpret the findings (Leshem & Trafford, 2007). Therefore, a conceptual framework introduces clarity in a research study by modelling the relationship between the concepts while showing the theories which influence the research and provides a theoretical basis to design and interpret research (Leshem & Trafford, 2007).

3.7.1 Value Chain Components

In order for mobile operators to successfully develop feasible and sustainable 5G business models, the connections between the value chain components should be accurately established by following the guidelines of the business model ontology developed by (Osterwalder & Pigneur, 2004). The following components of the 5G value chain have been identified.

Who? This component of the value chain focuses on identifying target customers, their specific needs, and how to offer differentiated services to ensure customer satisfaction, thereby ensuring that the customer value proposition is addressed. It describes the target customer segments to which the MNOs intends to provide the proposed value. Target customer segments include: public/government institutions, municipalities, private enterprises, residential customers and industries such as mining, manufacturing and energy sectors.

What? This part of the value chain explains the MNO's service offering (value proposition) to a particular customer segment with the aim of delivering value to the customer and capturing value for the operator. It describes the value that the MNO wants to provide to the target customer base. Examples include: eMBB services such as VR/AR and UHD video applications, mMTC services such as smart factories and smart energy grids applications, and uRLLC services such as autonomous vehicles and remote surgery applications.

How? This component of the value chain describes the technology design, network infrastructure, and network resources available to the operator to provide the relevant services to intended customers. It also explains how the MNO creates and delivers value to the target

customer segment. The “How?” component may include: 5G NSA and SA deployment modes; key technologies such as digital platforms, network slicing, massive MIMO and beamforming, ultra-densification, SDN/NFV, millimetre wave, green communications, IoT, and D2D communications; key activities such as site infrastructure sharing, outsourcing and training; key resources such as spectrum, baseband, radio and transmission resources; and key partners such as regulators, equipment vendors, device retailers, platform providers and 4C model providers (connection, content, context, and commerce).

How much? This part of the value chain serves as a blueprint for how an operator plans to optimise its revenues while minimising its costs within the 5G networks ecosystem. Specifically, it shows how much value the MNO will derive from the target customer segment. The following are some of the compositions of the “How much?” component: revenue structures consisting of profit margins, revenue streams and return on investment), pricing strategies such as on-demand pricing and slice-based pricing, and cost structures consisting of initial investments, deployment costs, capital expenditure (CAPEX) , and operational expenditure (OPEX).

Figure. 3.15 shows the relationships between components of the 5G network value chain.

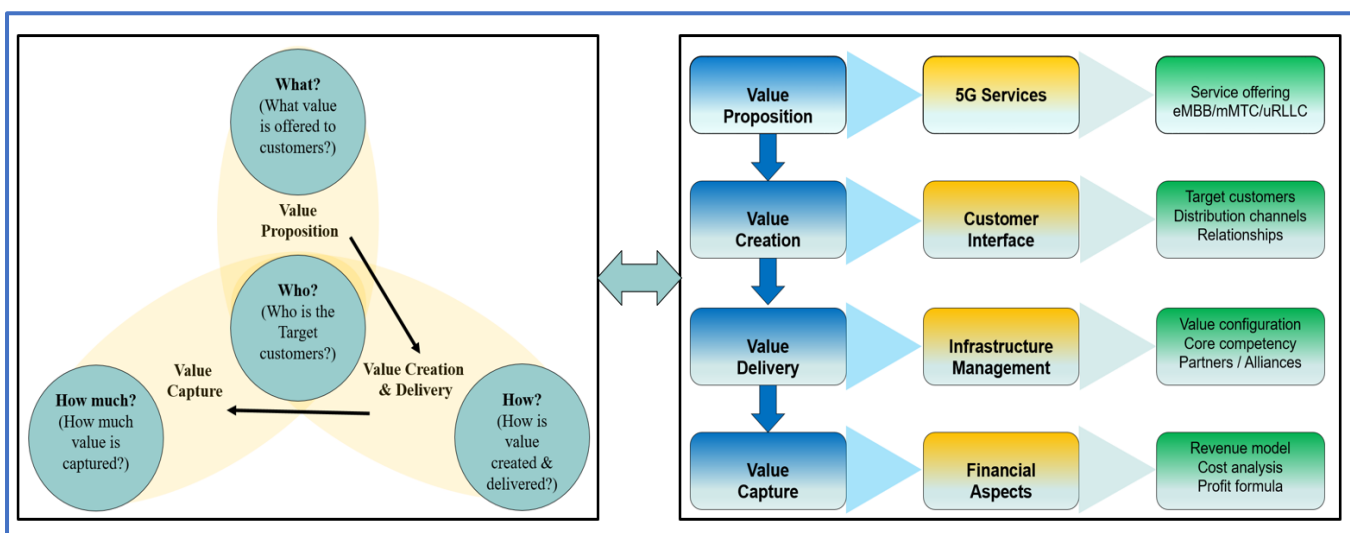


Figure 3.15: Relationships between components of the 5G value chain (compiled by research)

3.7.2 Conceptual Business Model Framework Components

The proposed conceptual framework is developed based on the results of the qualitative study, followed by content analysis and further literature review. This conceptual framework was subjected to quantitative testing to generalise the results. The business model framework for next-generation communications networks consists of four main components: 5G services (value proposition), customer interfaces, infrastructure management and financial aspects.

- **5G services (value proposition)**

The value proposition envisages a wide range of products and services that a mobile operator offers. The three main 5G service classes that form the value proposition component of the proposed conceptual business model framework are: (i) *enhanced mobile broadband (eMBB)* services tailored to throughput-sensitive applications such as high-speed broadband access, immersive mobile services, and high-quality video content applications ; (ii) *massive machine type (mMTC)* services targeting applications with high device connectivity density such as industrial IoT and commercial IoT applications; and (iii) *ultra-reliable low latency communications services (uRLLC)*, intended for low latency (delay) and high reliability communications, for example mission-critical applications such as industrial automation and remote surgery.

- **Customer interface**

The customer interface component of the proposed conceptual business model framework consists of three sub-components which include: (i) *customer segment* which describes the customer base to which a mobile operator wants to offer value, i.e., clients who are attracted by the value proposition. Examples include, government entities, local municipalities, private enterprises and vertical industries ; (ii) *customer relationships* which explain the kind of links a mobile operator establishes between itself and its various customer segments such self-services, personal assistant services, automated services and community based services ; and (iii) *distribution channels* which describes various means a mobile operator can utilise to get in touch with its customers as well as offer them the value proposition. Examples include, web-based sales, wholesales, mobile operator's own store outlets and partners' store outlets.

- **Infrastructure management**

The infrastructure management outlines the technology design, network infrastructure, and resources available to a mobile operator to provide the relevant proposed value to the intended customers. The infrastructure management component of the proposed conceptual business model framework consists of four sub-components: (i) *key partners* which demonstrate the essentiality of collaborative arrangements with external organisations in order to effectively provide and monetize the proposed value. These include, equipment vendors, device manufacturers, platform providers, regulations and policy makers, and other MNOs; (ii) *key resources* which outline the resources at the mobile operator's disposal to ensure that value is created and delivered according to the mobile operator's business goals. Examples include, physical, intellectual, human, financial, spectrum, and site equipment and infrastructure; (iii) *key activities* which describes the activities and competencies necessary to implement the mobile operator's business model. These include, managing partnerships, network design and maintenance, mobile service delivery, and customer technical service support; and (iv) *5G key enabling technologies* which describe the underling and supporting technologies which a mobile operator must design and implement in order to ensure that 5G services are created and delivered to the intended customers. Key technologies include, network slicing, green communication, digital platforms, SDN and NFV, ultra-densification, IoT and D2D communication, and massive MIMO and beamforming.

- **Financial aspects**

The financial aspects of the proposed conceptual business model frameworks outline the capability of a mobile operator to capture and monetize the proposed value delivered to the intended customers. The financial aspects consist of two elements which are: (i) *cost structure* which sums up the monetary consequences of the means employed in the business model such as fixed costs, variable costs, CapEx and OpEx; and (ii) *revenue streams* which describes ways a mobile operator makes money through a variety of revenue flows such as subscription fees, asset leasing/renting, advertisement and partnership revenue sharing.

Table 3.10 summarises the components of the proposed conceptual business model framework of the current research study.

Table 3.10: Components of the proposed conceptual business model framework (compiled by researcher)

5G Service (Value Proposition)				Customer Interfaces		
eMBB Class	mMTC Class	uRLLC Class		Customer Segment	Customer Relationships	Distribution Channels
• Human-Oriented services - VR/AR/ER applications • High speed broadband access - ultra-high definition (UHD) video - intelligent CCTV • Immersive mobile services - virtual presence - online gaming	• Industrial IoT applications - automated factory production lines • Commercial IoT applications - smart energy grids - intelligent metering systems - smart parking systems	• Mission critical applications - industrial automation - remote surgery - drone applications - vehicle platooning - industrial robotics		• Government/Public entities • Quasi-government entities • Local municipalities • Private enterprises • Individual consumers • Vertical industries - mining - healthcare - manufacturing - agriculture - education - transportation	• Personal assistant services • Self-services • Automated services • Co-creation partner services • Community-based services	• Web-based sales • Mobile operator's own store outlets • Partners' store outlets • Wholesales • Mobile operator's head or regional offices
Infrastructure Management				Financial Aspects		
Key Partners	Key Resources	Key Activities	Key Enabling Technologies	Cost Structure	Revenue Streams	
• Equipment vendors • Device manufacturers • Platform providers • Regulations & policy makers • Other MNOs	• Physical • Intellectual • Human • Financial • Spectrum • Site equipment & infrastructure	• Managing partnerships • Network design & maintenance • Mobile service delivery • Customer technical service	• Network slicing • Green communication • mmWave • massive MIMO • SDN & NFV • Digital platforms • IoT & D2D • Ultra-densification	• Fixed costs • Variable costs • Capital Expenditure (CapEx) • Operational Expenditure (OpEx) • Economies of scale • Economies of scope	• Subscription fees • Usage fees • Asset renting/leasing • Brokerage fees • Advertisement • Partnership revenue sharing	

3.8 Chapter Summary

This chapter reviewed the literature and provided the theoretical concepts of business model, business model innovation and 5G wireless technologies. It discussed in detail the business models and 5G MNOs (i.e., carrier MNOs and private 5G network operators). Current business models for MNOs and their limitations when applied to 5G and beyond networks were highlighted. Furthermore, emerging disruptive 5G business models, carrier (traditional) 5G MNOs' business models, private 5G networks' business models and business models for 5G and future (5G and 6G) MNOs were outlined. Lastly, a conceptual framework of business model design was presented. The next chapter links the literature reviewed in this chapter to the research design and methodology employed in this study.

CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

The research design and methodology outlines and specifies the overall approach to the research that is employed to test the thesis statement connecting the empirical data to the study's initial research objectives (Hofstee, 2011). Accordingly, Adams, Khan, Raeside, and White (2007) emphasize that the research methodology focuses on outlining the procedures which should be followed when conducting a research study. The methodology should address two key questions: (1) how was the data collected or generated? and (2) how was the obtained data analysed and interpreted? This study is based on a mixed-methods research approach which is outlined in detail in the subsequent sections of this chapter. The research design and methodology for this study included: research process, research design, research philosophy, research methods and approach to theory development, research strategy and time horizon, population and sampling strategy, data collection and analysis, reliability and validity, and ethical consideration.

4.2 Research Process

After identifying the research problem and the related research questions and objectives, the researcher must select an appropriate method and process to address the problem. For this study, the selection of the research methods and techniques was guided by the onion research approach suggested by (Saunders, Lewis, & Thornhill, 2019). In this approach, data collection and analysis which is in the centre of the research onion is guided by the choices in the outer layers of the onion. Saunders et al. (2019) further indicate that the outer layers of the onion include: research philosophy, approach to theory development, research methods, research strategies, time horizon, and data collection and analysis techniques.

For the current study, both interpretivism and post-positivism philosophies were selected. The next section explores the research philosophies available in business and management sciences

and justifies the choice of interpretivism and post-positivism as the underlying philosophies of the current study. The approaches that were used to link the selected philosophies were both inductive (qualitative part) and deductive (quantitative part). The strategies selected were, case study (qualitative part) and survey (quantitative part) with a cross-sectional time horizon. For primary data collection, interviews were used for the qualitative part and survey questionnaires were used for the quantitative part. Figure 4.1 illustrates the research methodology framework for the current study based on the guidelines suggested by (Saunders et al., 2019).

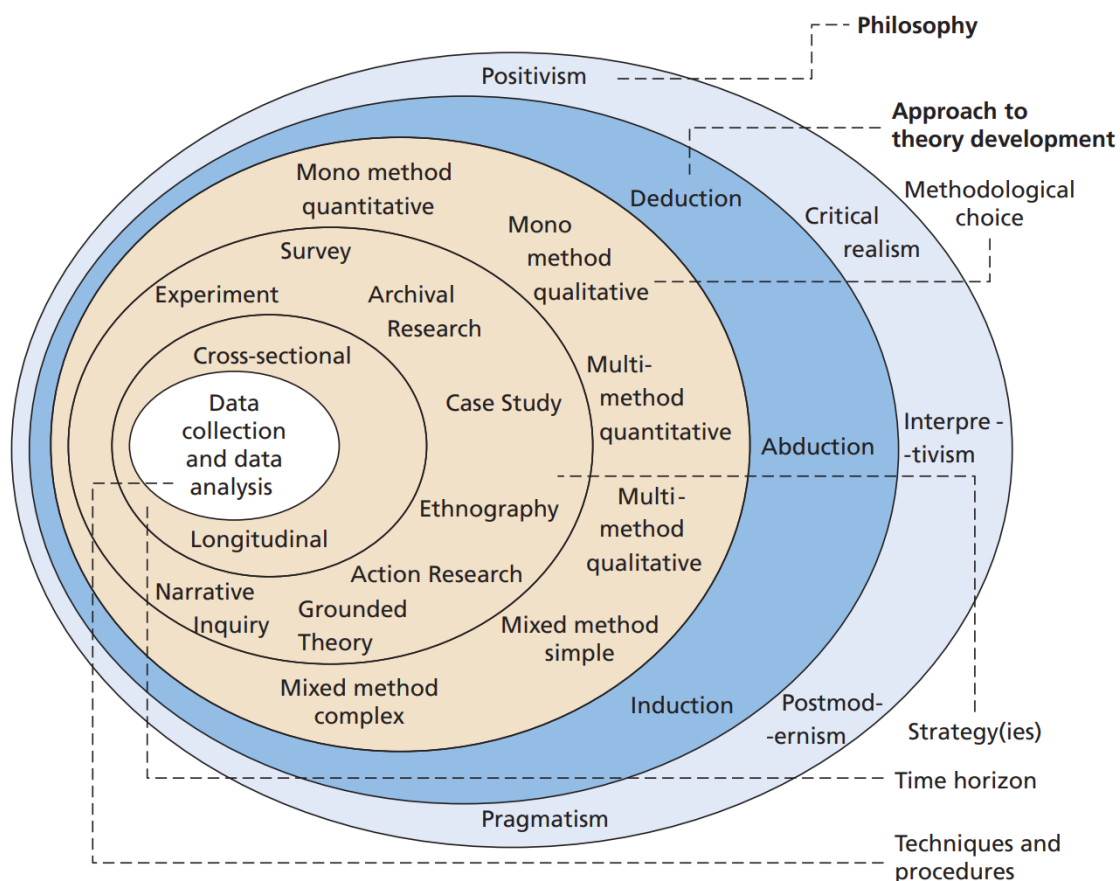


Figure 4.1: Research methodology framework for the study (source: (Saunders et al., 2019))

4.3. Research Design

Research design is the general plan of how the researcher will go about answering the research question(s) (Creswell & Creswell, 2018; Saunders et al., 2019), and thus, the importance of

clearly defining the research question(s) cannot be overemphasized. Furthermore, Saunders et al. (2019) stress the need for the research design to contain clear objectives derived from the research questions, specification of data sources and the proposed approach(s) to data collection and analysis.

The current research study was conducted in four phases using an exploratory sequential mixed-methods design proposed by (Creswell & Creswell, 2018). The choice of this design for the current study was appropriate as the results from the qualitative tests were used to expand and generalise the qualitative findings using the quantitative method (Gujral, 2016). Figure 4.2 depicts the proposed four-phased exploratory sequential mixed-methods design based on (Creswell & Creswell, 2018).

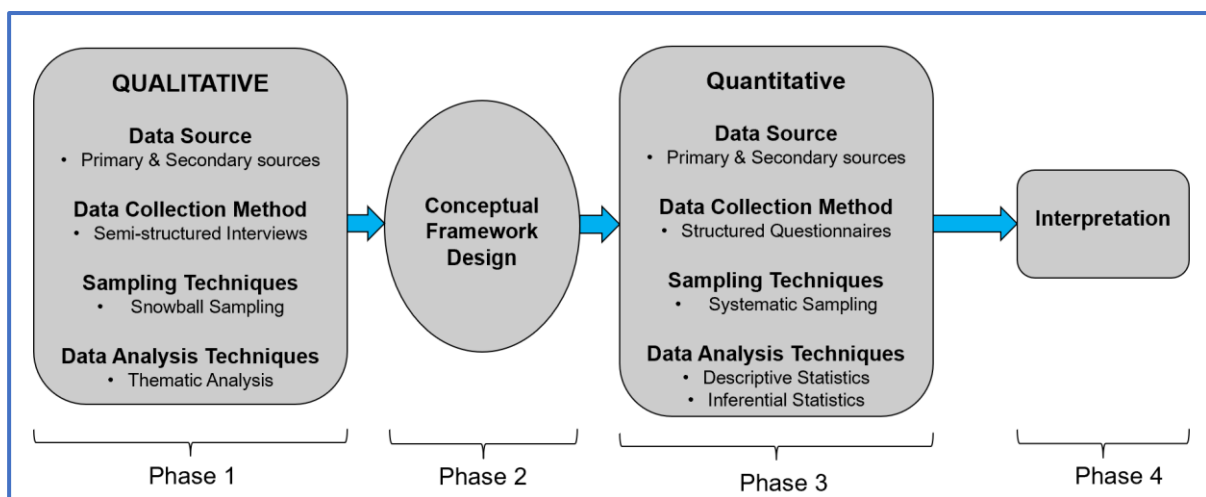


Figure 4.2: Exploratory sequential mixed method design, based on (Creswell & Creswell, 2018)

In this study, the four phases of the research design are:

• **Phase 1 (Qualitative Research Method)**

Qualitative research method is used to investigate the factors affecting the existing business models for next-generation communication networks. Data is gathered through in-depth interviews and snowball sampling strategy (Naderifar, Goli, & Ghaljaie, 2017). Data analysis

is then conducted using thematic analysis method (Braun & Clarke, 2006; Kiger & Varpio, 2020).

- **Phase 2 (Conceptual Framework Design)**

The results of the qualitative method in *phase 1* are used in designing a viable conceptual business model framework for next-generation networks (i.e., 5G and beyond) which can be implemented by mobile network operators.

- **Phase 3 (Quantitative Research Method)**

The conceptualised theoretical framework from *phase 2* is subjected to testing using quantitative method. Data is collected using structured questionnaires and by applying systematic sampling technique. Both descriptive and inferential statistics are used for data analysis.

- **Phase 4 (Result Interpretation)**

The analysed results obtained in *phase 3* are interpreted and presented.

4.4 Research Philosophy

A research philosophy is a set of basic beliefs that guide the design and execution of a research study, and different research philosophies offer different ways of understanding scientific research (HR & Aithal, 2022). Additionally, Saunders et al. (2019) consider a research philosophy as a system of beliefs and assumptions about the development of knowledge. The research philosophy is also referred to as a research paradigm (Bhattacharjee, 2012; Kamal, 2019; Myers, 2019) and philosophical worldview (Creswell & Clark, 2018). Paradigms represent the researchers' beliefs and values about the world, the way they define the world and the way they work within the world (Kamal, 2019). According to Bhattacharjee (2012), the research philosophy is usually hard to perceive as it is often implicit, assumed and conjectured in most research studies. In revisiting the paradigm controversies, Lincoln, Lynham, and Guba (2011) have updated the relationship between the three fundamental assumptions (i.e., ontology, epistemology and methodology) and the paradigms (positivism, post-positivism, critical theory, Interpretivism and pragmatism) by adding a new participatory paradigm

- **Positivism**

Positivism relates to the philosophical stance of the natural scientist and entails working with an observable social reality to produce law-like generalisations (Saunders et al., 2019). Positivism's ontological assumption is that of naive realism that posits that an objective reality exists that can be understood (Lincoln et al., 2011). Additionally, Easterby-Smith, Thorpe, and Jackson (2012) add that positivist approach focuses on hard data more than on opinion and that it looks for regularities in obtained data to produce generalisations from specific examples for a greater population similar to those of natural science.

- **Post-positivism**

According to Panhwar, Ansari, and Shah (2017) post-positivism is pluralist in its function which balances both positivist and interpretivist approaches. Panhwar et al. (2017) further articulate that the post-positivist theoretical perspective is a flexible research approach which allows the researcher to use multiple methods to conduct the research study according to the nature of the research questions. Post-positivism incorporates approaches to knowledge growth which were previously rejected by positivism as unscientific (Fox, 2008). Additionally, Henderson (2011) believes that post-positivism justifies the potential for using mixed methods as it offers a practical approach to collecting data using more than one method.

- **Critical Theory**

The critical theory paradigm situates its research in social justice issues and seeks to address the political, social and economic issues, which lead to social oppression, conflict, struggle, and power structures at whatever levels these might occur (Kivunja & Kuyini, 2017). The ontological position of critical theorists is that of historical realism while, epistemologically, critical theory is subjective in that it is assumed that no object can be researched without being affected by the researcher (Rehman & Alharthi, 2016).

- **Interpretivism**

Interpretivism (also known as constructivism) emphasises that humans are different from physical phenomena because they create meanings (Saunders et al., 2019). It has been regarded

as a response to the predominance of positivism (Grix, 2018). It therefore, rejects the notion that a single, verifiable reality exists independent of our senses (Rehman & Alharthi, 2016) by refusing to adopt any permanent, unvarying standards by which truth can be universally known and accepted (Lincoln et al., 2011).

- **Pragmatism**

Pragmatism arose among philosophers who argued that it was not possible to access the “truth” about the real world solely by virtue of a single scientific method as advocated by the positivist paradigm, nor was it possible to determine social reality as constructed under the interpretivist paradigm (Kivunja & Kuyini, 2017). Pragmatism asserts that concepts are only relevant where they support action (Kelemen & Rumens, 2008). Saunders et al. (2019) add that for a pragmatist, research starts with a problem and aims to contribute practical solutions that inform future practice.

4.4.1. Research philosophies for the current study (Interpretivism and Post-positivism).

This research study adopted both interpretivism and post-positivism paradigms, as generally implemented with mixed-methods approach where both qualitative and quantitative methods are combined in a single study (Creswell & Clark, 2018). The interpretivist paradigm is employed for phase-1 and phase-2 (i.e., qualitative method and theoretical framework design) before switching to a post-positivist paradigm in phase-3 (i.e., quantitative method) of the study. The interpretivist approach during the phase-1 and phase-2 of the study was aimed at gaining in-depth understanding of the underlying theoretical concepts as well as appreciate the multiple perspectives of the research area. In phase-3 of the study, a post-positivist approach was used to identify and measure variable parameters via statistical trends. Therefore, two research paradigms have been followed in this study and the paradigm shift from one phase of the study to the other is supported as stated by (Mayring, 2014).

According to Creswell and Clark (2018), interpretivism is generally associated with qualitative methods. Through interpretivism, researchers seek an understanding of the world in which they live and work. This understanding is formed through research participants and their subjective

views which are shaped by their social interaction with others in addition to their own personal experiences. Conversely, post-positivism is generally associated with quantitative approaches (Maksimovic & Evtimov, 2023). Determinism or cause and effect thinking (reductionism) are the main sources of post-positivist claims for knowledge. These claims are narrowed and focused on choosing variables to relate, describing observations and variables, and testing theories that are constantly improving (Creswell & Clark, 2018). The quantitative method (phase 3) embraced the post-positivist perspective by seeking answers to theory driven questions (Tashakkori & Creswell, 2007).

4.5 Research Methods and Approach to Theory Development

A research philosophy needs to be supported by appropriate research method (Saunders et al., 2019). Research methods describe the forms of data collection, analysis and interpretation that are used in a research study and there are three main categories; qualitative, quantitative and mixed-methods (Creswell, 2014; Williams, 2007). Saunders et al. (2019) further divide these three basic methods into six sub-methods which are: mono qualitative or quantitative, multi qualitative or quantitative, and simple or complex mixed-methods. According to (Kelle, 2006), the choice of the appropriate research method to use is mainly determined by substantive research questions as well as the mode of data collection. Research methods are linked to the three distinct approaches to theory development that include deduction, abduction and induction (Saunders et al., 2019).

4.5.1 Qualitative, Quantitative and Mixed-methods Approaches

Qualitative research is usually employed to explore, expand, describe and understand the meaning of complex phenomena that have not been previously researched. Creswell (2014) expounds that qualitative research is applied to exploratory research design in order to gain preliminary insights into a phenomenon. Qualitative research is often associated with an interpretive philosophy as researchers need to comprehend the subjective and socially constructed phenomenon under study (Denzin & Lincoln, 2018). According to (Saunders et al.,

2019), in qualitative research, participants' meanings and the relationships between them are used during data collection to develop a conceptual framework and ultimately make a theoretical contribution.

Quantitative research method is generally associated with positivist philosophical approach, especially when applied with predetermined and highly structured data collection techniques (Saunders et al., 2019). According to (Creswell & Guetterman, 2019), quantitative research is aimed at testing theories, determining facts, demonstrating relationships between variables, and predicting outcomes. Saunders et al. (2019) adds that quantitative research examines relationships between variables, which are measured numerically and analysed using a range of statistical and graphical techniques.

A mixed-methods research design integrates qualitative method with quantitative method within the same study in order to get a full understanding of the phenomenon under investigation (Powoh, 2016). Creswell and Clark (2018) argue that mixed-methods approach consolidates the individual strengths of qualitative and quantitative studies to produce a more reliable and robust research method.

4.5.2. Inductive, Deductive and Abductive Approaches

Inductive approach starts by collecting data to explore a phenomenon which is used to build theory (usually in form of a conceptual framework) (Saunders et al., 2019). Conversely, deductive approach involves the development of a theory that is then subjected to a rigorous test through a series of proposition, thus it is the dominant research approach in natural sciences where laws present the basis of explanation, allow the anticipation of phenomena, predict their occurrence and therefore allow them to be controlled (Saunders et al., 2019). Thus, inductive approach is referred to as moving from specific to the general, whereas the deductive approach refers to moving from the general to the specific (Collis & Hussey, 2013).

Saunders et al. (2019) describe abductive approach as the collection of data to explore a phenomenon, identify themes and explain patterns, to generate a new or modify an existing

theory which is subsequently tested through additional data collection. Contrary to moving from data to theory (as in induction) or from theory to data (as in deduction), an abductive approach moves back and forth, thereby combining inductive and deductive reasoning (Suddaby, 2006).

This study employed both induction and deduction approach across different phases of research. Phases 1 and 2 (qualitative part) undertook the inductive approach to build theory in form of conceptual framework from specified business models and mobile network operators. Deductive approach was followed in phase 3 (quantitative part), wherein hypotheses were deduced and tested from the results of the conceptual framework developed in phase 2 and further literature review.

4.6 Mixed-Methods Research Methodology

Mixed-methods is a branch of multiple methods research that merges the use of qualitative and quantitative data collection techniques and analytical procedures in the same research study (Creswell & Clark, 2018; Creswell & Creswell, 2018; Saunders et al., 2019). Further, Molina-Azorin, Bergh, Corley, and Ketchen Jr (2017) conclude that mixed-methods research is based on philosophical assumptions that guide data collection and analysis as well as the mixing of qualitative and quantitative collection techniques and analysis procedures. According to Saunders et al. (2019), researchers using mixed-methods approaches have a pluralist view of research methodology and may use a deductive, inductive or abductive approach to theory development.

4.6.1 Mixed-methods Research Typologies

Several researchers have developed mixed-methods research typologies (Cameron, 2009; Creswell & Clark, 2018; R. B. Johnson, Onwuegbuzie, & Turner, 2007; McKim, 2017). According to Cameron (2009), typologies are used to systematically classify types that have characteristics or traits in common and form part of models and theories. Neuman (2007) regards typologies as a means to classify theoretical concepts which are created by combining

two or more simple concepts to form a set of interrelated sub-types. The following mixed-methods research typologies have been studied in the literature.

Convergent Parallel mixed-methods – the researcher merges qualitative and quantitative methods by typically collecting both forms of data at roughly the same time and then integrates the information in the interpretation of the overall findings (Creswell & Creswell, 2018).

Triangulation mixed-methods – the researcher conducts qualitative and quantitative data collection in the same phase and merges the data during analysis and interpretation in order to compare how these data sets complement one another (Saunders et al., 2019).

Sequential explanatory mixed-methods – the researcher first conducts quantitative research, analyses the findings and then builds on the results to expound them in more details using a qualitative approach (Creswell & Creswell, 2018). Thus, it can be referred to as a double-phased approach where quantitative method is followed by qualitative research.

Sequential exploratory mixed-methods – the researcher first starts with qualitative method by exploring the views of the participants. Thereafter, the results are analysed and the findings are used to build into the second, quantitative part (Cameron, 2009; Creswell & Creswell, 2018). Sequential exploratory mixed-methods can therefore simply be described as a double-phased mixed-methods design where qualitative research is followed by quantitative research.

Sequential multiphase mixed-methods – the researcher employs multiple phases of data collection and analysis such as qualitative followed by quantitative, then by a further phase of qualitative or vice-versa (Saunders et al., 2019).

Embedded mixed-methods – this method embeds or nests one type of data collection within a larger design using the other type of data collection (Cameron, 2009). The embedded approach usually provides a supporting role to the main approach.

4.6.2 Justification for Adopting Sequential Exploratory Mixed-methods Approach

Scholars of qualitative and quantitative research methods claim that these two approaches are incompatible (Howe, 2012). However, Halcomb and Hickman (2015) as well as Doyle, Brady,

and Byrne (2009) assert that a research study can be accommodate to both methods. This approach is referred to as a mixed-methods research design (R. B. Johnson et al., 2007). The mixed-methods design is where the researcher do not choose between qualitative and quantitative but learn from each approach's strengths as they complement each other and minimise any flaws that qualitative and quantitative design may individually possess (Creswell & Creswell, 2018; R. B. Johnson et al., 2007; Saunders et al., 2019).

The present research study adopted a sequential exploratory mixed-methods research. The qualitative research phase ensured that local knowledge within the mobile operators' 5G and beyond ecosystem was examined in order to establish the most appropriate theoretical concepts and hypotheses. The quantitative phase consolidated and validated the qualitative findings by collecting data that was subjected to numerical and statistical analyses.

Sequential exploratory mixed-methods research is form of confirmatory mixed-method approach which entails not only putting together qualitative and quantitative research in one study but indicates how these two individual approaches corroborate and complement each other (Creswell & Creswell, 2018; Saunders et al., 2019).

4.7 Research Strategy and Time Horizon

A research strategy is a plan of how a researcher will go about answering the research question and thus, can be regarded as the methodological link between the philosophy and selected data collection and analysis techniques (Denzin & Lincoln, 2018). There are several strategies for conducting mixed-methods research inquiries. According to Creswell (2014) some of the viable strategies applicable to qualitative research include action research, case studies, ethnography, phenomenology, Grounded Theory and narrative studies. Conversely, quantitative research is principally associated with experimental and survey research strategies (Creswell & Guetterman, 2019; Saunders et al., 2019). In the current research, a case study and a survey strategy were adopted for the qualitative and quantitative part, respectively.

Another key factor to consider when designing a research study is the time horizon within which to conduct the study. Research time horizon can be broadly classified into cross-sectional and longitudinal studies (Creswell & Creswell, 2018; Creswell & Guetterman, 2019; Saunders et al., 2019). Cross-sectional study involves the study of a particular phenomenon (or phenomena) at a particular time where data is collected at one point in time. Contrastingly, longitudinal study is conducted over a period of time, with data collection spread over wider range of time period. As indicated by Saunders et al. (2019), most academic research studies are usually time constrained and naturally fit within the cross-sectional time horizon. The present research study is no different and was therefore be conducted using a cross-sectional approach.

4.8 Population and Sampling Strategy

- **Population of Interest**

According to Polit and Beck (2004), a population is the sum of all subjects that conform to a set of specifications, comprising the entire group of elements (people or objects) that is of interest to the researcher and to whom the research results can be generalised. In addition, Collis and Hussey (2021) define a research population as a set of people or collection of items in the field of inquiry. The population of interest for this research study included, top executives (e.g., CEOs, MDs, COOs, VPs and senior managers) as well as middle-level management (e.g., managers, principal engineers, and senior specialists) of large and well established mobile network operators (MNOs) in Africa. A large and well established company is described as a business with more than 1000 employees (Jain, 2006).

- **Sample Size and Sampling Methods**

LoBiondo-Wood and Haber (2017) define a sample as a subset of the research population selected to participate in a study for the purpose of data collection and analysis. Creswell (2014) emphasizes that for every research study to be meaningful, it should have a representative sample. Accordingly, a sample should be of an adequate size to provide reliable statistics that can be generalized to the population with a minimal level of error, and with a high level of precision and confidence (Sekaran & Bougie, 2016).

From the probability theory standpoint, there are two classes of sampling techniques. These are probability (i.e., representative or random) sampling and non-probability (i.e., non-random) sampling methods (Acharya, Prakash, Saxena, & Nigam, 2013; Saunders et al., 2019). In probability sampling, the sample is determined by using random selection with each unit of the population having an equal chance of being selected in the sample (Stratton, 2021). Conversely, non-probability sampling refers to the technique in which the population elements do not have a known chance of being selected in the sample size (Vehovar, Toepoel, & Steinmetz, 2016). Probability sampling is associated most commonly with survey research strategies where there is a need to make statistical inferences from the sample of a population (Saunders et al., 2019). However, for a target population of fewer than 50 cases, Henry (2009) discourages the use of probability sampling. Further, Malhotra, Nunan, and Birks (2017) contends that probability sampling is often costlier and time consuming.

In phases 1 and 2 (qualitative part) of the current research design, snowball sampling, a non-probability sampling technique was employed. Phases 1 and 2 samples consisted of mobile operators' staff who are directly involved in the deployment of next-generation communication networks (i.e., 5G and beyond). Snowball sampling is a purposeful volunteer sampling procedure in which subsequent respondents are obtained from information provided by initial respondents and is usually applied when samples with the target characteristics are not easily accessible (Naderifar et al., 2017). Additionally, E. R. Babbie (2020) concludes that snowball sampling is used for exploratory purposes where the target population is difficult to locate and therefore, the researcher can only collect data from few members of the identified population. Therefore, since phase 1 of this exploratory mixed-methods design is qualitative by nature, snowball sampling was used as the sampling technique to select the sample participants.

In phase 3 (quantitative part) of the study, systematic sampling, a probability sampling method was employed to gather survey-based opinions of employees of well-established mobile network operators (MNO) in Africa. Systematic sampling involves selecting samples at regular intervals from the sampling frame. Every n th element is selected from a reliable sampling frame, starting with a randomly chosen element from 1 to n with the final sample representing

the population characteristics (Mostafa & Ahmad, 2018; Taherdoost, 2016). According to Joseph F and Robert P (2003), systematic sampling guarantees even sampling of the target population and works equally well with a small or large number of cases. Additionally, Saunders et al. (2019) justifies the use of systematic sampling as being suitable for geographically dispersed cases where the researcher does not require face-to-face contacts with the subjects. Therefore, systematic sampling was a best fit for the quantitative part of this study as online survey questionnaires were used for data collection as opposed to the in-person methodical approach.

- **Unit of Analysis**

The unit of analysis is a key aspect in both qualitative and quantitative research designs. Collis and Hussey (2013) content that a well-defined unit of analysis is critical to the development of reasonable scientific theory as it minimises the probability of making conclusions on a single unit of analysis based on the analysis of another (Rule & John, 2011; Yin, 2009). In the current study, an individual level of analysis outlined by S. Kumar (2018) was adopted, where individual employees of various African mobile operators who participated in research data collection were the unit of inquiry. Therefore, data from both the interviews and survey questionnaires was analysed and aggregated to each respondent.

4.9 Data Collection Methods

Data collection procedures involves setting the boundaries for the research study through sampling and recruitment; collecting information through unstructured or semi-structured observations and interviews, documents, and visual materials; as well as establishing the protocol for recording information (Creswell & Creswell, 2018). The first step in facilitating data collection consists of negotiating access to sample case studies. Successful access to sample case studies guarantees the trustworthiness of the findings, while lack of access is one of the major pitfalls in conducting research successfully (Johl & Renganathan, 2010).

Data collection procedures vary depending on the type of mixed-methods design under study. In concurrent data collection, qualitative and quantitative data are collected at roughly the same time and the two forms of data are independent of each other (Creswell & Clark, 2018). In sequential data collection, qualitative and quantitative data are collected one after the other and the two forms of data are related to each other (Creswell & Clark, 2018). In the current study, which was based on exploratory sequential design, sequential data collection approach was employed. Qualitative data was collected first, and the qualitative analysis results then infused the qualitative form of data collection.

Polit and Beck (2004) define data as “information obtained during the course of an investigation or study”. Research data can generally be categorised into primary and secondary data (Saunders et al., 2019). Primary data is one that is collected by researchers directly from the main sources, while secondary data is one that has already been collected through primary sources and made readily available for researchers to use for their own investigation (Ajayi, 2017). In the current study, both primary and secondary data were incorporated.

- **Secondary Data Sources**

An extensive investigation and analysis of secondary data was undertaken on all relevant and current information regarding business models for mobile operators in the context of next-generation communication networks. Secondary data sources included: peer reviewed journal articles, conference proceedings, book chapters, academic books, equipment vendor publications, technical reports, and so forth. Secondary data was used to theorise and conceptualise the research goals of the study.

- **Primary Data Sources**

When conducting case study research, typical primary data sources include: interviews, observations, documentaries, questionnaires, archival records, physical artefacts and field notes (Bhattacharjee, 2012; Collis & Hussey, 2021; Eisenhardt & Graebner, 2007; Saunders et al., 2019). The primary data collection procedure of the current study consisted of both survey questionnaire and survey interviews. Primary data collection via surveys allows to obtain the latest and accurate data directly from the sampling population for the purpose of the research

study (Bell, Bryman, & Harley, 2022). This ensures data accuracy and reliability since data is collected objectively with careful planning by the researcher in order to gather the information aimed at attaining the main goal of the research study. In the current research, primary data was used to evaluate the effects of the business model concept on MNOs' performance in terms of value proposition, value creation, value delivery and value capture.

4.9.1 Research Instruments: Qualitative Study (Semi-structured Interviews)

During the qualitative data collection method, semi-structured face-to-face and in-depth interviews were conducted. Patton (1987) defines an interview as a data collection technique in which an interviewer (the researcher) asks questions of an interviewee (the research participant). Interviewing has the advantage of flexibility in terms of adapting, adopting and changing the questions as the researcher proceeds with the interviews (Creswell & Creswell, 2018; Gujral, 2016). Moreover, interviews ensures that data is obtained more efficiently in terms of the researcher's time, energy and costs (Gujral, 2016). Research participants were experts in 5G and beyond networks from various MNOs in Africa.

The goal of qualitative research is to research is to attain saturation (Glaser & Strauss, 2017). Saturation occurs when the addition of more participants to the study does not result in additional perspectives or information. According to Lewis (2015), there is no specific number of in-depth interviews needed for a qualitative study as the main goal is to attain saturation. Nonetheless, for qualitative data collection via interviews, Marshall and Rossman (2014) suggest 30 to 50 interviews while Creswell and Creswell (2018) suggest only 20 to 30 interviews. Practical examples of research articles using semi-structured interviews and the related numbers of interviews conducted include; University hospital in USA - 10 interviews (Chang, Llanes, Gold, & Feters, 2013), National Health Service (NHS) in England - 34 interviews (Croxon, Ashdown, & Hobbs, 2017), Veterans Affairs Medical Centre in USA - 15 interviews (DeJonckheere et al., 2018), Four UK specialist diabetes antenatal clinics - 15 interviews (Griffiths, Lowe, Boardman, Ayre, & Gadsby, 2008), and Medical school in Japan - 25 interviews (Saigal, Takemura, Nishiue, & Feters, 2007). In the current research study, 10

semi-structured interviews were planned and conducted. This was an appropriate sample size to achieve the saturation recommended by (Glaser & Strauss, 2005). The average duration of the interview per participant was 57 minutes. Table 4.1 summarises the profiles of the participants who were interviewed. Table 4.2 shows the case study mobile network operators.

Snowball sampling, a non-probability sampling technique was employed in the qualitative part of the current study as it is applicable to cases where samples with targets characteristics are not easily accessible (Naderifar et al., 2017), which is typical in mobile communication environments. During snowball sampling, data is collected on a few located members of the target population. The researcher then asks these individuals to provide the information from their know circle (E. R. Babbie, 2020).

Table 4.1: Interview participants' profiles

No.	MNO Case	Position of Interviewee	Representative Country	Date of Interview	Duration
1	MNO - A	Chief Technical Officer - Wireless Networks	Ethiopia	9 March, 2023	50 min
2	MNO - B	Managing Executive	South Africa	6 July, 2023	65 min
3	MNO - B	Senior Manager - Strategic Radio Optimization	South Africa	8 July, 2023	77 min
4	MNO - C	Senior Manager - Strategic Network Operations	South Africa	15 October, 2023	52 min
5	MNO - D	Head of Strategy - CEO's Office	Zambia	24 October, 2023	70 min
6	MNO - E	Managing Executive - Core & Transport Networks	South Africa	28 October, 2023	53 min
7	MNO - F	Senior Projects Manager	South Africa	11 November, 2023	52 min
8	MNO - D	Chief Technical Officer	Zambia	4 December, 2023	42 min
9	MNO - G	Manager - Radio Access Network Support	Eswatini	4 January, 2024	52 min
10	MNO - H	Senior Manager - Network Design	Kenya	20 January, 2024	58 min

Table 4.2: Case study mobile network operators (MNOs)

Case Study	Type of MNO	MNO Context	Type of BM	BMI Key Drivers
Case Study A. (MNO A).	Public MNO. (State-owned).	A state-owned telecommunication company and has historically held a monopoly over the country's telecommunication services. Major services include; mobile voice, data, fixed-line, and internet services. Established in November, 2010, the MNO has a market share of over 60%	Value-driven.	Technological advancement. Market factors. Regulatory factors.
Case Study B. (MNO B).	Public MNO. (Privately-owned).	A leading and purpose-led African mobile communication company that provides a wide range of services to individual consumers and enterprise business. The company's consumer products include voice, data, messaging and financial services whereas enterprise products include connectivity, managed mobility (IoT), cloud and hosting, managed services, security and unified communication. The company has business operations in many African countries.	Purpose-driven.	Technological advancement. Market factors. Regulatory factors. Growth aspirations. Resource availability.
Case Study C. (MNO C).	Public MNO. (Privately-owned).	A multinational corporation and mobile telecommunications provider with business operations in Africa and the Middle East, making it one the largest mobile network operator in the world. The MNO's vision is to be a leader in telecommunications in emerging markets. Core offering include, voice services, data services, ICT and digital services such as fintech.	Value & Resource-based.	Technological advancement. Market factors. Regulatory factors. Growth aspirations. Resource availability.
Case Study D. (MNO D).	Public MNO. (State-owned).	A state-own telecommunication firm that provides fixed lines, mobile, internet and other value added services to business and personal clients. The company provides voice, data, multimedia and digital services.	Value-driven.	Technological advancement. Market factors. Regulatory factors.
Case Study E. (MNO E).	Public MNO. (Privately-owned).	A customer-first mobile operator that delivers world-class propositions that empower and connect all people to digital services to help change the world. Established 22 years ago, the MNO offers a range of mobile plans and services including voice, data and messaging as well as digital services.	Value-driven.	Technological advancement. Market factors. Regulatory factors. Growth aspirations.
Case Study F. (MNO F).	Public MNO. (Privately-owned).	A private company specializing in telecommunications services and has been in the industry for 30 years. The company is the country's market leader with the largest market share and provides communication solutions in all provinces of the country. Its services include voice, data and digital services such as fintech.	Value & Resource-based.	Technological advancement. Market factors. Regulatory factors. Growth aspirations.
Case Study G. (MNO G).	Public MNO. (Privately-owned).	The company is a subsidiary of a multi-national group and the country's leading mobile communications company. Since its founding in 1998, the company has consistently been at the forefront of delivering a bold, new digital world to its customers through voice and data solutions to enable its customers to live much better lives. Its services include voice, data and digital services such as fintech.	Value & Resource-based.	Technological advancement. Market factors. Regulatory factors. Growth aspirations.
Case Study H. (MNO H).	Public MNO. (Privately-owned).	Founded in 1997, the company is the largest telecommunications provider in the country and one of the most profitable companies in the East and Central Africa region. The company offers mobile telephony, mobile money transfer, consumer electronics, e-commerce, cloud computing, data, music streaming and fiber optic services. The company controls approximately 64.5% of the national market in 2020 with an estimated subscriber base of approximately 35.6 million.	Purpose-driven.	Technological advancement. Market factors. Regulatory factors. Growth aspirations. Resource availability.

4.9.2 Research Instruments: Quantitative Study (Survey Questionnaires)

Questionnaires were adopted for the quantitative part of the current study to measure the participants' rating of business models for next-generation communication networks for MNOs in Africa. According to Polit and Beck (2004), a questionnaire is a self-reported data collection instrument that each research participant completes as part of a research study. Thus, it can be regarded as a tool for collecting and recording information about a particular area of interest.

This research was a cross-sectional study. An online software, Qualtrics was used to design, distribute, capture and summarise the quantitative data. Structured online questionnaires and self-completion questionnaires were used for the quantitative data collection. The quantitative data collection method targeted at least 50 questionnaire participants as recommended by (Henry, 1990) and the average completion time per respondent was 25 minutes. Questionnaires consisted of seven sections with different question types: dichotomous questions (i.e., yes/no questions), multiple choice questions, ranking scale questions, or rating scale questions (Trigueros, Juan, & Sandoval, 2017). The questionnaire sections tested the variables that formed the conceptual business model. These included: (A) General Information, (B) Infrastructure Management, (C) 5G Service Offerings (Value Proposition), (D) Customer Interface, and (E) Financial Aspects.

Researchers use questionnaires in an attempt to measure different kinds of characteristics such as thoughts, feelings, attitudes, values, behavioural intentions and so forth (Polit & Beck, 2004). Questionnaires are more ideal in quantitative study where a large sample size is expected to yield more reliable data, thereby considerably minimising the sampling errors (Gujral, 2016; Jung, Kim, & Kim, 2020; Kushwaha, 2020). This is because questionnaires can support large sample sets with less costs while yielding valid and reliable analysis results (Gujral, 2016). Moreover, questionnaire respondents usually have adequate time to digest and grasp the questions before they respond.

Systematic sampling, a probability sampling technique was used for the qualitative data collection part of the current study. According to this method, units of the population are numerically, geographically and alphabetically arranged and every n th item of the numbered

elements is selected as a sample item (George, 2021). Systematic sampling ensures that the research population is evenly sampled (Joseph F. Hair, Bush, & Ortinau, 2003), and is often used for online and email based survey questionnaires (Fricker, 2008).

- **Measurement Scale**

The quantitative part (Phase-3) of this study employed the 5-point Likert scales as shown in Table 4.3. Nemoto and Beglar (2014) describe a Likert scale is a psychometric scale that has multiple categories from which respondents choose to indicate their opinions, attitudes, or feelings about a particular issue. Furthermore, E. Babbie (2010) emphasizes that Likert scales are generally used for testing perceptions, behaviours, views and so forth, and are often applied in research surveys. These scales are aimed at improving the level of measurement and determine the relative intensity of various measured items (Nemoto & Beglar, 2014). Taherdoost (2019) suggests the use of a Linkert scale in the range “5-point to 7-point” to ensure results’ reliability and validity as well as maintain respondents’ preferences and concentration levels.

Table 4.3: 5-point Likert scale

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Disagree	Strongly Agree

4.10 Data Analysis and Interpretation Techniques

Data analysis is the process of examining and moulding collected data for interpretation so as to discover relevant information, draw or propose conclusions and support decision-making to solve a research problem (Creswell & Creswell, 2018). Data interpretation involves attaching meaning and significance to the analysis, explaining descriptive patterns, and looking for relationships and linkages among descriptive dimensions (Krueger, 2014). In the current study, a mixed-methods analysis was used. This involved using both qualitative and quantitative data analysis techniques within the same study (Onwuegbuzie & Combs, 2011).

4.10.1 Thematic Data Analysis: Qualitative Study (Phase-1 and Phase-2)

Qualitative data refers to all non-numeric data or data that have not been quantified (Saunders et al., 2019). According to Dudovskiy (2018), qualitative data analysis can be divided into the following categories: content analysis, narrative analysis, discourse analysis, framework analysis, and thematic analysis. Thematic analysis is the process of systematically identifying and organising patterns or themes within qualitative data (Maguire & Delahunt, 2017). Thus, thematic analysis involves reading through a data set and looking for patterns to derive themes.

The choice of thematic analysis for the qualitative data analysis part of the current study was arrived at due to the advantages this method has over the alternatives. One advantage of thematic analysis is that, unlike most qualitative analysis techniques, it is not tied to a particular epistemological or theoretical perspective (Maguire & Delahunt, 2017). The other key benefit of thematic analysis is the ease of use, accessibility and flexibility, teaching one mechanics of coding and analysing qualitative data systematically and in a manner that analysis can be linked to the theoretical or conceptual framework (Braun & Clarke, 2006). Furthermore, Braun and Clarke (2012) establish that thematic analysis offers a systematic and rigorous process of data analysis, thereby ensuring that the research problem is studied in detail for practical implementation. The outcome of this study's thematic data analysis (Phase-1) fostered creativity and critical thinking for the conceptual framework formulation (Phase-2) which was key to the quantitative part (phase-3) of the study.

Braun and Clarke (2006) recommend six phases in thematic analysis: familiarisation with data, generating initial codes, searching for themes, reviewing potential themes, defining and naming themes, and producing the report. The thematic analysis six-phase approach is illustrated in Figure 4.3.

Phase 1- Familiarisation with data

Data familiarisation is the first step in the theme analysis process. At this point, the researchers fully immerse themselves in the data to gain an intimate understanding of it. Following the transcription of audio or video files, the researcher examines the complete set of data for trends

and meanings. A researcher should read and reread their data and take brief notes about any analytical ideas related to the data in order to delve deeply into the text and identify key passages and introductory themes. Then, the statements that best capture the essence of the data and suitably represent a range of opinions and trends relevant to the study's goals are chosen. The researcher became familiar with the data used in this study by reading the transcripts of the interviews, in addition to the technical report analysis and documentary that were obtained from standards organizations, sample mobile network operators (MNOs), and other third parties. After that, the researcher could begin formulating hypotheses regarding the data, such as how the business models of MNOs were created. The process of developing the initial codes came after the data familiarization stage.

Phase 2 - Generating initial codes

In this phase, each data unit within a data element (e.g. a transcript or document) is labelled with a code that symbolizes or summarizes the meaning of the extract. The coding process ensures that every piece of data of interest to the researcher is accessible for further analysis. A code is a single word or short phrase, which can also be abbreviated in use. A coded data extract is called a data unit. A unit of data can be a number of words, a line of transcript, a sentence, a series of sentences, a complete paragraph, another piece of text data, or a visual image summarized by a specific code. The exact size of a data unit is determined by its meaning. Some data units overlap, and others are encoded with more than one code. The key to code identification is ensuring that codes are relevant to the research question and creating a code manual that can be used as an information management tool. In generating the initial codes, Braun and Clarke (2012) emphasize that thematic analysis does not prescribe how to segment data as a code, but suggests coding each time one identifies something potentially relevant to the research question. Furthermore, there is no prescribed maximum number of codes, but codes should capture the diversity and patterns within the data and appear in more than one data element (Braun & Clarke, 2012).

Phase 3 - Searching for themes

In order to generate a short list of themes pertinent to the research question under consideration, researchers start this phase by examining the lengthy list of codes for patterns and relationships. A theme is a broad category that contains several codes that seem to be connected to one another and suggest a notion that is significant to the research question. Condensing the raw data by first coding it and then organizing the coded data into analytical categories includes searching for themes. By developing themes, the researcher progresses from a thorough examination of codes and categories to a more abstract interpretation. These themes are more than just reoccurring components; they represent organized meanings that connect the data and research questions. Reviewing the coded data to find areas of overlap and similarity between codes, as well as summarizing and grouping codes that have consistent qualities to form a coherent, meaningful data pattern to reflect, is an active process for generating themes as opposed to discovering themes.

Phase 4 - Reviewing potential themes

During the review process, many of the topics or subtopics are either merged with other (main) topics or discarded. By examining patterns in the data and identifying relationships between themes, the researcher can develop testable statements or hypotheses. The themes developed must be part of a coherent set so that they provide the researcher with a well-structured analytical framework for conducting the analysis.

Phase 5 - Defining and naming themes

Determining the core of each theme and the elements of the data that each theme captures are necessary steps in defining and labelling themes. Reading through the primary topics, subtopics, codes, and excerpts helps to further refine the topics. Furthermore, naming and characterizing themes necessitates in-depth analytical work that shapes the analysis to the tiniest detail. It organises the data inside a broad conceptual framework and goes beyond the data itself, utilising both interpretive and descriptive analysis.

Phase - Report writing

Writing a report is the final stage in narrating a data set's story. To demonstrate the validity of his analysis, the researcher gives careful thought to the subjects. The researcher should also ensure that the report tells a succinct, logical, coherent, and non-repetitive story within and between topics.

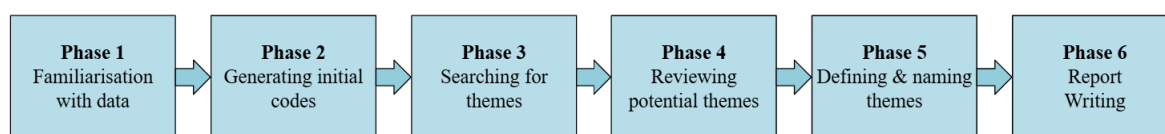


Figure 4.3: Thematic analysis six-phase approach based on (Braun & Clarke, 2006)

4.10.2 Statistical Data Analysis: Quantitative Study (Phase-3)

Quantitative data refers to numerical data or data that have been quantified (Saunders et al., 2019). A quantitative approach is usually associated with finding evidence to either support or reject hypotheses that have been formulated and may include the calculations of frequencies and variances among the variables under study (Dudovskiy, 2018). Quantitative data analysis is mainly driven by statistical analysis (Lutabingwa & Auriacombe, 2007). Besides, Welman, Kruger, and Mitchell (2005) observe that data analysis via statistical techniques assists researchers in investigating variables as well as their effects, relationships and their patterns of involvement within our world of research. There are two main classes of statistical techniques that are used; descriptive statistics and inferential statistics (G. Byrne, 2007). Descriptive statistics helps in understanding the details of the population sample while inferential statistics aims to make predictions about what can be found in the entire research population (Amrhein, Trafimow, & Greenland, 2019; G. Byrne, 2007). The descriptive statistics of the current research study consisted of the demographic profile of the sample such as gender, position in the company, functional area / department and years of experience in the mobile communication sector. Inferential statistics was applied during the testing of the formulated hypothesis and when answering the research questions.

Most quantitative data analysis procedures are conducted with computers in which data is stored electronically. There are many available data analysis software programs that are able to examine several variables simultaneously and can compute a variety of statistics (E. Babbie, 2010). The current research study used SPSS (Statistical Package for the Social Sciences) to clean data and conduct descriptive statistical analysis and SmartPLS software for hypotheses testing using structural equation models (SEM) to derive various coefficients. SmartPLS is a software with graphical user interface for variance-based SEM using the partial least squares (PLS) methods (Ali, Rasoolimanesh, Sarstedt, Ringle, & Ryu, 2018).

In this study, the SEM-PLS modelling approach was adopted due to its broad applicability in exploratory research with small sample size and when little is known about the relationships between theoretical variables (Wong, 2013). Figure 4.4 shows the stages of the statistical analysis approach of the current study alongside the implementation software.

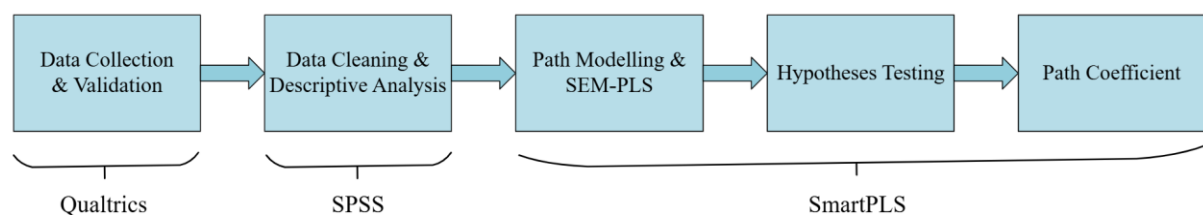


Figure 4.4: Statistical analysis approach (compiled by researcher)

4.11 Research Validity and Reliability

Validity and reliability play a vital role when conducting academic research. The validity and reliability of the data collected and the response achieved by the researcher depend largely on the design of the questions, the structure of the research instruments used, along with associated ethical and access issues (Saunders et al., 2019). Accordingly, Morse, Barrett, Mayan, Olson, and Spiers (2002) emphasize that validity and reliability form an integral part of implementing self-correcting verification strategies when conducting research inquiry, thereby attaining the desired research rigour.

- **Validity**

Validity refers to the degree to which a research instrument measures what it is supposed to measure (Considine, Botti, & Thomas, 2005). Additionally, Collis and Hussey (2021), consider validity as a way of explaining the degree to which research findings precisely reflect the phenomena under investigation. Pellissier (2008) broadly classifies research instruments validity into external and internal validity.

External Validity: Concerned with the applicability of the findings in other settings or with other subjects (Zohrabi, 2013). That is, how generalizable is a particular research to other contexts or subjects? (Burns, 2003). This usually depends on the degree to which the sample represents the population (Burns, 2003; Creswell & Clark, 2018). To increase the external validity of the current research study, the researcher selected a larger sample size for the quantitative and a comparatively smaller sample size for the qualitative data collection phases (Creswell & Clark, 2018). Furthermore, high-level external validity was enhanced by extending the population sample from top executives and middle-level management to include low-level management of MNOs in Africa.

Internal Validity: Mainly concerned with the congruence of the research findings with reality (Zohrabi, 2013). It deals with the degree to which the researcher observes and measures what is supposed to be measured (Merriam, 1998). To increase the internal validity of the current research study, respondents who participated in the qualitative phase (i.e., semi-structured interviews) were followed up to participate in the quantitative phase (i.e., online survey questionnaires).

- **Reliability**

Reliability is the degree to which a research instrument produces the same results with repeated administration (Considine et al., 2005; Polit & Beck, 2004). Validity is closely related to reliability because for an instrument to be valid, it must be reliable (Polit & Beck, 2004). However, the distinction between the two should be emphasized. Reliability refers to the extent to which the research results are likely to be repeated while validity is concerned with the extent

to which results accurately reflect the phenomena being investigated (Crabtree & Miller, 2022). Triangulation (Jick, 1979), which is the use of multiple sources of data or multiple approaches in data analysis in an investigation was used to improve the reliability of the research findings. Different sources of data (i.e., primary and secondary data sources) as well as different data analysis procedures were triangulated to examine the evidence from the data sources (Creswell & Clark, 2018).

4.12 Ethical Considerations

Ethical considerations are vital when conducting a research study as they deal with safeguarding respondents' right as well as protecting them from physical harm, embarrassment or loss of personal privacy. Accordingly, Rabionet (2011) suggests that in any research that involves human participants, there is a need to respect ethical guidelines and moral considerations. The present research study took into consideration all the ethics requirement and adhered to the University of the Witwatersrand's ethics policy. The ethics clearance certificate was obtained from the university's ethics committee prior to commencing data collection (see Appendix B – Ethics Clearance Certificate). For the qualitative phase of the study, the respondents were experienced top executives and senior managers while the respondents for the quantitative phase of the study included, top executives, senior managers, middle-level managers, principal engineers, and senior engineers who are directly involved in the deployment of 5G and beyond networks. All respondents were officially invited to participate voluntarily in the present research study. In addition, each respondent signed the consent form which contained the following assurances:

- All the information obtained from the respondent would be strictly confidential.
- Data collected would only be for academic research purposes and would not be given or sold to any third party.
- The respondent was free to withdraw their consent and discontinue participation in the study at any time without consequences.

Furthermore, the researcher's additional responsibility was to keep the identities of the respondents anonymous. Therefore, it was imperative that only the researcher knew the respondent's true identities (McMillan & Schumacher, 2010).

4.14 Chapter Summary

This chapter described the research design and methodology which was employed to generate and collect data alongside the justifications for the selected research strategies and techniques. Both interpretivism and post-positivism research philosophies were adopted. The research approaches which were selected to link with the interpretivist and post-positivist philosophies were inductive and deductive, respectively. Furthermore, the selected research studies were case study (qualitative part) and survey study (quantitative part) with a cross-section time horizon. Research instruments for qualitative data collection were semi-structured interviews while structured online survey questionnaires were used for quantitative data collection.

A justification for adopting a sequential exploratory mixed-methods approach was presented. Furthermore, population of interest alongside the sample size and sampling methods (i.e., snowball sampling - qualitative part and systematic sampling - quantitative part) were highlighted. Lastly, data analysis procedures of the qualitative and quantitative studies were discussed, followed by discussions on validity, reliability and ethical considerations. The next chapter will present a detailed data analysis and research findings from both the qualitative (phase-1 and phase-2) and quantitative (phase-3) parts of the research study.

CHAPTER 5: DATA ANALYSIS AND FINDINGS

5.1 Introduction

The chapter explores and presents the data analysis and findings in terms of case studies' contextual background and empirical findings from the survey results. Firstly, qualitative data analysis is presented from the interviews' (case study) outcome, followed by the conceptualisation of the theoretical framework. Thereafter, quantitative data analysis is outlined using the data collected from online survey questionnaires. The central research questions that guided the data collection, analysis and findings are re-stated to a recollection of the current study focus.

Main Research Question

The overarching research question of the study was:

How can a viable business model framework for next-generation communication networks be designed to achieve increased economic value for mobile operators in Africa?

Sub-questions

The following sub-questions were identified to address the main research question under study.

- What factors limit existing business models in enabling next-generation communication networks?
- How can a business model for next-generation communication networks be conceptualised and developed?
- How can the designed business model framework have a positive impact on the business viability and sustainability of mobile operators?

According to Braun and Clarke (2006), when presenting the research results and findings, the reporting should provide a captivating story about the data via the analysis of such data. Likewise, Braun and Clarke (2012) suggest that result presentation on the collected data should provide an interesting account that is convincing to the reader in terms of merit and validity of analysis by being concise, coherent and logical.

Creswell and Creswell (2018), has stressed that in an exploratory sequential mixed methods design, the researcher analyses two databases (i.e., qualitative and quantitative) separately and uses the findings from the initial exploratory database (i.e., qualitative) to build into a feature that can be analysed quantitatively. Therefore, Creswell and Creswell (2018) observe that the integration in an exploratory sequential mixed method design involves using the qualitative findings to inform the design of the quantitative phase of the research such as the development of a measurement instrument or new variables.

5.2 PHASE 1: Qualitative Data Analysis – Case Studies

This phase describes the steps of qualitative data analysis using case studies. Through qualitative analysis, a conceptual framework is derived that is tested quantitatively to determine what influences usage intention. The purpose is to examine the connection between the theory and the derived conceptual framework and how these affect the implementation of the designed business model and the intention to use it. The aim of the qualitative data analysis of the current study was two-fold: (1) to analyse the limitations and challenges of current mobile operators' business models in promoting next-generation communication networks; and (2) developing a conceptual business model framework for mobile operators suitable for next-generation communications networks.

5.2.1 Reflexive Thematic Analysis

An interpretive paradigm was used that employed a qualitative research design. To examine the qualitative data provided by participants and thus address the research objectives of the study, a reflexive thematic analysis method was used, as suggested by the Braun and Clarke (2019). Reflexive thematic analysis is an accessible and theoretically flexible interpretive approach to qualitative data analysis that facilitates the identification and analysis of patterns or themes in each data set (D. Byrne, 2022). Reflective thematic analysis was conducted using an interpretive

software MAXQDA24, a Computer-Assisted Qualitative Data Analysis Software (CAQDAS)(Verbi, 2021).

Online research interviews were conducted with 10 participants via Zoom platform, a video telephony software program developed by Zoom Video Communications (Gray, Wong-Wylie, Rempel, & Cook, 2020). Both video and audio files of the recorded interviews were stored on the researcher's laptop and external hard drive for backup purposes. Additionally, the researcher made notes, which provided additional contextual information. The reflexive thematic analysis process described by Braun and Clarke (2019) was carried out in the MAXQDA24 software according to the guide developed by (Uştuk, 2022).

Step 1: Data familiarisation

Data grouping in MAXQDA24 software

MAXQDA24 software was beneficial in the data familiarisation stage as it allowed the researchers to experiment with the grouping of various data sources, allowed getting engaged in diverse data types, and transcribed audio files easily. MAXQDA24's document system allowed the researcher to group the data in various ways.

Data transcription in MAXQDA24 software

Different audio files were uploaded into MAXQDA24's document system. The interviews audio files were transcribed to ensure that everything participants said was captured. The original audio recordings were played back to ensure that the researcher could become familiar with the data for the purposes of analysis and interpretation. Interview notes were used as described by Becker (2009) to capture texts that could not be transcribed to obtain a holistic view of participants' perspectives. Written Microsoft Word documents were also created for each interview; thus, each interview was transcribed into a referenceable and analysable text. The researcher went through the interviews after transcription and systematically removed any typographical errors. Participants' identifying information was removed from each transcript and pseudonyms were assigned to ensure their identities were protected. The researcher delved

into the data from interview transcripts and written notes by reading the text repeatedly, consolidating all analytical ideas and insights from the interviews.

Step 2: Generation of initial codes

Coding in Reflexive Thematic Analysis

As soon as the document system takes shape, qualitative coding begins. Data coding serves as the basis for key research findings and can be designed to test, improve or validate existing literature, develop a new model or supplement it (Creswell & Creswell, 2017; Punch & Oancea, 2014). Braun and Clarke (2019) state that codes are the building blocks of qualitative analysis that aid investigators in interpreting their data in light of the preliminary research inquiries. Kuckartz and Rädiker (2019) state that researchers take a subset of the data and code it. There are two general approaches to this: the data-driven, inductive approach and the concept-driven, deductive approach. Both methods of coding are acceptable in thematic analysis, and the coded segments can happen concurrently and have connections between them.

Coding procedures in MAXQDA24 software

The initial codes were generated using a deductive approach by assigning codes based on the pre-conceptualised theoretical framework developed in Section 3.7.2 of the literature review chapter and summarized in Table 3.10. During the initial code generation, the researcher used the following MAXQDA24 features: *Paraphrasing* to ensure concise, precise and clear meaning of the coded data segments; *Memos* to assist in tracing back the original rationalisation when a new code is created for the previous coded segments; *Comments* to give a high-level summary of the coded segments; and *Colours* to distinguish the level of clarity and importance of the coded segments (i.e., Green = key and clear response; Yellow = not applicable; Red = unclear response). Figures 5.1 and 5.2 show the MAXQDA24 code system and code matrix browser of the generated codes, respectively.

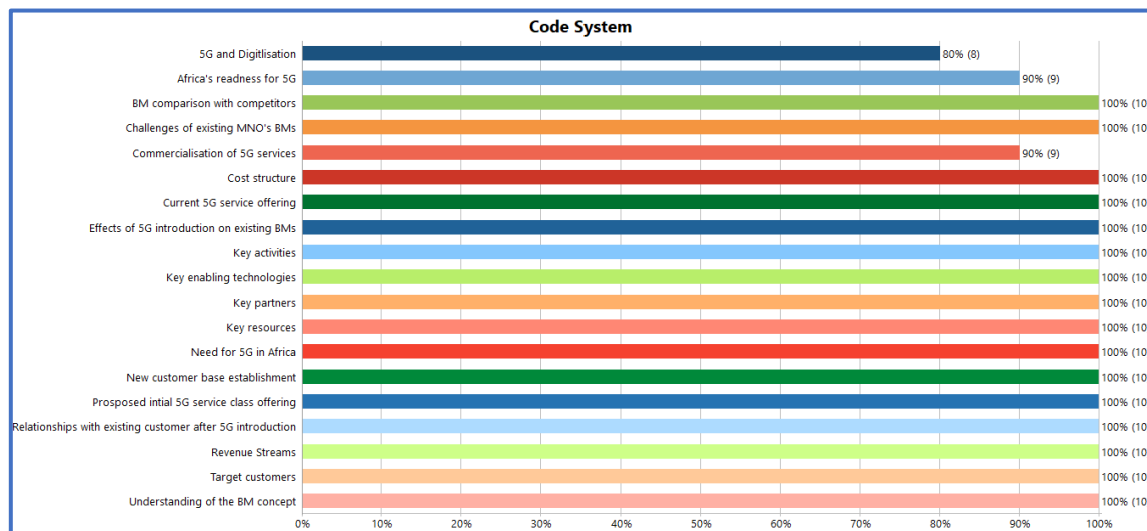


Figure 5.1: Code system of the generated codes

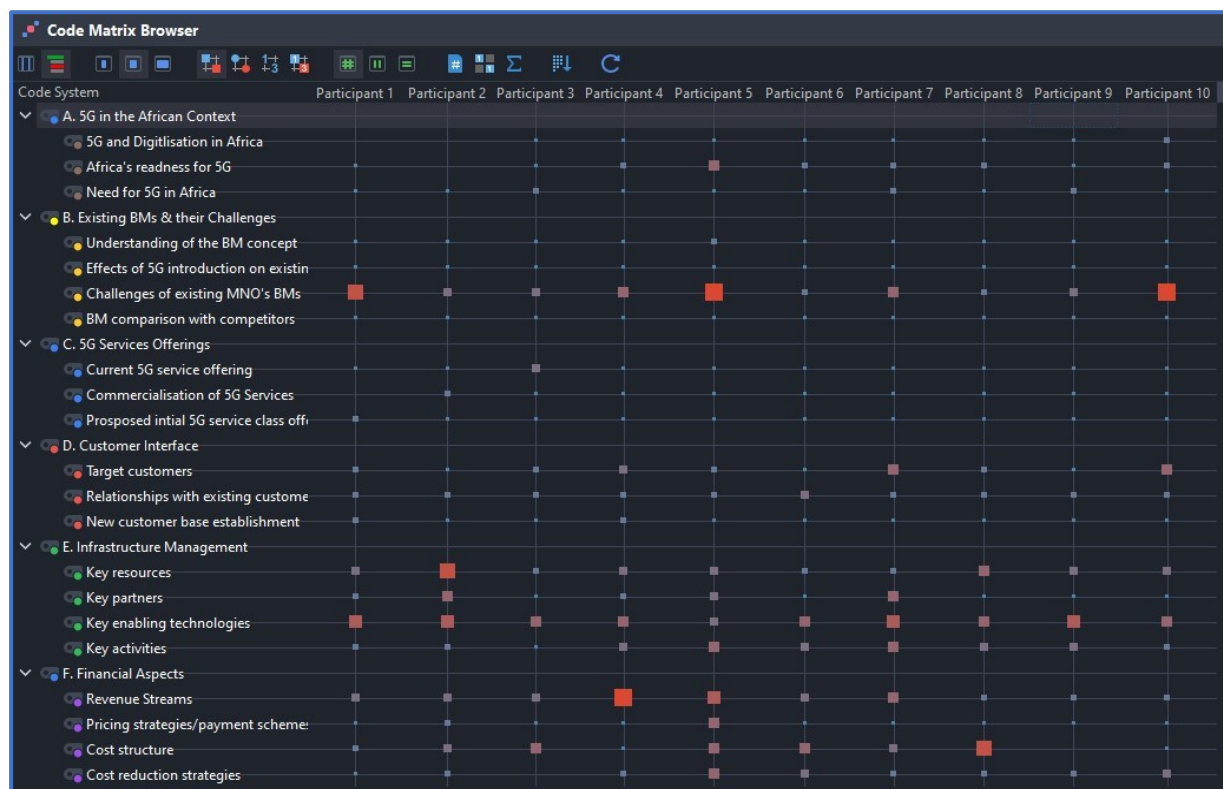


Figure 5.2: Code matrix browser of the generated codes across the 10 participants

Step 3: Search for Themes

Observing emerging themes

This step was about organizing the generated codes and beginning to identify recurring themes.

Themes encompass a wider scope than codes, often consolidating various codes into a theme,

and necessitate the interpretation of the codes and data. A theme encapsulates a significant aspect of the data in relation to the research objective and signifies a pattern or connection within the dataset (Braun, Clarke, Hayfield, Davey, & Jenkinson, 2023). Discovering shared themes across codes is an iterative process that enables you to navigate between codes to pinpoint similarities.

Identifying patterns through MAXQDA24 visualisation tools

While communicating with the data at a conceptual level, the researcher was able to synthesize the information using three MAXQDA24 visualization features: Code Maps, MAXMaps, and Questions, Themes & Theories (QTT). MAXQDA24 allowed the researcher to create code maps that analyse the relationship of codes as they occur or occur simultaneously within a certain proximity in data documents. MAXMaps provided the researcher with a space for simulated brainstorming about the codes and initial themes. MAXMaps allowed the researcher to retrieve codes and documents as symbols, create and label relationships between them with links and arrows, and create code models. Finally, the researcher could create QTT worksheets that allow the import related codes and themes, coded segments and all the visual materials I create in one worksheet. On the QTT worksheet, the researcher could constantly refer back to the research questions and memos as he tries to move from the questions to the topics and even beyond to later theories.

Step 4: Review Potential Themes

In this step, the initial themes created in the previous step are reviewed and compared with the entire code system, coded segments, and documents. The themes, data and research questions must be relevant and coordinated. In doing so, the researcher may combine some emerging themes to achieve overarching themes, while some emerging themes may be singled out and found irrelevant, even though they may seem very interesting.

Guiding inquiries for reflexive thematic analysis

As suggested by Braun and Clark (2019), to review the potential themes and construct overarching themes by combining multiple emerging themes, the following guiding inquiries were considered in the context of the current research study.

- Is this a theme (or it could just be a code)?
- Does the potential theme constructed provide a template for the 10 case study participants?
- Does the constructed potential theme relate to the research questions of the study?
- Does the constructed potential theme include or exclude many coded segments of the entire data set?
- Is there enough data to support potential theme as a strong and final theme?
- Is the data from various sources supporting the potential theme coherently?

Identifying main themes using the Visual Tools of MAXQDA24 Software

The visual tools of MAXQDA24 were used as a guide to further review the potential themes. Both the *Code Relations Browser* and the *Document Comparison Chart* were used to review and decided on whether the initial themes were strong enough to construct relevant main themes out of them. Specifically, the *Code Relations Browser*, were used to further understand the relationship between codes. This ensured that the coded segments were revisited to check if further themes could be constructed from the identified code relationships. Similarly, the Document Comparison Chart assisted in reviewing the generated codes using the guiding question in Braun and Clarke (2019) as stated above.

Step 5: Defining and naming of themes

In reviewing emerging themes and constructing main themes, the researcher should ensure that these main themes are not repeated and that overlapping themes are merged. To this end, Braun and Clarke (2012) suggest that researchers should define and name themes only when they have a clear focus and address research questions or objectives.

The QTT assisted in maintaining focus on the qualitative research questions after reaching five main themes of the study: (1) *existing MNOs' BMs challenges and constraints*, (2) *value propositions/BM offerings*, (3) *customer interfaces*, (4) *infrastructure management*, and (5) *financial aspects*. By using MAXQDA24 code system, themes were coloured differently. Furthermore, the drag and drop across the entire code system was used in creating code nodes

in sub-codes. This allowed the researcher to create families of codes that helped define and name the main themes. Figure 5.3 shows the main themes, sub-themes and their interrelationship.

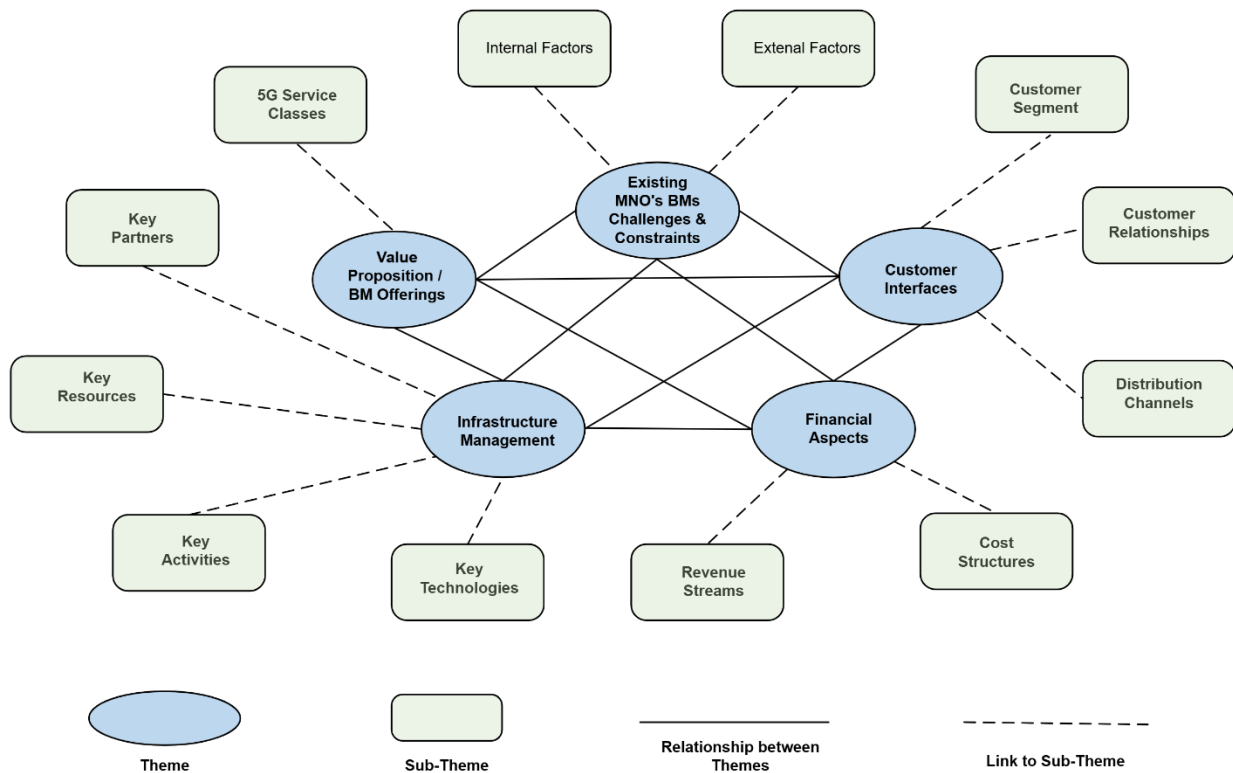


Figure 5.3: Final thematic map indicating candidate themes and sub-themes

The relationships between the defined main themes, sub-themes, associated codes and the addressed qualitative research questions are summarised in Table 5.1.

Table 5.1: Defined main themes, sub-themes, associated codes and addressed research questions

Main Theme	Sub-Theme	Associated Codes		Addressed Research Question
		Code	Occurrence Frequency	
Existing MNOs' BM Challenges & Constraints	Internal / External Factors	Understanding the BM concept	11	What factors limit existing business models in enabling next-generation communication networks?
		Effects of 5G introduction on the company's BM	10	
		Company's BM compared with competitors	10	
		5G and digitalisation	9	
		Africa's need for 5G	13	
		Africa's readiness for 5G	17	
		Challenges for existing BMs	45	
Value Proposition / BM Offerings	5G Service Classes	Proposed initial 5G services	11	How can a business model for next-generation communication networks be conceptualised and developed?
		Current 5G service offering	12	
		Commercialisation of 5G services	10	
Customer Interfaces	Customer Segments	Target customers	22	
		New customer base establishment	12	
	Customer Relationships	Relationships with existing customers	21	
	Distribution Channels	Key activities	27	
Infrastructure Management	Key Technologies	Key enabling technologies	51	
	Key Partners	Key partners	20	
	Key Resources	Key resources	33	
	Key Activities	Key activities	27	
Financial Aspects	Revenue Streams	Revenue streams	36	
		Pricing strategies/Payment methods	15	
	Cost Structures	Cost structures	30	
		Cost reduction strategies	21	

Step 6: Producing the Report

The distinction between steps five and six can often be fuzzy. Furthermore, this “final” step would rarely occur until the end of the analysis. In contrast to the practices typical of quantitative research, in which the researcher conducts the analysis and then writes it up, the writing of qualitative research is closely integrated into the entire process of analysis (D. Byrne, 2022). Recursive report writing will probably be necessary, just like in the earlier steps.

Throughout the analysis process, codes and themes may alter, and this could also affect the final

report. In the current study, the final report covered the analysis of the existing MNOs' business models and the conceptualisation of the theoretical business model framework.

5.2.2 Analysis of Existing Business Models for MNOs

In analysing the existing business models for MNOs, the focus was on the constructed main theme, "existing MNOs' business models challenges and constraints." The aim was to address the following research question (*sub-question 1*):

What factors limit existing business models in enabling next-generation communication networks?

Theme: Existing MNO's BM challenges and constraints

This theme describes the challenges and constraints presented by current business models that make them unable to support emerging next-generation networks such as 5G and 5G advanced. These challenges and constraints originate from both technological and socio-economic levels. Furthermore, challenges and constraints of existing business models can be broadly divided into two sub-themes, namely internal and external factors. Internal factors are those that occur within a particular MNO organisation, while external factors are those that lie outside the boundaries of the MNO organisation.

Responses from interview participants

Participant 1: The rollout of 5G requires higher bandwidth, which in turn requires more spectrum resources, which are relatively scarce. The 5G requirement for higher bandwidth leads to more site locations, and the introduction of more site locations brings challenges such as indoor quality issues and huge power consumption due to the high location density. Furthermore, as a new technology, 5G requires the development of new capabilities within the organisation. In terms of business process, the shortage of 5G devices in developing markets such as Africa poses a challenge. Furthermore, the investment price of 5G is high compared to 4G as we cannot distinguish the price from 4G as the business use cases of 5G are still not

mature. As a result, most operators work with suppliers on the CAPEX model, building businesses from small companies within telcos, and the technology dynamics are affecting operators' business models. Key challenges identified include integrating too many nodes into the 5G network architecture, lack of 5G-supporting devices, pessimistic monetisation goals, and lack of adequate 5G skills among employees.

Participant 2: 5G products and services as well as target customers differ from previous mobile networks (i.e. 2G, 3G and 4G). Therefore, positioning and marketing products and services in 5G will be challenging. Additionally, distribution channels will also be challenging due to new types of customers in different verticals.

“If you look at human resources, it is obvious that it is the same for men and women. But if you look at the actual products, for example the way we market telemedicine or artificial intelligence/machine learning, it's completely different than how we used to market our normal mobile products like cell phones or data services. For 5G, we look at industries like manufacturing, with its different marketing strategies and different ways to position products for such an environment.” – Participant 2

The need for high bandwidth capacity for 5G is one of the constraints mobile operators are currently facing. Tower space requirements and load capacity pose another major challenge as most towers/masts are already overloaded with antennas and other radio equipment, exceeding the tower utilization factor. In such cases, the operator should restore the existing antennas and replace them with modern 5G-capable antennas, which can be a costly affair. Other challenges observed include input costs and indirect costs.

Participant 3: Two key challenges to the current business model were identified: (1) In some cases, deployed base stations can hardly carry any traffic and therefore bring minimal revenue. (2) Some deployed base stations transmit overwhelmingly large traffic and are therefore heavily congested but are not upgraded due to financial constraints.

“I think speaking from the company's perspective, which is a source of frustration, you will find a site that makes millions of rand and yet it is still congesting. And you ask yourself the question: why can't this site be upgraded if we can get more revenue from it? Therefore, I think that the business model does not take into account scientific principles of network planning. The other challenge is that you deploy multiple sites in a cluster and only 15-20% of the total sites are actually carrying adequate traffic. Most sites do not carry reasonable traffic, but do

consume resources, electricity, rental space, and other costs associated with site deployment. These are the two extreme cases that make the practice lopsided.” – Participant 3

The other limitation is acquiring space for deploying 5G, especially when deploying 5G with Massive MIMO antenna technologies, as the space requirement would be much larger compared to traditional antennas. Furthermore, another challenge for African mobile operators is to educate consumers about the importance of 5G and the diverse opportunities that 5G brings. Finally, the challenge posed by 5G as a new technology is that mobile operators face high costs of introducing 5G as some equipment manufacturers sell their products and solutions at extremely high prices compared to 4G. Therefore, the costs of 5G deployment are significantly higher.

Participant 4: The first challenge is device affordability, as mass-market 5G-enabled devices are quite expensive. Also, the possibility of benefiting from revenue through investments in 5G remains sceptical for most operators. In addition, frequency acquisition also represents a significant limitation for mobile operators. The current imbalance in society in many African countries is even evident in the deployment of 5G, as operators target wealthy suburban areas where fibre optic infrastructure is available, in contrast to rural outskirts with poor infrastructure. Finally, the other challenge focuses on macroeconomic variables, as African mobile operators face huge 5G rollout costs when using foreign equipment, whose prices can be influenced by the exchange rate.

“The cost of 5G-supporting devices is extremely high for most subscribers. The other challenge is that operators tend to roll out 5G in metropolitan and suburban areas, which are typically fibre-connected areas, while neglecting rural areas and townships. Furthermore, we do not manufacture 5G devices in Africa but rely on foreign devices from America, Europe, China, South Korea or Japan. This equipment is expensive and is controlled by the exchange rate controlled by the global economy. For example, global prices, including prices for 5G equipment, are affected by the ongoing Russia – Ukraine war.” – Participant 4

Participant 5:

The challenges and limitations faced by existing business models for mobile operators are neither universal nor standardised but vary from operator to operator. First, the way operators previously priced products and created revenue channels has become challenging in the era of

5G. In addition, the deployment costs for 5G are significantly higher than for previous mobile networks. The deployment costs are related to the capital injection, which can be a major challenge, especially for state-owned mobile operators. The other limiting aspect is the low level of consumer readiness for the African market. This is mainly because the majority of consumers are still on 2G and 3G as 5G smart devices are exorbitantly expensive. Therefore, device maturity is quite slow. Another challenge is Africa's tendency to lag behind in terms of technological advancement and the establishment of supportive regulatory frameworks.

“As a continent, we are always lagging when it comes to regulation. As new technologies come onto the market, you will find that on the regulatory side we are not prepared to provide a regulatory framework that governs the introduction and use of this new technology. We are also constantly lagging behind technologically, which is another problem that needs to be addressed. It is a challenge that impacts the accelerated adoption of new technologies such as 5G.” – Participant 5

Another major challenge is that mobile operators' business models traditionally place value on customers' data consumption. However, this perception has changed as customers are not only interested in data consuming, but also in the value they get from consuming the data. Therefore, the old and current business models are not able to match up to that transformation in customers' changing behaviour. There is a need to reconfigure current business models to match changes in customers' value perception as well as looking into financing of the business operations to have improved access to working capital support both CAPEX and OPEX requirements. Finally, the impact of over-the-top (OTT) applications, where operators' infrastructure is simply used as conduits to run OTT services, poses a challenge to existing business models. OTT application providers are not subject to deployment costs or operating costs, but they use the operator's connectivity infrastructure.

Participant 6: Internally within organizations, the key challenges are the lack of skills required to support the rollout of 5G technologies and the huge CAPEX investments required to roll out 5G. External challenges arise mainly from the regulatory uncertainty surrounding the deployment of 5G, as 5G has so many other underlying technologies such as cloud computing, edge computing, IoT, AI, etc. that could pose regulatory challenges.

The other challenge is to disrupt the existing business models where most operators have been quite successful in building mobile businesses in Africa. The main problem is to accept the disruptive nature of 5G without compromising the interests of shareholders. The lack of long-term business goals from operators makes it difficult to seamlessly introduce new technologies, as most goals tend to focus only on maximising profits.

“In my opinion, the lack of short-sightedness lies in the way business is conducted, where we are almost randomly forced by technology to change our business plans and therefore do not act proactively.” – Participant 6

Participant 7: The deployment of 5G and its use cases are capital intensive as many network nodes need to be changed and numerous features and improvements need to be implemented before the full potential of 5G can be realised. This is a major challenge in the African market where most operators are price sensitive. Additionally, investing in 5G is costly as the equipment and services are significantly more expensive compared to previous 4G or 3G networks. A viable 5G network requires hardware and software changes in the radio access network, transport network and core network, as operators do not want to deploy 5G while end users still experience 4G services.

In addition, most African operators' revenue margins are lower than in other regions such as North America, Europe or East Asia, largely due to less diversification of their revenue streams. In the African market, operators have long relied heavily on voice revenue streams and have had some difficulty fully commercialising data services. On some networks, data service demands, and usage may account for 70-80% of available capacity but only contribute 30% of total revenue. A number of operators have decided to venture into digital services just to diversify their revenue streams.

“Most African operators are probably what you would call tier-3 or tier-4 operators. Their revenues are much lower than those of European operators due to their voice centric revenue sources.” – Participant 7

The other challenges to operators' current business are the expensive 5G-ready devices for users, especially prepaid subscribers, and the limited spectrum availability in terms of cost and spectrum reuse to ensure enough spectrum carriers are available to users.

Participant 8: The biggest challenge for operators' current business models is the high cost and low presence of 5G devices in the market. Therefore, even if operators were to introduce 5G, few customers would use the associated services. The other factor is that most operators on the continent are not yet ready for 5G in terms of human resources and technical resources such as software and hardware to support the technology. Licensing and spectrum resources also pose a major challenge, with regulators charging exorbitant fees when acquiring operating licenses and auctioning spectrum resources.

Given the rapid pace of technological change, operators are faced with the challenge of managing this. Therefore, MNOs' companies must deal with the changes brought about by new technologies such as 5G. In addition, mobile operators need a large injection of capital to roll out 5G networks, which is not readily available, especially for state-owned operators. Additionally, some equipment suppliers focus on selling their products to operators without guaranteeing a return on investment.

“Challenges include the rapid pace of technological change and user demands. Another challenge is the enormous need for capital injections.” – Participant 8

Participant 9: The biggest challenge for operators is the shortage of spectrum and the enormous acquisition costs. The next challenge is limited backhaul/transmission resources due to low fibre penetration in Africa.

“Key challenges include spectrum shortages and pricing, as well as the lack of sufficient backhaul or transmission resources due to limited fibre deployment.” – Participant 9

In some countries, crime rates are high, and most sites are prone to vandalism, which negatively impacts mobile operators' operating costs. Additionally, power outages due to load shedding in certain regions has had a negative impact on ensuring consistent service delivery to network subscribers.

Participant 10: Mobile operators do not have a solid business model to guide them when introducing new technologies such as 5G. Operators rely too heavily on equipment vendors and solution providers who pressure them to upgrade or deploy 5G. The bottom line is that some operators have rolled out 5G but have few 5G users on their network. Therefore, low profitability is a challenge for African operators.

“To be honest, I haven't seen a solid business model, even though I'm telling you here that I see more opportunities in the corporate and corporate space. It looks a little more haphazard. I think mobile network operators are very listening to providers about how they can roll out 5G without developing their own business models.” – Participant 10

Another key challenge is low digital literacy in most African regions, especially in rural areas. Furthermore, the low availability of 5G devices, coupled with limited power supply in rural areas, where society's largest population lives, means that the level of digital literacy is insurmountable. The final issue is that the way operators previously priced their products and created revenue channels has become a challenge for 5G to do the same. In order to develop a new pricing model, a variety of novel 5G use cases that were previously unknown must be considered.

Summary analysis of existing MNOs' BM challenges and constraints' theme

Regarding the challenges and limitations faced by current business models for mobile network operators, both the literature and the respondents covered comparable aspects: deployment costs, exorbitant spectrum prices, unavailability and unaffordability of 5G devices, inadequate 5G infrastructure (e.g., low fibre penetration), societal issues (e.g., crime and vandalism), unreliable power supply (e.g., frequent loadshedding) and impact of over-the-top (OTT) service applications on operators' current business models. However, some topics covered in the literature review were not addressed by any of the interview participants. These include impact of disruptive non-cellular broadband technologies such as WiFi-6, challenges posed by outsourced and managed service models, challenges caused by new market acquisition models, and limitations of current business-to-business (B2B) and business-to-consumer (B2C) models. Table 5.2 summarizes respondents' responses to the challenges faced by current business models for mobile network operators.

Table 5.2: Summary of current business models' challenges and constraints from participants

BM Challenge & Constraint	Category	Participant	Internal / External
High deployment costs	Costs	Participant 1 Participant 3 Participant 4 Participant 5 Participant 6 Participant 7	Internal
High operating costs	Costs	Participant 9	Internal
High device prices	Device/costs	Participant 4 Participant 7 Participant 8	Internal & External
Low device maturity	Device	Participant 1 Participant 8 Participant 10	Internal & External
Limited tower infrastructure spaces	Site acquisition	Participant 2 Participant 3	Internal & External
Low 5G skills & competence	Competence	Participant 1 Participant 6 Participant 8	Internal
Indefinite regulatory frameworks	Regulation	Participant 5 Participant 6	External
Low fibre penetration	Network infrastructure	Participant 4 Participant 9	External
Unreliable and limited power supply	Network infrastructure	Participant 9 Participant 10	External
Limited spectrum resources	Network resources	Participant 1 Participant 2 Participant 4 Participant 7 Participant 9	External
Exorbitant spectrum prices	costs	Participant 4 Participant 8 Participant 9	External
Exorbitant licence fees	costs	Participant 8	External
Challenges by OTT service applications	competitors	Participant 5	External
Customer value perception issues	customers	Participant 5	Internal & External
Customers' readiness issues	customers	Participant 5	Internal & External
MNOs' readiness issues	Network operator	Participant 5 Participant 6 Participant 8	Internal
Consumers' low digital literacy levels	Customers	Participant 3 Participant 10	External
Inaccurate network planning & dimensioning	Competence	Participant 3	Internal
Societal issues	Governance	Participant 9	External

5.3 PHASE 2: Conceptual Framework Design

The main purpose of this phase was to conceptualise the business model framework design which addresses the following research question (*sub-question 2*):

How can a business model framework be conceptualised and developed for next-generation communication networks?

5.3.1 Business Model Framework Themes

In this section, analysis of qualitative findings is presented. The qualitative data was analysed using the QDA software MAXQDA. The four main themes (outlined in Table 5.1) which were used in the formulation of the conceptual business model framework are, value proposition (business model offerings), customer interfaces, infrastructure management, and financial aspects. These themes were further categorised, interrelated and refined into final themes and sub-themes, using an iterative approach by moving back and forth between and across data sets as suggested by (Braun & Clarke, 2019). Firstly, the main themes and preposition are described before formulated the conceptual framework and the related hypotheses.

Theme: Value Proposition (Business Model Offerings)

This theme describes the products and services that a mobile network operator offers to its intended customers. The products and services can be divided into three broad classes: (i) *eMBB class*, which consists of human-oriented services such as VR, AR and XR applications, high-speed broadband access offering services such as ultra-high definition (UHD) applications, and immersive mobile services such as virtual presence; (ii) *mMTC class*, which provides industrial IoT applications such as automated factories, and commercial IoT applications such as smart energy grids, smart metering systems, and smart parking systems; and (iii) *uRLLC class*, which provides mission-critical applications such as industrial automation, remote surgery, drone surveillance, vehicle platooning, and industrial robotics. For the value proposition theme, interview questions focussed on the initial service deployments for an MNO launching 5G, the

current 5G services an MNO offers to its customers, and the best ways to commercialise 5G services to reach intended customers.

Responses from interview participants

Participant 1: Currently, 5G services are still a pilot project with a focus on link connection protection for enterprise customers. Thus, 5G currently provides connection redundancy for banks/enterprises as well as manufacturing and agricultural companies, albeit on a small scale. The best way for a mobile operator to commercialize 5G services is to have clearly defined use cases, develop products and raise awareness among its customers, offer affordable pricing strategies and build a sustainable infrastructure. For a mobile operator, uRLLC (ultra-low latency) is the appropriate starting point for the initial 5G service class.

Participant 2: Current 5G services include eMBB streaming services as well as mMTC services such as narrowband Internet of Things (NB-IoT) and artificial intelligence (AI) applications. Additionally, mMTC enables MNOs to connect not just people but also things at scale, enabling smart offices, smart factories, and smarter things via what originally started as IoT. With such smart sensors and devices, 5G can improve the quality of work as these smart devices are capable of collecting and interpreting data, since data now forms the basis for the pursuit of higher productivity and profitability.

“With 5G services, I think what we’ve seen now, especially streaming different applications, narrow band IoT, and AI, those are the services that we’ve been pushing a lot.” – Participant 2

Commercialization of 5G services is best achieved through a partnership model such as value co-creation with enterprise customers, device manufacturers, and technology and solution providers. This is crucial as MNOs evolve from pure telecommunications companies to technology companies. Additionally, due to the dynamic environment of technology sectors, MNOs should examine the internal and external competencies they need to respond to the changing environment and remain competitive in the long term.

“The only thing that I think needed to happen was to partner with the likes of IoT.next which my company has ended up acquiring.....But partnering with the likes of technology and

solutions providers such as Cisco and Microsoft as enabled our organisation to differentiate itself within the technology space.” – Participant 2

The proposed 5G service that should serve as a starting point for a mobile operator is broadband services (eMBB), but that depends on the broadband context as there are multiple definitions such as fixed or mobile broadband.

Participant 3: The current 5G service is offered as an eMBB class of service and can be configured in various ways. It can be configured as either a mobile service or a fixed wireless access (FWA) service. 5G FWA has dominated over cellular services and is applicable to both postpaid and prepaid customers. Additionally, eMBB has created tremendous value for the company due to its advantage over fibre optic connections in terms of customer mobility. eMBB has been a cornerstone of operators' mobile data usage, as evidenced by network statistics showing the exponential growth in data volumes with 5G significantly faster than in the early days of 4G or 3G. In terms of use cases, fintech services are doing well as banks and other financial institutions have started venturing into the mobile space by selling devices and SIM cards to subscribers.

“Just as banks have entered the mobile space, with 5G operators can do the same and compete in spaces that were non-traditional mobile spaces, including the Fintech space.”- Participant 3

The starting point for the commercialisation of 5G services is the deployment of the non-standalone 5G option 3X to provide the basic 5G services with eMBB use case. The transport and radio access domain must be upgraded to 5G-ready status before deploying the 5G core network, which is very costly. Only after the activation of the 5G core network can the operator provide end-to-end services via network slicing functions for all three service classes eMBB, mMTC and uRLLC. Finally, the eMBB service class is the appropriate starting point for the deployment of 5G services by a mobile operator.

Participant 4: The 5G services currently offered by mobile operators are eMBB in the form of 5G Fixed Wireless Access (FWA) services. This is crucial because fibre infrastructure only reaches wealthy suburbs and rarely reaches rural or poor urban areas. Therefore, FWA is a way to provide 5G services in poor communities. 5G service packages are offered to customers at affordable prices via FWA using an indoor or outdoor Customer Premises Equipment (CPE).

This ultimately leads to new revenue streams for operators, as previous fixed broadband access was predominantly based on fibre connections.

“Our current 5G service offering is FWA for high-speed mobile broadband connectivity. At this stage, we are only providing 5G data with no voice services on 5G because we still need to invest into the 5G core” – Participant 4

To commercialise 5G services, mobile operators should invest in the new cloud-based 5G core network as the existing evolved packet core (EPC) cannot support end-to-end 5G services. Therefore, there is a need to migrate from non-standalone to standalone core network so that services in various vertical industries will be able to run smoothly on top of 5G networks.

“Take the healthcare sector as an example: using 5G for remote surgery applications would mean a doctor in Cape Town performing a surgical procedure on a patient in Johannesburg, which would mean extremely low latency communication as it is a matter of life and death. This can only be achieved through network slicing enabled on the 5G core network” – Participant 4.

Starting with FWA, an ultra-high data rate eMBB service, is a realistic and cost-effective way for a mobile operator to launch 5G services as it does not necessarily require the deployment of the 5G core. A new 5G core network should then be introduced for the standalone network to enable large connections and densification as well as ultra-low latency communication. Although most transport network nodes are located on fibre infrastructure, a new standalone 5G core network is required for a mobile operator to utilise the 5G service classes (eMBB, mMTC and uRLLC).

Participant 5: To commercialize 5G services, mobile operators should first understand the nature and operations of target industries and identify the current challenges these industries face in managing their daily operations. Mobile operator can then redesign the business solutions to address these specific challenges.

“Only after we understand the challenges faced by vertical industries can we redesign enterprise solutions to address challenges faced by various vertical industries” – Participant 5

Moreover, to actualise these solutions, mobile operators should form strong strategic partnerships by building an ecosystem of app developers and innovators whose expertise lies in developing solutions for specific vertical industries.

“Right now, I don’t think operators want to do it all. It’s about strategic partnerships. You build partnerships that can help you deliver solutions to these vertical industries.”- Participant 5

Mobile operators should start with eMBB for higher data rates when rolling out 5G networks as an evolution of 4G mobile broadband.

Participant 6: When commercialising 5G services to the vertical industries, it is imperative that the mobile operator to know the target industry and understand how a particular industry is to embrace 5G technology. If the integration and customer are not properly identified, it may lead to non-achievement of the intended target.

“The best approach is to conduct in-depth research on the type and needs of a particular industry before loading them with multiple 5G services, some of which they may not even need”
– Participant 6.

Regarding the proposed initial 5G services for a newly deployed network, eMBB should serve as a starting point, since when a network is launched, speed tests are generally first carried out to observe cell data throughput for uplink and downlink transmissions. Later, mMTC and uRLLC services can be integrated as the network matures.

“As soon as you launch 5G, the very first thing you do is do a speed test because you want to show that you can achieve high throughput, where you can reach close to a gigabyte per second on the downlink. This means that when you watch a 4K or 8K video, you can watch it without buffering. You can do live streaming. So that should be the first starting point for our organization and later we can go for ultra-low latency communication for specific use cases and then I think mMTC would follow considering such types of communication like self-driving cars that exist more context specific. However, in South Africa we are not yet ready for self-driving cars.” – Participant 6

Participant 7: Some operators are currently using eMBB services in the form of wireless to the x (WTTx) as an offering to vertical industries such as the mines and as a branding tool. Additionally, to provide a better user experience for 4G customers who have had painful experiences due to congestion and high resource utilisation. When commercializing 5G services, operators should engage original equipment manufacturers (OEMs) who are developing the technology and have extensive knowledge and experience from different parts of the world. In addition, some operators are large multinational corporations that can take advantage of

developments in various markets where they have a strong presence. Mobile operators should also engage and socialise with vertical industries on the possibilities of 5G technology before offering them essential end-to-end 5G solutions that can serve as examples for other industry players. As a starting point for a newly launched 5G network, eMBB is preferred for ultra-high data rates as the biggest pain point for current 4G networks is degraded mobile broadband connectivity.

Participant 8: For some operators, their current 5G service offering is primarily based on eMBB as they still have non-standalone 5G networks. When the 5G core is deployed in due course and the network is configured as a standalone network, advanced use cases can then be run end-to-end on the 5G network. The proposed initial service offering for 5G is eMBB. As the network matures, the mMTC and uRLLC service classes can then be introduced.

Participant 9: Mobile operators provide eMBB data services in the form of FWA to enterprises and industries such as manufacturing and healthcare. In addition, 5G broadband services is being offered over fibre infrastructure for residential and corporate developments. For mobile operators to commercialize 5G services across vertical markets, industrial customers should gain context and awareness of key 5G features and how 5G technology can improve their productivity.

“Some people in various industries do not even know what 5G is about. So, there is a need to make them aware of 5G is. This can be done via roadshows and promotions such as TV or radio commercials as well as billboard advertisement.” – Participant 9

As a starting point for 5G service offerings, eMBB is the best choice as it is an enhancement of current 4G mobile broadband. In most cases, 4G and 5G services are housed in a single physical location. This allows traffic to be balanced between the two technologies if one of them experiences network congestion.

Participant 10: The mobile operator does not offer any unique 5G services. The value of existing 4G technology will be realized through increased customer spending on internet services due

to improved data connectivity and higher data rates. In order to commercialize 5G services, the internal structures of existing organizations must first be changed by involving intermediary industry-specific partners. These intermediary partners can be either internal or external partners who understand the current challenges and business landscapes of specific vertical industries such as mining, healthcare, education, etc.

“The way we are currently structured means that our solutions team cannot develop a solution for a financial industry, for example, as we are still structured in the traditional sense. We sell data and voice, so a change in the internal structure is required by deploying people who know the full 5G service functions and understand what is going on in the market and in these industries and see where we can provide solutions. Even though we currently have 5G services, we're just doing the traditional thing.” – Participant 10

The second aspect of commercialising 5G services is a deep understanding of what is happening in the targeted vertical industries, what challenges need to be addressed and educating customers about the features and benefits of 5G. In addition, mobile operators must position themselves as partners for the digital transformation of various industry verticals.

“Being a third world country, we have many computer literacy issues, which is why operators need to provide digital training with the support of other partners such as state and local authorities.” – Participant 10

An initial 5G service class for a mobile operator would be eMBB as this would be a smoother progression from the current 4G mobile broadband. Thereafter, mMTC and uRLLC services can be integrated.

Summary analysis of the value proposition (BM offerings) theme

Regarding 5G services and use cases, the literature and interview data were relatively similar, with minor differences as the interview data mainly focused on eMBB use cases, while the literature focused on all three 5G service categories, eMBB, mMTC and uRLLC services. This was unexpected for the researcher, who expected that uRLLC services such as mission-critical applications would become more popular among interview participants as these topics gain attention in the literature and in the daily operations of MNOs. According to the interview data, eMBB services are provided in the form of fixed wireless access (FWA) and mobile broadband access. In terms of how a mobile operator can commercialise 5G services to the industry vertical,

the interview data offered a wide range of options, including clear definition of use cases, partnership models, understanding customer needs, restructuring internal organisation, and promoting digital transformation. According to interview data, the proposed initial 5G service offering is ultimately the eMBB as it is seen as a smoother progression from the current 4G mobile broadband services. Moreover, the provision of eMBB services does not necessarily require the costly deployment of the 5G core network. This confirms the reviewed literature, which shows that most African operators have deployed non-standalone 5G networks and currently only offer eMBB for ultra-high data rates.

Theme: Customer Interfaces

Customer interfaces involve the interaction and communication between a company and its customers. Companies improve their viability and ability to innovate by attracting customers to their needs and knowledge. The theme “Customer Interfaces” is divided into three sub-themes, (i) *customer segments*, which describe the customer base to which an MNO aims to provide the proposed value, (ii) *customer relationships*, which explain the nature of links an MNO establishes between itself and various customers, and (iii) *distribution channels*, which highlight the different means that an MNO can use to reach its customers and offer them the proposed value. The interview questions revolved around target customers, establishment of new customer bases, relationships with existing customers, and key activities for the MNO.

Responses from interview participants

Participant 1: The mobile operator's 5G target customers will primarily include business enterprises, financial institutions, manufacturing, agriculture and VIPs. There are no new customers and no impact on customer behaviour as 5G is still in the pre-commercial testing phase. Currently customer relationships only exist for 2G, 3G and 4G services.

Participant 2: The mobile operator's 5G target customers include the government, farming areas, medical institutions, manufacturing industries, mining sector and small to medium enterprises (SMEs) businesses. The introduction of 5G has led to the creation of new customer

base mostly in the vertical industries such as mining, agriculture and manufacturing sectors. Relationships with existing customers has been solidified through the sale of new products and services as well as through upselling which is now proving to be the norm.

“We expect different types of customers which will include: the government, farming areas, medical institutions, manufacturing industries, mining sector and SMEs businesses, just to mention a few.” – Participant 2

Participant 3: The target customers in the 5G era will come from the private 5G network sector and will focus on vertical markets such as finance and mining, and to some extent other industries such as seaports. This is the provision of 5G services in the form of WTTx, where fibre infrastructure is problematic. The application of IoT and AI will be integrated into mainstream 5G and applied in various sectors such as agriculture and manufacturing in the form of private 5G networks.

“For example, by using IoT in smart agriculture, we can provide solutions that allow farmers to leverage off machine learning and artificial intelligence for them to increase their crop yields.” – Participant 3

Additionally, existing individual and residential customers will continue to be the target of 5G services. Most new customers come from industries such as mining and financial services where private 5G networks are deployed. Customer behaviour has changed as data consumption has increased. In the future, 5G services will allow customers to consume more data than in the past, either by using the service for much longer for different applications or by consuming more data in a short period of time, leading to a change in behaviour.

“For example, from a data perspective, what I've seen with my kids is that with unlimited free data, all they do is spend time watching and streaming huge amounts of data every day.” – Participant 3

New relationships have been established with existing customers as the introduction of 5G has made more capacity available and operators are now able to sell more connections to private and commercial customers. A significant number of existing customers have upgraded to 5G and added more capacity, meaning new relationships are based on new connectivity lines.

Participant 4: One of the most important developments in 5G is the private network. A prominent application of private 5G networks is in the mining sector, which represents a key business customer target for mobile operators. Mines are taking the step of having their private 5G networks on-site to enable them to carry out their daily operations by implementing safety features such as collision avoidance, early emergency warnings and increased productivity. Other target customers are existing postpaid and contract customers. The plan is to successfully migrate them to 5G while introducing affordable devices for new customers, as 5G devices are currently expensive. Building a new customer base is primarily happening in the mining and manufacturing industries through the use of private 5G networks.

“Through the use of private 5G networks, Anglo Gold (mining) and Toyota (manufacturing) are among our new customers. Toyota uses a private 5G network for scanners at its manufacturing facilities, while Anglo uses a private 5G network for collision avoidance at its mining sites.” – Participant 4

Customer behaviour has changed as data prices become more affordable through segmentation of cheap data packages among existing customers. New relationships with existing customers have been cultivated through the introduction of various 5G services and solutions.

“A new relationship has been established with our long-standing industry customer Anglo Gold Mines. This came after deploying private 5G networks at some of their mining sites to increase productivity. In fact, most of their employees are now connected to our network and access our mobile services.” – Participant 4.

Participant 5: Due to the slow adoption rate of 5G caused by high device costs and low technology maturity, the mobile operator is initially targeting enterprise customers with private networks for the mining and manufacturing sectors to provide industrial automation. Once the mass market is ready, a phased approach will be implemented to roll out the 5G network in areas with high population density before finally implementing widespread coverage of the entire network. Even though 5G is not yet rolled out, the mobile operator believes that 5G is likely to attract new customers once it is introduced and, due to the slow adoption rate, the focus will initially be on enterprise customers and then on localised areas such as airports, stadiums and shopping centres before reaching the mass markets. No new relationships have been established with existing customers as the mobile operator has not yet rolled out 5G.

Participant 6: Apart from the existing customer base, the targeted customers are the industrial type where 5G can be the enabler of connectivity. These include mining, manufacturing and transportation. Additionally, the deployment of FWA has made 5G services available and affordable to customers in both residential and commercial areas. With the advent of 5G, customer behaviour will be influenced by comprehensive immersive video applications such as VR/AR virtual presence use cases. The mobile operator has not yet launched 5G services, so there is no data on the creation of a new customer base or new relationships with existing customers.

Participant 7: The mobile operator is targeting three types of customers: home users for WTTx, small and medium-sized enterprises (SMEs) and the mines. There were no significant changes in terms of new customers. This is because 5G is being employed where there are existing customers and is being offered to customers who are already using 4G services, thus the uptake of 5G is relatively slow. Customer behaviour has changed with customers demanding end-to-end 5G services and solutions.

“I think with 4G, customers asked more about the availability of 4G and then they decided what they wanted to do with it. But with 5G, there is a huge demand for end-to-end services, for example, complete modernization of a mine, deployment of IoT or AI tools, and they will look to operators for such end-to-end solutions.” – Participant 7

New relationships with existing customers have been established primarily with the mines through the deployment of IoT-based private 5G networks at their sites.

Participant 8: The target customer base of the mobile operator is broad, but sectors such as mining and then the mass market will take priority. Customer behaviour is likely to change from simply purchasing data bundles to purchasing capacity in terms of data throughput. Although 5G has not yet been deployed, customers expect new and extensive services such as more capacity and higher data rates. This will create new relationships and strengthen existing ones.

Participant 9: The target customers are predominantly corporate businesses for which services such as IoT applications are provided, and to some extent also the provision of services to private customers. Since the introduction of 5G, the number of subscribers in the network has increased significantly, which is reflected in the increase in data traffic, especially in large cities. The new customer base mainly comes from industries such as mining and manufacturing. When it comes to relationships with existing customers, both private and corporate customers are satisfied with the current 5G services. However, the demand for more services and solutions continues to increase.

“People are definitely happy with the 5G services we offer them. I think right now we are probably the number one 5G service provider in the country and customers are happy with our 5G services.” – Participant 9

Participant 10: The mobile operator expects to target customers in industries such as manufacturing, corporations and enterprises by offering solutions that go beyond internet services. Customer behaviour should change by viewing mobile operators as solution providers to customers' technology needs and challenges, as opposed to the current perception where operators are viewed solely as providers of voice and data internet services. In addition, operators should be viewed as partners, especially in the digital transformation of enterprise businesses.

“The first thing I expect, and this would take a lot of effort from us as mobile network operators, is that our customers change their perception of us, how they know us and what they know about us. Because we have always been known as a provider of voice and Internet services, but we are much more.” – Participant 10

The introduction of 5G has resulted in the acquisition of new customers, in the sense of increasing the number of customers receiving the same but improved services, such as higher internet data throughput, than before. However, there were no new customers in terms of operators offering a different service portfolio or bundle of services. No new relationships have been established with existing customers since the launch of 5G.

Summary analysis of the customer interface theme

According to the interview data, mobile operators are primarily targeting customers in vertical industries with their 5G service offerings. In particular, mining, manufacturing and financial sectors through the use of private 5G networks. To a certain extent, corporate businesses, SMEs and residential/private customers are also being addressed. However, mass markets seem to be the lowest priority at the moment. This confirms the literature data that 5G is intended for various industrial and residential use cases. When it comes to creating a new customer base, new customers seem to come from industries such as mining, manufacturing and enterprise businesses. Some operators have seen an increase in subscriber numbers within existing customer segments, largely due to improved internet data services delivered over 5G networks. Customer behaviour is moving towards demand for end-to-end 5G solutions, unlike previous 4G technologies where demand was primarily focused only on network availability. In addition, user data consumption has increased significantly since the introduction of 5G on most mobile networks. When it comes to building new relationships with existing customers, some operators have seen no changes, while other operators have built new relationships and strengthened existing ones, particularly from the perspective of industrial customers who are benefiting from private 5G networks.

Theme: Infrastructure Management

Infrastructure management is an essential component of any business model regardless of the nature of the business under consideration. This theme outlines the process management, technology design, network infrastructure and the resources available to an MNO in providing value to the intended customers. Sub-themes include (i) *key technologies* which describe the underlying technologies which an MNO must design and implement to ensure that 5G services and products are delivered to the intended customers, (ii) *key partners* which demonstrate essentiality of collaborative arrangements with external organisations to effectively provide and monetise the proposed value, (iii) *key resources* which outlines the resources at the MNO's disposal to ensure that value is created and captured according to the MNO's business goals,

and (iv) key activities which highlight the activities and competencies necessary to implement the MNO's business model. The interview questions were centred on these four sub-themes.

Responses from interview participants

Participant 1: The mobile operator's 5G network is in pre-commercial state. Key technologies and resources deployed so far are the non-standalone (NSA) network architecture (4G-based core network), the fibre-based transport network and the 3.5 GHz frequency spectrum (C-band). As for the main activities related to the migration from 4G to 5G, the most cost-effective way is to start with the NSA solution and introduce a common radio access network that supports 2G, 3G, 4G and 5G, so that the investment costs are minimised. Additionally, fibre connectivity should be used for transmission unlike microwave links. The mobile operator's spectrum resources include low-bands, 900MHz, 1800Mz, 2100MHz and mid-band, 3.5GHz (C-band) and the operating license is primary carrier for both voice and data services.

“In my opinion, 5G should be introduced as an NSA to protect the initial investment with the existing 4G if it is intended for significant customers such as private networks for enterprises. Lower power consumption solutions should also be considered in the design.”

Tower sharing is a crucial key activity and serves as a source of revenue for mobile operators and reduces operational costs such as energy supply costs. However, it should be noted that if implemented improperly, data traffic may shift to the competitor.

Participant 2: Key 5G technologies that the mobile operator has deployed include Massive MIMO for increased capacity, Narrowband IoT (NB-IoT) for smart sensors, and cloud computing services that move software and applications to the cloud. Currently, a non-standalone 5G network has been implemented. Key activities undertaken include extensive sharing of both active (e.g. transmission resources) and passive (e.g. antennas) resources with other operators. This is the most cost-effective way to upgrade 4G to 5G networks as it brings benefits in terms of reducing deployment costs, hence CapEx minimization.

“Resource and infrastructure sharing is beneficial since it cuts on deployment costs, thereby reducing CapEx. Active sharing is already happening on the fibre transmission in some areas with our partners, Dark Fibre Africa who are fibre infrastructure suppliers.” – Participant 2

Since 5G is an integration of multiple technologies, the mobile operator will need to partner with other industry experts, especially when transitioning from a telco company to a technology company. Key partners include technology companies such as Cisco, Microsoft, Dark Fibre Africa, Amazon and many more. Current spectrum resources include the existing low bands 700 MHz, 900 MHz, 1800 MHz, 2100 MHz and the recently acquired mid-band 3.5 GHz. The operating license is a primary commercial license for voice and data services.

Participant 3: The mobile operator has implemented the following 5G enabling technology. Network slicing for effective resource allocation, Massive MIMO for more capacity, Beamforming for more capacity, Industrial IoT for more device connectivity, and Network densification for more capacity. In terms of network architecture, 5G non-Standalone has been implemented and this is considered as the most cost-effective way to upgrade 4G to 5G networks if the operator has the traditional 4G core network.

“Operators are recommended to start with non-standalone deployments where signalling to the 4G core network occurs exclusively at the 4G control plane and then combines 4G and 5G data at the user plane. This is the most cost-effective way to upgrade 4G to 5G as the investment cost in the 5G core is huge.” – Participant 3

Partnerships for business model development are important because partners such as industry verticals have an integrated understanding of their environment, while operators simply provide the conduit for the flow of services. By engaging partners, operators gain insights that can be critical to optimizing their business models. Sharing 5G resources and infrastructure will help reduce costs, just as it does with 4G networks. Therefore, it is crucial to share resources such as transmission and infrastructure such as cell towers to reduce the cost of 5G rollout and deployment.

“In Canada we are already seeing resource and infrastructure sharing, with Telus and Bell providing each other with roaming services to provide coverage where the other does not have coverage.” – Participant 2.

In terms of 5G spectrum resources, 700 MHz, 2600 MHz and 3500 MHz are available to the mobile operator for radio access, while the millimetre wave spectrum (26 GHz) is typically

used for point-to-point transmission links. The operator has a primary commercial license for voice and data services.

Participant 4: Millimetre wave technology has been used for fixed wireless access (FWA) in some residential and commercial establishments. Other key enabling technologies for 5G that have been implemented include massive MIMO, IoT, network slicing and cloud computing with a non-standalone 5G network architecture. Partnering with other operators by sharing resources and infrastructure is considered the most cost-effective way to upgrade 4G to 5G networks as this would reduce deployment costs and ultimately minimize capital expenditure. With 5G still in its infancy in most African countries, operators should consider resource and infrastructure sharing as the fastest way to reach their customers, rather than mere competition. This is even more important for new entrants to the 5G market with existing, established mobile operators.

Participant 5: The mobile operator has not yet rolled out 5G, but it is being considered by the management and technical team. The operator plans to launch 5G through the implementation of the non-standalone architecture as it will focus on investments in the radio access side before deploying the 5G core network. It is believed that one of the best ways to upgrade from 4G to 5G is for operators to come together and agree on pooling spectrum resources, rather than each operator purchasing separate spectrum from the regulator at huge cost. The other options for upgrading from 4G to 5G are active sharing of equipment by operators to reduce 5G deployment costs and financing by equipment vendors as opposed to traditional capital markets such as banks and equity. Vendor financing would allow vendors to deliver devices to operators on flexible payment terms, allowing operators to monetize the devices and solutions provided, which could lead to revenue sharing between operators and equipment vendors.

“Vendors such as Huawei, ZTE, Nokia and Ericsson are now opening up the possibility of revenue sharing. When providing equipment, vendors must be aware that operators will not immediately make money to pay for the equipment supplied. This allows them to work with operators on a revenue-sharing basis. Unlike what is happening today, as long as operators

have purchased the equipment, regardless of whether they make profits or not, they are obligated to a vendor.” – Participant 5

For a telco company to survive in the long term, it must form alliances to leverage the strength of its partners to drive scale in various aspects of the business. Therefore, mobile operators need to build an ecosystem of software and application developers whose products will be integrated into the 5G network.

“To give just one example: Our company is pushing for an e-health platform at the Ministry of Health. We have partnered with an Indian company to develop a platform that provides e-health services through which doctors can communicate with hospitals and clinics and care for patients remotely.” – Participant 5

Sharing network resources and infrastructure is beneficial for mobile operators because it reduces both deployment and operating costs. Customers are not interested in towers or active equipment, only in the cost and quality of the services provided to them. Therefore, where possible, resources and infrastructure should be shared between operators and competition should only take place in the downstream market. As for spectrum resources, the operator plans to use the 2600 MHz and 3500 MHz frequencies for 5G New Radio and has the primary operator license for voice and data services.

Participant 6: Unfortunately, the mobile operator has not yet introduced 5G. However, they are in the process of building a fully cloud-based core that will be used to deliver some 5G services. Furthermore, the proposed initial network structure is non-standalone 5G, which is seen as a natural evolution of the existing 2G, 3G and 4G networks. As a phased approach, a non-standalone approach is carried out for small coverage areas for specific niche use cases. It is observed that sharing infrastructure and resources between network operators is the most cost-effective way to upgrade 4G networks to 5G networks as it significantly reduces deployment costs. Sharing infrastructure and resources applies not only to physical towers, but also to radios, antennas and transmission domain.

“Site infrastructure and resource sharing are becoming increasingly important for operators to reduce deployment costs. Unlike in the past, when operators could build separate towers in

the same location, which was costly and unnecessary, today site infrastructure sharing is the way to.” – Participant 6

Partner involvement in designing a business model is important because 5G is supported by several underlying technologies such as cloud computing, big data, IoT and to some extent artificial intelligence, which do not necessarily fall within the competence or expertise of mobile operators. For example, when operators work with certain technology providers such as Amazon, Microsoft or IBM to provide cloud computing services, they bring in their expertise and infrastructure such as data centres that leverage the operators' design of effective business models. In addition to the existing 900 MHz, 1800 MHz and 2100 MHz low bands, operators recently acquired the 3500 MHz band to be used for 5G New Radio. The operator has a primary commercial license for voice and data services and also has mobile virtual network operators (MVNOs) using its network.

Participant 7: Network slicing and Massive MIMO are the two key 5G technologies which the mobile operator has deployed and a non-standalone 5G network has been implemented. New technologies such as IoT, artificial intelligence or machine learning impact operators' business models as mobile operators need to lead and guide the market in introducing and adopting these new technologies. The use of L2600 (i.e. LTE in the 2600 MHz band) enables smooth modernisation and upgrade from 4G to 5G networks. This is because the L2600 band is supported by many devices on the market, including 5G devices. It is important for operators to involve partners such as equipment vendors who actually own the technology as they bring extensive knowledge to mobile operators. Additionally, device manufacturers are key partners who can play a critical role in price-sensitive markets such as Africa by offering devices to end users at affordable prices, thereby driving 5G adoption. The operator's spectrum resources available for 5G are 2600 MHz and 3500 MHz and the operating licence is the commercial carrier for voice and data services.

Participant 8: The mobile operator has not yet launched 5G but believes that new technologies such as artificial intelligence and machine learning will impact their business model by improving the efficiency of operations compared to the current traditional approach.

Furthermore, the management of these new technologies will require new skillsets which can only be attained via trainings from experts and the best way to achieve that is to use the approach of the developed markets as a guide. The most cost-effective way to upgrade from 4G to 5G is firstly to start with the non-standalone 5G network since most current 4G equipment can support non-standalone networks as they just need licence activation by the original equipment manufacturers (OEMs). Secondly, is to use the existing 4G spectrum like L2300 or L2600 which work for both 4G and 5G radio access. It is important to involve network and business partners like equipment manufacturers when designing business models as they bring in extensive knowledge and experience. In this way, operators' 5G implementation failure rate is minimised. Active equipment sharing between mobile operators is beneficial in the early stages of 5G when the subscriber base is still low. However, when the network matures, and more capacity is needed, active equipment sharing is not recommended. For passive infrastructure such as tower space, sharing model is recommended as it minimises investment costs in building such towers. Spectrum resources available include 2600 MHz (low band), 3500 MHz (mid band) and 26 GHz (high band). Operating licence is a full voice and data service primary cellular network carrier.

The mobile operator has not yet rolled out 5G but believes new technologies such as artificial intelligence and machine learning will impact its business model by improving operational efficiency compared to the current traditional approach. In addition, managing these new technologies requires new skills that can only be acquired through training from experts. The best way to achieve this is to adopt the developed markets approach. The most cost-effective way to upgrade from 4G to 5G is to start with the non-standalone 5G network first, as most current 4G devices can support non-standalone networks as they only require license activation from the original equipment manufacturers (OEMs). Secondly, there is the possibility of using the existing 4G spectrum such as L2300 or L2600, which is suitable for both 4G and 5G radio access. When designing business models, it is important to include network and business partners such as equipment manufacturers, as they bring extensive knowledge and experience. In this way, operators' error rate in 5G implementation is minimised. Active equipment sharing

between mobile operators is beneficial in the early stages of 5G, when the subscriber base is still small. However, when the network is mature and more capacity is needed, active equipment sharing is not recommended. The sharing model is recommended for passive infrastructure such as tower space as it minimises the investment costs for building such towers. Available spectrum resources include 2600 MHz (low-band), 3500 MHz (mid-band), and 26 GHz (high-band). The operating license is a primary wireless carrier with full voice and data service.

Participant 9: Current 4G technologies such as massive MIMO, beamforming and network densification are deployed in a non-standalone 5G network. New technologies such as artificial intelligence, machine learning and IoT will impact the operator's business model by improving business processes and increasing productivity. The transition from 4G to 5G requires initial investment in 4G, which can be achieved by building 5G-ready sites. After that, only a few hardware and software upgrades are required, which can reduce deployment costs and shorten the deployment period. Involving partners such as equipment manufacturers and technology solution providers can help in the development and transfer of technical skills as well as in the implementation of the business model. However, this should be done with caution and not involve too many third parties in the value chain to ensure the privacy of the network and avoid sharing internal information with competitors. Sharing resources and infrastructure reduces deployment costs for operators who lease such infrastructure or resources. On the other hand, the owner of the resources and infrastructure creates additional revenue streams in form of rents. The 5G spectrum resource is 3500 MHz and the operating license is the primary carrier for commercial voice and data services.

Participant 10: The key 5G technologies that the mobile operator has deployed so far are massive MIMO, millimetre wave (mmWave) and network slicing using a non-standalone 5G network. New technologies such as network slicing, IoT, artificial intelligence and machine learning will impact operators' business models targeting large corporations and industries such as mining and manufacturing to improve operational efficiency and reduce costs. For mobile operators in developing markets such as Africa, the non-standalone approach is the most cost-effective way to transition from 4G to 5G. The other option is for equipment manufacturers to

recover obsolete network equipment and sell new 5G network nodes to operators at affordable prices. 5G is entirely based on a network of partners. Therefore, network design partners, service provider partners and industry partners must be involved in the design and implementation of the operators' business models.

“For example, if you are considering the manufacturing industry, you need to select partners who have expertise in areas of IoT and can provide IoT-based solutions that can leverage our network upstream and downstream to provide solutions for manufacturing processes.” – Participant 10

Sharing resources and infrastructure can be beneficial for mobile operators not only at the tower level, which is common, but also at the transport/backhaul resource level, which is currently uncommon. The available spectrum resource for 5G is 2600 MHz (low-band) and 3500 MHz (mid-band) and the operating license is a commercial primary carrier for voice and data services.

Summary analysis of the infrastructure management theme

Data collected from interviews suggests that most African mobile operators have deployed 5G as a non-standalone configuration. This is consistent with the literature, which suggests that non-standalone networking is the easiest, fastest and most cost-effective way to deploy 5G for operators who already have 4G networks. But even as the global rollout of 5G has intensified, most African operators are yet to deploy the technology, while a sizeable number are in the pre-commercial testing phase. When it comes to key technologies for 5G, operators have deployed massive MIMO, beamforming, network slicing, millimetre wave (mmWave), network densification and IoT. This confirms the literature data, as these deployed technologies form the basis of the 5G network architecture. Furthermore, operators believe that emerging technologies such as network slicing, artificial intelligence, machine learning and IoT, if successfully adopted, can improve operational efficiency and increase productivity within the 5G value chain. When it comes to the most cost-effective ways to upgrade 4G to 5G networks, most operators consider the non-standalone 5G network approach to be the best option for two reasons. Firstly, it enables a smooth transition from 4G to 5G with minimal configuration

changes and secondly, it reduces the huge investment costs associated with deploying the 5G core network. Operators emphasize that engaging partners such as equipment manufacturers, technology and solution providers, App developers and device manufacturers is critical to developing an effective business model, as these partners bring extensive knowledge and expertise to leverage operators' business objectives. Sharing resources and infrastructure between active and passive equipment is important because it reduces both deployment and operating costs for mobile operators. Finally, most African operators have relatively sufficient 5G spectrum resources such as 2600 MHz (low-band), 3500 MHz (mid-band) and 26 GHz (high-band), and they possess primary carrier licences for commercial voice and data services.

Theme: Financial Aspects

Introduction of a new technology such as 5G leads to considerable changes in the financial aspects of the company's business model. Financial aspects' theme outlines the capability of an MNO to capture and monetise the proposed value delivered to the intended customers. Financial aspects' theme has two sub-themes, (i) *revenue streams* which describes ways an MNO makes money through a variety of revenue flows such as subscription fees, asset leasing/renting, advertisement and partnership revenue share, and (ii) *cost structure* which sums up the monetary consequences of the means employed in the business model such as fixed cost, variable costs, CapEx and OpEx.

Responses from interview participants

Participant 1: The mobile operator's 5G network is still in the pre-commercial testing phase. Therefore, no new revenue streams or cost structures have been implemented for 5G. The operator expects current 4G payment systems and pricing strategies to remain in place during the initial commercialisation of 5G until the network matures enough to trigger changes in both revenue and cost models. Just like the current 4G network, additional 5G revenues and cost reductions will be achieved by sharing resources and infrastructure with other mobile operators.

Participant 2: Most 5G customers are contract based. The operator is trying to reach the low-income base by making 5G devices affordable by ensuring customers pay monthly, thereby accommodating prepaid customers. The introduction of 5G has increased revenue from various sources, but most of the increase is due to high usage of 5G services by both residential and commercial customers.

“We have seen new revenue from various sources. And maybe it’s more of usage. Now, most of our customers enjoy fast data speeds, largely due to the increasing fibre connections to most households. But it’s more of the usage that has increased.” – Participant 2

Input and indirect costs are major challenges when redesigning a business model's revenue schemes. This is because, despite the huge costs to the operator that is associated with providing 5G connectivity and services, customers want to pay the same prices they are used to, even cheaper. The introduction of 5G leads to changes in the cost structure of the business model through deployment costs associated with hardware equipment, spectrum acquisition and infrastructure management.

Participant 3: For the 5G network, no specific changes have been introduced in terms payment schemes or pricing strategies other than the current 4G scenarios. The operator simply converted all 4G users into 5G users. Therefore, the existing data packages and payment modes have remained the same, but only the user profile has been switched from 4G to 5G.

“For example, if a 4G data bundle cost, say, R89 for 1.0 GB, it will remain the same, but the user’s subscription profile will change from 4G to 5G once the SIM card is inserted into a 5G-capable device.” – Participant 3

The operator has observed that new 5G revenue streams are emerging through fixed wireless access (FWA) especially in areas where fibre penetration is very low or non-existent. Another new revenue stream observed is the sale of 5G capacity to enterprise businesses. One of the biggest challenges in reinventing the revenue scheme is convincing senior management of the viability of certain 5G features, just as with 4G.

“At the moment we are having a heated debate about where 5G should be deployed, how 5G should be deployed and what spectrum should be used. As far as revenue streams are concerned, they either come from the business side or the consumer side.” – Participant 3

The introduction of 5G has an impact on the cost structure of the business model. However, whether it is profitable or reduces costs depends on a number of different factors prevailing in a particular environment. For example, 5G is generally deployed using massive MIMO wherever possible, which automatically significantly increases deployment costs. When amortized by the operator, the costs are passed on to the customer, who is locked into longer but affordable contracts.

Participant 4: Most 5G customers are contract-based residential or commercial customers and the operator reaches them via affordable FWA using millimetre wave technology. This is one of the new revenue stream potentials being exploited. The other new source of revenue is the deployment of private 5G networks in the mining and manufacturing industries. The biggest challenge in reinventing revenue schemes for 5G is the uncertainties surrounding return on investment (RoI) in less mature African markets. In addition, the huge cost of 5G equipment from manufacturers and the expensive 5G spectrum pose major challenges that impact operators' RoI. The cost structure for mobile operators is often influenced by the introduction of 5G. Cost impacts can come from global economic volatility, such as: post Covid-19 effects, the ongoing war between Ukraine and Russia and the current Middle East conflict, which have resulted in unstable exchange rates, thereby impacting the cost of 5G devices, products and solutions.

Participant 5: Since the operator has not yet launched 5G networks, no new 5G payment schemes or pricing strategies have been introduced and no 5G-related revenue streams have emerged. Nevertheless, the operator believes that a key challenge in the rollout of 5G will be service monetization due to the high cost of data, the difficulty in assessing customer needs and the high cost of deployment due to the lack of flexible regulations and policies. Therefore, operators may have to pass on the costs to customers, resulting in higher service and product prices downstream. The introduction of 5G brings with it some changes in the cost structure of

mobile operators. This is because 5G technology increases operational costs due to the need for more internet data. Cost reduction can be achieved by advocating for lower costs of deploying 5G through sharing resources and infrastructure, ultimately allowing the benefits to be passed on to customers through the provision of affordable services.

Participant 6: As the operator has not yet launched 5G networks, no new 5G payment schemes or pricing strategies have been introduced and no 5G-related revenue streams have emerged. The challenges in redesigning revenue schemes are mainly related to return on investment (RoI) due to huge capital expenditures associated with exorbitant 5G spectrum prices from regulators and high 5G equipment prices from original equipment manufacturers (OEMs). Therefore, the mobile operator's cost structure changes due to the CapEx investments that have to be deferred.

Participant 7: Regarding payment schemes, the operator has developed contract pricing strategies for 5G data related to new service key performance indicators (KPIs) that were not previously available. With the introduction of 5G, only higher data pricing is being considered a new revenue stream, while all 4G revenue streams remain unchanged. Deployment of use cases and lack of product familiarity are the biggest challenges in redesigning operators' revenue schemes. This is largely because the deployment of 5G is done through experimentation to see if the market accepts the offering or to make adjustments if the market does not respond well. The cost structure in operators' business models consists of tower service companies offering higher rental, energy and security costs, thereby increasing OpEx. Additionally, 5G deployment involves higher CapEx compared to 4G networks.

Participant 8: Since the operator has not yet launched 5G networks, no new 5G payment systems or pricing strategies have been introduced and no 5G-related revenue streams have emerged. The introduction of 5G is leading to changes in the operator's cost structure as there is a shift in product offering from data packages (bundles) to capacity (speed). As a result, most operators are selling 5G services to their residential and business customers based on speed or capacity, unlike the 4G era which was more package focused.

Participant 9: 5G payment schemes are mostly postpaid plans and these are mainly corporate entities as 5G services remain unaffordable for most prepaid subscribers. New revenue streams which have opened up due to 5G include IoT applications in certain industries as well as the implementation of network slicing where different 5G service classes can be offered to different customers using the same physical infrastructure. Since the cost structure of a mobile operator can be impacted by the introduction of 5G, cost reduction can be achieved by implementing a set of diversified revenue streams.

Participant 10: Previously, pricing and charging strategies were mostly based on the size of the data packages. With the introduction of 5G, the charging schemes are unlimited in terms of data consumption volume but, limited only to data speeds or capacity. Since the mobile operator introduced 5G on its network, no new revenue streams have emerged. Therefore, the existing 4G revenue streams continue to apply to 5G. One of the biggest challenges in creating revenue streams is that the way products were previously priced and revenue channels created is not viable for 5G. Therefore, developing a new model for billing 5G services becomes challenging. The cost structure for 5G is high for both CapEx and OpEx. However, the use of new technologies such as IoT, network slicing, artificial intelligence and machine learning can reduce costs, especially operational costs for maintenance.

Summary analysis of the financial aspects theme

With respect to the financial aspects theme, most mobile operators in Africa are yet to commercialise their 5G services. Therefore, they have not established 5G revenue streams and cost structures. However, for a considerable number of operators that have deployed commercial 5G services, there were similarities between the interview feedback and the literature data regarding the financial aspects theme. New revenue streams have been created through the deployment of private 5G networks for industrial customers such as mining and manufacturing. In addition, the use of FWA for residential and commercial customers is another additional source of revenue for operators. This is consistent with the literature as both private 5G networks and fixed 5G broadband networks such as FWA have been extensively researched in industry and academia. To maximise their sales and earnings, some operators have

redesigned their payment schemes and pricing strategies, moving from selling data packages (bundles) to selling broadband capacity (speed) due to customer demand for end-to-end 5G solutions. From interview data and supported by the literature, it can also be observed that the introduction of 5G leads to changes in the cost structure of operators' business models. The costs associated with purchasing equipment, deploying network nodes and acquiring spectrum have a major impact on capital CapEx, while costs associated with network maintenance, rentals, energy supply and daily operations significantly impact operators' OpEx. Effective ways to minimize these costs and make 5G affordable for end users include: building a range of diversified revenue streams, implementing a revenue-sharing model with partners such as equipment manufacturers, sharing resources and infrastructure with other operators, and initially deploying 5G as a non-standalone configuration.

5.3.2 Formulation of a Conceptual Framework

The main themes obtained from the qualitative data analysis using the MAXQDA 24 software were categorised in terms of their characteristics and dimensions. The themes have been summarised to fit the components of the business model framework. After categorisation, the researcher formulated a series of prepositions representing the relationships between the themes. Table 5.3 presents the prepositional inventory for the business model for next-generation (5G and beyond) communications networks and mobile operators. The inventory serves as a mechanism for specifying prepositions to guide theory building and quantitative research to generalise findings from qualitative data analysis.

Table 5.3: Prepositional inventory for the business model conceptual framework

Supporting Themes	Preposition developed using Thematic Analysis Approach	Relevant Literature Review	Final construct for developing a conceptual model
Value Proposition (BM offerings), Customer Interface, Financial Aspects & Infrastructure Management	Infrastructure management (i.e., activities, partners, resources and enabling technologies) has direct effects on all the other three components of the conceptual BM framework (i.e., 5G service offering, customer interface and financial aspects)	(Rao & Prasad, 2016) (Frisanco, Tafertshofer, Lurin, & Ang, 2008)	Infrastructure Management
Value Proposition (BM offerings) & Infrastructure Management	The quality of the 5G services offered by a mobile operator is supported and impacted by the underlying infrastructure management (i.e., activities, partners, resources and enabling technologies). ¹	(G. Liu et al., 2020) (S. S. Yrjölä, Ahokangas, & Matinmikko-Blue, 2022) (Lehr, Queder, & Haucap, 2021)	5G Service Offerings
Infrastructure Management & Customer Interface	The management of infrastructure by a mobile operator impacts customer interface.	(Rao & Prasad, 2016) (Frisanco et al., 2008)	Customer Interface
Value Proposition (BM offerings) & Customer Interface	The performance and quality of 5G services has a relationship with customer interface of a mobile operator.	(Rao & Prasad, 2016)	
Customer Interface & Financial Aspects	The available customer interface has an impact on the financial position (financial aspects) of a mobile operator.	(Camps-Aragó, Delaere, & Ballon, 2019)	Financial Aspects
Infrastructure Management & Financial Aspects	The management of infrastructure impacts both the revenues and costs (financial aspects) of a mobile operator.	(Koratagere Anantha Kumar & Oughton, 2023)	
Value Proposition (BM offerings) & Financial Aspects	The performance of 5G services has an influence on the revenue returns or profits (financial aspects) of a mobile operator.	(S. S. Yrjölä et al., 2022)	

The findings on the relationships between different themes depicted in Table 5.3 above are summarised in form of the following prepositions.

P1 The quality of 5G services offered by a mobile operator is influenced by the underlying infrastructure management.

P2 The management of infrastructure by a mobile operator impacts customer interface.

P3 The performance and quality of 5G services has a relationship with customer interface of a mobile operator.

P4 The available customer interface has an impact on the financial aspects of a mobile operator.

P5 The management of infrastructure impacts the financial aspects of a mobile operator.

P6 The performance of 5G services has an influence on the financial aspects of a mobile operator.

5.3.3 Conceptual Framework and Hypotheses

Based on qualitative thematic analysis (Braun & Clarke, 2006) and identified variables, a conceptual framework representing business models for next-generation communication (5G) networks is proposed and illustrated in Figure 5.4. The researcher conducted further literature review to match the identified main themes with proposed variables and scales for developing of measuring instruments (Kuckartz & Rädiker, 2019).

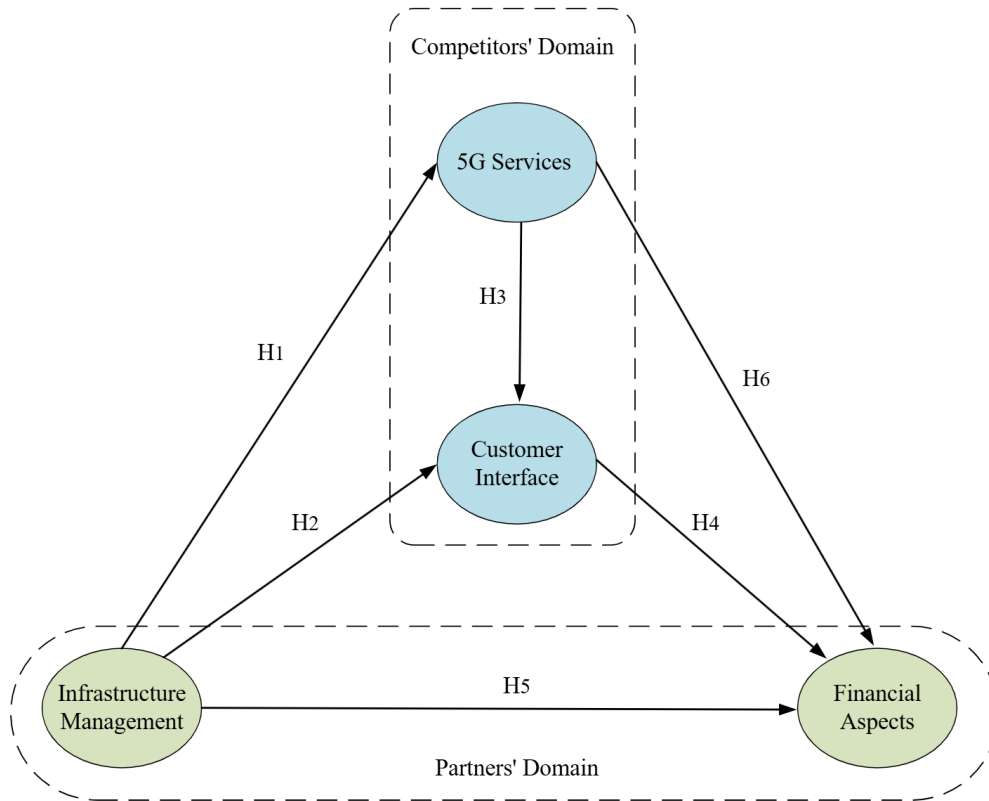


Figure 5.4: Formulated Conceptual framework

In formulating the research hypotheses related to the current study, two main domains were established: partners' domain and competitors' domain.

Partners' domain: These are entities with which a mobile operator has some business alliances to ensure that the proposed value is appropriately created and delivered to the intended customers. Partners' domain includes, original equipment manufacturers (OEMs), device manufacturers, infrastructure providers, and regulation and policy makers.

Competitors' domain: These are business entities who can offer the same or similar services to target customers of a mobile operator. These include over-the-top (OTT) content providers and other service providers.

Hypothesis

Based on the theoretical and empirical literature reviews, and the results of the qualitative analysis, the present research postulates the following hypotheses:

Hypothesis 1

There is a significant positive impact of Infrastructure Management (IM) on 5G Service Offerings (SO).

Hypothesis 2

There is a significant positive impact of Infrastructure Management (IM) on the Customer Interface (CI).

Hypothesis 3

There is a significant positive influence of 5G Service Offerings (SO) on the Customer Interface (CI).

Hypothesis 4

There is a significant positive influence of Customer Interface (CI) on the Financial Aspects (FA).

Hypothesis 5

There is a significant positive impact of Infrastructure Management (IM) on the Financial Aspects (FA).

Hypothesis 6

There is a significant positive influence of 5G Service Offerings (SO) on the Financial Aspects (FA).

5.4 PHASE 3: Quantitative Data Analysis – Statistical Analysis

This phase of data analysis focuses on quantitative analysis to validate the conceptual framework derived from the qualitative analysis. The quantitative analysis was conducted on 62 respondents across sub-Saharan Africa of various mobile network operators (MNOs) and demographic profiles. Data collected through online survey questionnaires were tested for reliability and reliability as well as path modelling statistics. The aim of the quantitative data analysis was to answer the following research question (*sub-question 3*):

How can the designed business model framework have a positive impact on the business viability and sustainability of mobile operators?

This section consists of two parts. In the first part, descriptive statistics are provided for both demographic data and the measurement instruments using SPSS software. The second part provides results for hypothesis testing using structural equation models (SEMs) to derive various coefficients using SmartPLS software.

5.4.1 Demographic Data Descriptive Findings

The descriptive results of the demographic data represent the sample characteristics, which include the sample response rate, the gender of the respondent, the position held in the company, the functional area of the company and years of experience in the mobile communications industry. SPSS software was used to clean data and conduct descriptive statistics. This is presented using frequency tables and bar-charts.

Sample response rate

A total of 102 questionnaires were distributed for the study. There were 71 (69.6%) responses. However, only 62 (60.8%) responses were found to be usable for data analysis. The summary of sample response rate is shown in Table 5.4.

Table 5.4: Sample response rate

Questionnaire distributed	102
Questionnaires returned	71
Usable questionnaires	62
Usable response rate	60.8%

Primary source

Study participants by gender

Demographic data results by gender reveal that more males 67.7% (42 out of 62) than females 32.3% (20 out of 62) were sampled overall. Table 5.5 and Figure 5.5 illustrate how the sample is distributed according to participants' gender.

Table 5.5: Gender of study participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	42	67.7	67.7	67.7
	Female	20	32.3	32.3	100
	Total	62	100	100	

Primary source

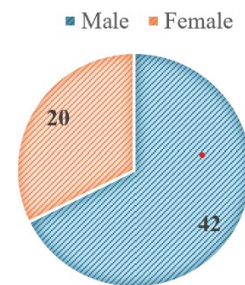


Figure 5.5: Gender graph

Study participants by position in the company

Most study participants are represented at middle-level management (32.3%) and junior/employee level (29.0%). A significant number of participants were senior managers (21.0%), while a few were top executives (12.9%). Table 5.6 and Figure 5.6 show the demographic distribution of participants by position in the company.

Table 5.6: Participants' positions in the company

		Frequency	Cumulative Frequency	Percent	Valid percent	Cumulative Percent
Valid	Top Executive	8	8	12.9	12.9	12.9
	Senior Manager	13	21	21.0	21.0	33.9
	Middle-level Manager	20	41	32.3	32.3	66.2
	Employee	18	59	29.0	29.0	95.2
	Others	3	62	4.8	4.8	100
	Total	62		100	100	

Primary source

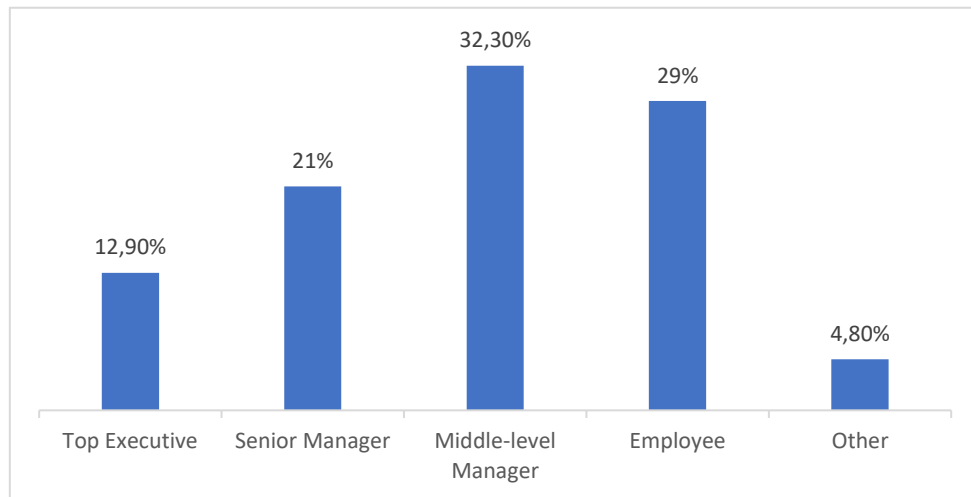


Figure 5.6: Participants' positions in the company

Study participants by functional area in the company

Responses by functional area within the company indicate that the majority of participants came from the networks/technical area (69.4%), followed by the information technology (IT) area (17.7%). Other functional areas such as finance, sales/marketing and logistics were hardly represented. Table 5.7 and Figure 5.7 show the demographic distribution of participants by functional area in the company.

Table 5.7: Participants' functional area in the company

		Frequency	Cumulative Frequency	Percent	Valid percent	Cumulative Percent
Valid	Networks/Technical	43	43	69.4	69.4	69.4
	Information Technology	11	54	17.7	17.7	87.1
	Finance	2	56	3.2	3.2	90.3
	Sales/Marketing	4	60	6.5	6.5	96.8
	Logistics	1	61	1.6	1.6	98.4
	Others	1	62	1.6	1.6	100
	Total	62		100	100	

Primary source

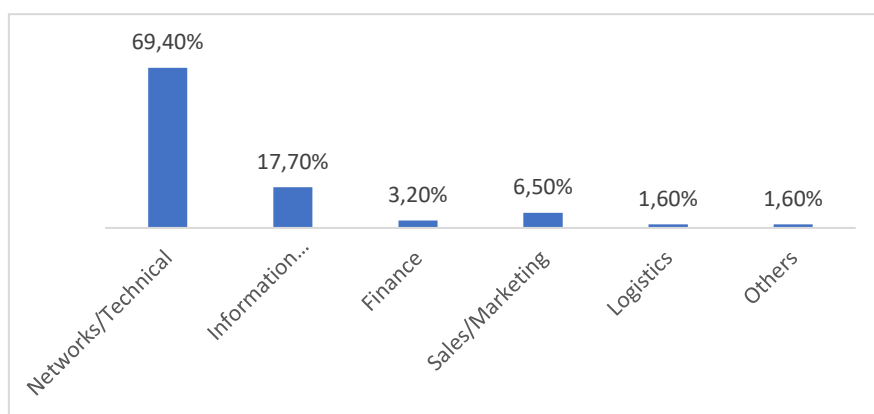


Figure 5.7: Participants' functional area in the company

Participants' years of experience in the mobile communications industry

The participants in the study stated their years of experience in the mobile communications industry. Sample data shows that the majority of participants had more than 10 years of experience (62.9%). Those with 6 to 10 years of experience accounted for 24.2%, while those with 1 to 5 years of experience accounted for 12.9% of the total sample response. Table 5.8 and Figure 5.8 summarise the sample response of years of experience in the mobile industry.

Table 5.8: Participants' years of experience in mobile industry

		Frequency	Cumulative Frequency	Percent	Valid percent	Cumulative Percent
Valid	1 – 5 years	8	8	12.9	12.9	12.9
	6 – 10 years	15	23	24.2	24.2	37.1
	Over 10 years	39	62	62.9	62.9	100
	Total	62		100	100	

Primary source

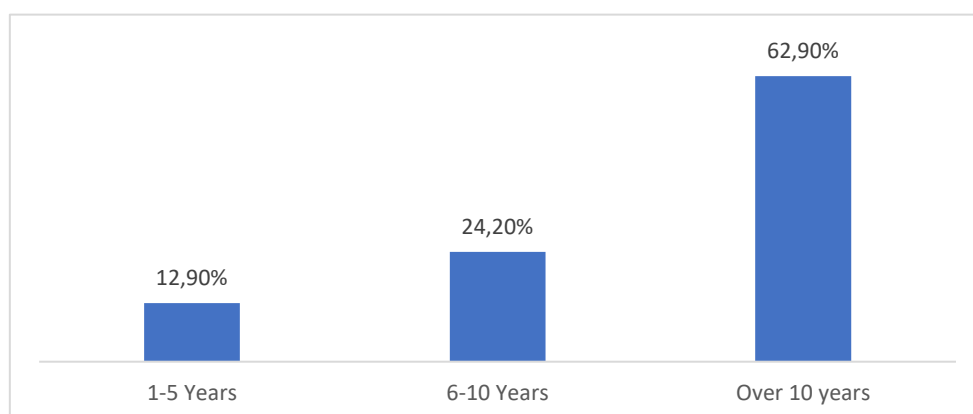


Figure 5.8: Participants' years of experience in mobile industry

5.4.2 Structural Equation Modelling Approach

Structural equation modelling (SEM) is widely used in many areas of quantitative business research (Sarstedt, Ringle, Smith, Reams, & Hair Jr, 2014). SEM is a popular multivariate technique used in scientific investigations to test and evaluate multivariate causal relationships. It differs from other modelling approaches in that it tests direct and indirect effects on assumed causal relationships (Fan et al., 2016). SEM is basically a framework that involves the simultaneous solution of systems of linear equations and includes techniques such as regression, factor analysis and path analysis (Beran & Violato, 2010).

Two popular methods dominate SEM in practice: covariance-based SEM (CB-SEM) and partial least squares SEM (PLS-SEM, also known as PLS path modelling) (Joseph F Hair Jr et al., 2021). CB-SEM is mainly used to estimate model parameters that minimise the differences between the observed sample covariance matrix (calculated before analysis) and the estimated covariance matrix after confirming the revised theoretical model (Ali et al., 2018). Therefore CB-SEM is used to confirm and reject theories by determining how well a model can estimate the covariance matrix (Basbeth, Muhammad, Bin, Mohd, & Hery, 2017). In contrast, PLS-SEM is used to maximise the variance explained in the dependent variables (Joe F Hair Jr, Matthews, Matthews, & Sarstedt, 2017). Basbeth et al. (2017) also adds that PLS-SEM is used for theory development by focusing on explaining variance in the dependent variables, estimating path coefficients, and maximising the R^2 values of the target construct to achieve the prediction objectives. Furthermore, Leguina (2015) claims that the fundamental difference between the two methods is that CB-SEM is based on the common factor model while PLS-SEM is based on the composite model.

Implementing PLS-SEM algorithms and techniques with SmartPLS software requires performing confirmatory factor analysis (CFA) and path analysis simultaneously (Memon et al., 2021). The function of CFA is to evaluate how well the latent variables are measured by the observed variables (Chen, Zhang, Liu, & Mo, 2012), while path analysis is to examine causal relationships between unobserved variables (Nusair & Hua, 2010). According to Joseph F Hair Jr et al. (2021), there are three things to consider to utilise the application of PLS-SEM in

qualitative data analysis: (1) research objectives, (2) data characteristics (3) model complexity and evaluation. Table 5.9 shows the characteristics of PLS-SEM applications and explains the reasons for using PLS-SEM as examined by (Basbeth et al., 2017).

Table 5.9: Characteristics of PLS-SEM applications (source: (Basbeth et al., 2017))

Research Objective	
Predictive Oriented	PLS-SEM is a variance-based SEM approach. It applies ordinary least squares (OLS) regression with the aim of estimating coefficients that maximize the R^2 values of the endogenous construct. Therefore, PLS-SEM is the preferred method for a predictive-oriented research objective, variance explanation and theory development. It provides R^2 values and indicates the significance of relationships between constructs.
Data characteristics	
Sample size	The minimum sample size should ensure that the results of statistical methods have sufficient statistical power and that the results of statistical methods are robust. PLS-SEM works efficiently with small sample sizes because it is based on ordinary least squares (OLS) properties.
Measurement scales	PLS-SEM works with all measurement scales: nominal, ordinal, interval, ratio scale and binary coded data with certain limitations.
Data Distribution	PLS-SEM does not require normal data distribution as it is a non-parametric statistical method. The advantage of PLS-SEM is that it can handle extremely abnormal data (e.g. high skewness).
Missing Data	Most missing data techniques (e.g. mean replacement, pairwise deletion) can be used for less than 5% missing data per indicator.
Model Complexity and Additional Analysis	
Model complexity	PLS-SEM processes many structural models or complex models and easily integrates reflective and formative measurement models.
Additional Analysis	Mediating and moderating impact analyses.

Below are some of the benefits of PLS-SEM that have been observed in the research community.

- SEM-PLS modelling approach has broad applicability in exploratory research with small sample size and when little is known about the relationships between theoretical variables (Wong, 2013).
- PLS-SEM is often used when dealing with complex models, limited sample sizes, and the need for prediction (Edeh, Lo, & Khojasteh, 2023).

- PLS-SEM can incorporate latent constructs into the analysis while accounting for measurement error in the estimation process (Leguina, 2015)
- PLS-SEM does not require normal data distribution as it is a nonparametric statistic, hence can handle extremely non-normal data (e.g., high levels of skewness) (Chin & Newsted, 1999).

5.4.3 PLS-SEM Analysis

When using the PLS-SEM approach, the research model is evaluated using a two-step process: measurement model and structural model (Joseph F Hair Jr et al., 2021). The measurement model specifies relationships between the constructs (i.e., latent variables) and the indicators (i.e., measured variables)(Joe F Hair, Sarstedt, Ringle, & Mena, 2012). The structural model indicates how the constructs relate to each other, with the order and location of the constructs based on the theory observed by the researcher (Joseph F Hair, Ringle, & Sarstedt, 2013). Latent variables that function only as independent variables are called exogenous latent variables, while latent variables that function only as dependent variables are called endogenous latent variables (Zhao, Lynch Jr, & Chen, 2010).

5.4.3.1 Measurement Model Evaluation

A reflective measurement model was used in this study. The measurement model has reflective indicators that can be viewed as representative samples of all possible indicators within the constructs (Kline, 1999). The direction of the arrows is from the construct to the indicators, illustrating the theory that constructs cause the measurement of the indicator variables (Joe F Hair Jr et al., 2017). Additionally, indicators in the reflective measurement model should be highly correlated and interchangeable (Basbeth et al., 2017). The criteria for evaluating the reflective measurement model include (1) internal consistency, (2) convergent validity, and (3) discriminant validity.

- **Internal consistency**

Internal consistency or reliability is a quality criterion of a construct that requires a high level of correlation between indicators of a particular construct (Janadari, Sri Ramalu, Wei, & Abdullah, 2016). Additionally, FHJR Joseph, Barry, Rolph, and Rolph (2010) emphasize that reliability refers to whether a variable or set of variables is consistent with what it is intended to measure. There are two common measures of construct reliability: Cronbach's alpha and composite reliability.

Cronbach alpha: A Cronbach alpha coefficient is used as a more conservative item measure and estimates the reliability of multiple item scales (Janadari et al., 2016). Therefore, it is used to assess the reliability of the scales in research questionnaires. The scale is reliable if the value of the Cronbach alpha coefficient is higher than 0.7 (Joe F Hair et al., 2012). Nevertheless, Nunnally (2014) states that the Cronbach alpha coefficient between 0.5 and 0.6 is also acceptable. The measurement is carried out using the following formula:

$$\alpha = \frac{N \times \bar{c}}{\bar{v} + (N - 1)\bar{c}}$$

where

N is the number of measured items,

$\bar{c}$ is the mean covariance between measured items,

$\bar{v}$ is the mean item variance

Composite Reliability (CR): The Composite Reliability Index (CR) is used to measure the internal reliability of the measuring instrument and is mainly concerned with individual reliabilities related to different outer loadings of the indicator variables (Sarstedt, Ringle, & Hair, 2021). According to Sarstedt et al. (2014), the acceptable composite reliability index should be greater than 0.7. However, Henseler and Sarstedt (2013) conclude that the cut-off value for composite reliability is identical to any reliability measure and a value between 0.6 and 0.7 is a good indicator of construct reliability. CR is measured using the following formula:

$$CR_{\eta} = (\sum \lambda_i)^2 / [(\sum \lambda_i)^2 + \sum \varepsilon_i]$$

where

λ_i is the completely standardised loading factor of the i th indicator,

ε_i is the variance of the error term for the i th indicator

- **Convergent validity**

Convergent validity is the extent to which a measure is positively correlated with an alternative measure of the same construct (Janadari et al., 2016). Schwab (2013) concludes that convergent validity fundamentally tests the correlations between scales in the same direction, with other measures of the same construct and therefore indicates the validity of the construct. Convergent diversity can be measured using either Average Value Extracted (AVE) or outer loading.

Average Value Extracted (AVE): AVE is the average variance between a construct and its measurements. It is defined as the grand mean value of the squared loadings of the indicators associated with a particular construct (the sum of the squared loadings divided by the number of indicators) (Joseph F Hair et al., 2013). An AVE of 0.5 or more means that the construct explains, on average, more than half of the variance of its indicators. Conversely, an AVE value of less than 0.5 indicates that more error remains in the items than the average variance explained by the constructs. According to Joseph F Hair et al. (2013), an AVE value equal to or greater than 0.5 is accepted. On the other hand, Fraering and Minor (2006) claim that the AVE must be greater than 0.4 for the construct to be considered reliable. The AVE is measured using the following formula:

$$AVE = \sum \lambda_i^2 / [\sum \lambda_i^2 + \sum \varepsilon_i]$$

where

λ_i is the completely standardised loading factor of the i th indicator,

ε_i is the variance of the error term for the i th indicator

Outer Loading: Convergent validity in the reflective measurement model can also be obtained by examining the outer loading of the indicators. High outer loadings on a construct indicate that the associated indicators have many similarities that are captured by the construct (F Joseph, Hult, Ringle, & Sarstedt, 2022). The magnitude of the outer loading is also commonly referred to as indicator reliability (F Joseph et al., 2022). The construct should explain at least 50% of the variance of each indicator, and the square of the outer loading represents how much variance is explained by the construct. The standardised outer loadings should be at least 0.708 (Basbeth et al., 2017; F Joseph et al., 2022).

● Discriminant Validity

Discriminant validity is the extent to which a construct truly differs from other constructs according to empirical standards (F Joseph et al., 2022). Therefore, establishing discriminant validity implies that a construct is unique and captures phenomena that are not represented by other constructs in the model (Joseph F Hair et al., 2013). The three common measures of discriminant validity are the Fornell-Larcker criterion, cross-loadings and the heterotrait-monotrait ratio (HTMT).

Fornell-Locker criterion: This method of assessing discriminant validity by Fornell and Larcker (1981) who proposed that discriminant validity is measured by examining the correlation between the measures of potentially overlapping constructs. The Fornell-Larcker criterion compares the square root of the AVE values with the latent variable correlations and, in particular, the square root of the AVE of each construct should be greater than its highest correlation with any other construct (F Joseph et al., 2022). The logic of the Fornell-Larcker method is based on the idea that a construct has greater variance with its associated indicators than with any other construct (F Joseph et al., 2022).

Cross-loadings: Measuring discriminant validity by cross-loading is done by correlating the individual values of the latent variable component with all other items (Chin & Newsted, 1999). According to this measurement criterion, the outer loading of an indicator on the associated construct should be greater than all of its cross-loadings (i.e., its correlation) on other constructs. (Ringle, Da Silva, & Bido, 2015). F Joseph et al. (2022) found that cross-loadings are unable to detect even severe violations of discriminant validity, resulting in reduced selection for applied research.

Heterotrait-Monotrait Ratio (HTMT): The third method for assessing discriminant validity is to use the Heterotrait-Monotrait Ratio (HTMT) developed by Henseler, Ringle, and Sarstedt (2015). According to Henseler et al. (2015), the HTMT criterion is defined as the average of the heterotrait-heteromethod correlations (i.e., the correlations of indicators across constructs measuring different phenomena) relative to the average of the monotrait-heteromethod correlations (i.e., the correlations of indicators within the same construct). Therefore, HTMT is

simply the ratio of the correlations between traits to the correlations within traits (F Joseph et al., 2022). An HTMT value above 0.9 indicates a lack of discriminant validity (Basbeth et al., 2017; Henseler et al., 2015).

Summary of Measurement Model Evaluation Results

(a) Measurement accuracy statistics

Based on the collected data, Table 5.10 below highlights the basic measurements of the mean, standard deviation (SD), variance along with factor loading, Cronbach alpha, Composite Reliability (CR) and Average Value Extracted (AVE).

Table 5.10: Scale accuracy analysis

Research Construct		Scale Item			Measurement Item			
		Mean	SD	Variance	Factor Loading	Cronbach alpha	CR	AVE
Infrastructure Management	IM2	10.71	1.046	1.095	0.811	0.715	0.787	0.649
	IM5	9.97	1.071	1.146	0.800			
5G Service Offerings	SO2	10.71	0.876	0.767	0.911	0.765	0.902	0.809
	SO3	10.44	0.958	0.917	0.888			
Customer Interface	CI1	10.89	0.960	0.921	0.832	0.836	0.892	0.678
	CI2	11.10	1.082	1.171	0.851			
	CI3	10.61	1.077	1.159	0.919			
	CI4	10.97	1.008	1.015	0.670			
Financial Aspects	FA1	10.68	1.052	1.107	0.505	0.798	0.857	0.508
	FA2	10.21	0.813	0.660	0.724			
	FA3	10.24	0.881	0.777	0.751			
	FA4	10.31	0.916	0.839	0.803			
	FA5	10.35	0.889	0.790	0.856			
	FA6	9.74	1.085	1.094	0.567			

SD= Standard Deviation, CR= Composite Reliability, AVE= Average Variance Extracted

** Scores: 1 – Strongly Disagree; 2 – Disagree; 3 – Neutral; 4 – Agree; 5 – Strongly Agree*

(b) Internal Consistency Confirmation

To check the internal consistency or reliability of the study, the Cronbach's alpha and composite reliability (CR) checks were conducted. This was done to ensure that there was a high level of correlation between indicators of a particular research construct (Janadari et al., 2016). With internal consistency tests, the researcher can deduce if a variable in question is consistent with the intended measurement (F Joseph et al., 2022).

Cronbach alpha test

A higher value of the Cronbach alpha coefficient indicates a higher reliability of the measurement scale (Janadari et al., 2016). From the results presented in Table 5.10: Scale accuracy analysis, the Cronbach's alpha coefficient values for the four research constructs: infrastructure management, 5G service offerings, customer interface and financial aspects are 0.715, 0.765, 0.836 and 0.798, respectively. As these values are above 0.6 as recommended by Nunnally (2014), validity is indicated. Therefore, the Cronbach's alpha results displayed in Table 5.10 validate the reliability of the measures used in the current research study.

Composite reliability (CR) test

The composite reliability test was conducted in order to determine the internal reliability of the measuring instrument as recommended by (Sarstedt et al., 2021; Sarstedt et al., 2014). The CR was calculated by means of the following formula: $CR_{\eta} = (\sum \lambda_i)^2 / [(\sum \lambda_i)^2 + \sum \varepsilon_i]$ and tabulated in Table 5.11.

Table 5.11: Composite reliability test estimates

Research Construct		Factor Loading	Composite Reliability		
			$(\sum \lambda_i)^2$	$\sum \epsilon_i$	CR
Infrastructure Management	IM2	0.811	2.595	0.702	0.787
	IM5	0.800			
5G Service Offerings	SO2	0.911	3.236	0.382	0.902
	SO3	0.888			
Customer Interface	CI1	0.832	10.706	1.290	0.892
	CI2	0.851			
	CI3	0.919			
	CI4	0.670			
Financial Aspects	FA1	0.505	4.208	0.702	0.857
	FA2	0.724			
	FA3	0.751			
	FA4	0.803			
	FA5	0.856			
	FA6	0.569			

For the composite reliability to be accepted, the CR index value should be greater than 0.7 (Sarstedt et al., 2014). From the results provided in Table 5.11, the CR index values for the four research constructs: infrastructure management, 5G service offerings, customer interface, and financial aspects are 0.787, 0.902, 0.892, and 0.857, respectively. Therefore, the results confirm the existence of internal reliability for all the research constructs of the study.

CR calculations:

Infrastructure Management

$$(\sum \lambda_i)^2 = (0.811 + 0.800)^2 = 2.595$$

$$\sum \epsilon_i = (1 - 0.811^2) + (1 - 0.800^2) = 0.702$$

$$CR = 2.595 / (2.595 + 0.702) = 0.787$$

5G Service Offerings

$$(\sum \lambda_i)^2 = (0.911 + 0.888)^2 = 3.236$$

$$\sum \varepsilon_i = (1 - 0.911^2) + (1 - 0.888^2) = 0.382$$

$$CR = 3.236 / (3.236 + 0.382) = 0.902$$

Customer Interface

$$(\sum \lambda_i)^2 = (0.832 + 0.851 + 0.919 + 0.670)^2 = 10.706$$

$$\sum \varepsilon_i = (1 - 0.832^2) + (1 - 0.851^2) + (1 - 0.919^2) + (1 - 0.670^2) = 1.290$$

$$CR = 10.707 / (10.707 + 1.290) = 0.892$$

Financial Aspects

$$(\sum \lambda_i)^2 = (0.505 + 0.724 + 0.751 + 0.803 + 0.856 + 0.569)^2 = 4.208$$

$$\sum \varepsilon_i = (1 - 0.505^2) + (1 - 0.724^2) + (1 - 0.751^2) + (1 - 0.803^2) + (1 - 0.856^2) + (1 - 0.569^2)$$

$$= 0.702$$

$$CR = 4.208 / (4.208 + 0.702) = 0.857$$

(c) Convergent Validity Confirmation

Convergent validity was examined to ascertain the extent to which an indicator positively correlates with an alternative indicator measure of the same construct. To examine the convergent validity, the average variance extracted (AVE) and factor (outer) loading test were performed.

Average Variance Extracted (AVE) Test

The AVE test results reflect the overall amount of variance in all indicators accounted for by a particular construct, and therefore indicate the average variance between a construct and its measurements (F Joseph et al., 2022). The AVE was calculated by means of the following formula: $AVE = \sum \lambda_i^2 / [\sum \lambda_i^2 + \sum \varepsilon_i]$ and tabulated in Table 5.12.

Table 5.12: Average Variance Extracted (AVE) test estimates

Research Construct		Factor Loading	Composite Reliability		
			$\sum \lambda_i^2$	$\sum \varepsilon_i$	AVE
Infrastructure Management	IM2	0.811	1.298	0.702	0.649
	IM5	0.800			
5G Service Offerings	SO2	0.911	1.618	0.382	0.809
	SO3	0.888			
Customer Interface	CI1	0.832	2.710	1.290	0.678
	CI2	0.851			
	CI3	0.919			
	CI4	0.670			
Financial Aspects	FA1	0.505	3.045	0.702	0.813
	FA2	0.724			
	FA3	0.751			
	FA4	0.803			
	FA5	0.856			
	FA6	0.569			

An AVE value of 0.5 or more is acceptable and confirms the convergent validity of a construct (Joseph F Hair et al., 2013). As shown in Table 5.12, the AVE test values of the four research constructs: infrastructure management, 5G service offerings, customer interface, and financial aspects are 0.649, 0.809, 0.678, and 0.813, respectively. Therefore, the results confirm the fulfilment of convergent validity for all the research constructs of the study.

AVE calculations:

Infrastructure Management

$$\sum \lambda_i^2 = (0.811^2 + 0.800^2) = 1.298$$

$$\sum \varepsilon_i = (1 - 0.811^2) + (1 - 0.800^2) = 0.702$$

$$AVE = 1.298 / (1.298 + 0.702) = 0.649$$

5G Service Offerings

$$\sum \lambda_i^2 = (0.911^2 + 0.888^2) = 1.618$$

$$\sum \varepsilon_i = (1 - 0.911^2) + (1 - 0.888^2) = 0.382$$

$$AVE = 1.618 / (1.618 + 0.382) = 0.809$$

Customer Interface

$$\sum \lambda_i^2 = (0.832^2 + 0.851^2 + 0.919^2 + 0.670^2) = 2.710$$

$$\sum \varepsilon_i = (1 - 0.832^2) + (1 - 0.851^2) + (1 - 0.919^2) + (1 - 0.670^2) = 1.290$$

$$AVE = 2.710 / (2.710 + 1.290) = 0.678$$

Financial Aspects

$$\sum \lambda_i^2 = (0.505^2 + 0.724^2 + 0.751^2 + 0.803^2 + 0.856^2 + 0.569^2) = 3.045$$

$$\sum \varepsilon_i = (1 - 0.505^2) + (1 - 0.724^2) + (1 - 0.751^2) + (1 - 0.803^2) + (1 - 0.856^2) + (1 - 0.569^2) = 0.702$$

$$AVE = 3.045 / (3.045 + 0.702) = 0.857$$

Factor Loading Test

Convergent validity can also be achieved by examining the factor loading (outer loading) of a construct's indicators with higher values suggesting that the associated indicators have many similarities that are captured by the construct (F Joseph et al., 2022). Table 5.13 shows the factor loading values associated with the four research constructs of the present study.

Table 5.13: Factor loading test results

Research Construct		Factor Loading
Infrastructure Management	IM2	0.811
	IM5	0.800
5G Service Offerings	SO2	0.911
	SO3	0.888
Customer Interface	CI1	0.832
	CI2	0.851
	CI3	0.919
	CI4	0.670
Financial Aspects	FA1	0.505
	FA2	0.724
	FA3	0.751
	FA4	0.803
	FA5	0.856
	FA6	0.569

According to Anderson and Gerbing (1988), a factor loading value above 0.5 entails fulfilment of convergent validity while F Joseph et al. (2022) emphasized that a value above 0.708 is even

better. Therefore, in the current study, all the indicators loaded well on their respective constructs as the factor loading values range from 0.505 to 0.919 as displayed in Table 5.13. The results confirm convergent validity for all indicators and the associated research constructs of the study.

(c) Discriminant Validity Confirmation

To establish the extent to which a construct uniquely varies from other constructs according to empirical standards, discriminant validity test was conducted as suggested by (F Joseph et al., 2022). The measurement criterion which was used to measure discriminant validity is the heterotrait-monotrait ratio (HTMT) as it is considered to be a more accurate approach when compared to other alternatives such as the Fornell-Larcker criterion or cross-loadings measurements (Basbeth et al., 2017; Joseph F Hair et al., 2013; Henseler et al., 2015)

The Heterotrait-monotrait ratio (HTMT) Test

To assess if there was discriminant validity, there was a need to check if the correlation between research constructs was less than 1.0 as recommended by (Joseph F Hair et al., 2013). An HTMT value above 0.9 indicates a lack of discriminant validity (Henseler et al., 2015). Table 5.14 shows the HTMT values between the research constructs. As can be observed from the table, all HTMT values are below the 0.9 threshold. Therefore, the results confirm the presence of discriminant validity of all research constructs of this study.

Table 5.14: The Heterotrait-monotrait ratio (HTMT) test results

	Infrastructure Management	5G Service Offerings	Customer Interface	Financial Aspects
Infrastructure Management				
5G Service Offerings	0.810			
Customer Interface	0.657	0.548		
Financial Aspects	0.605	0.440	0.849	

5.4.3.2 Structural Model Evaluation

Assessment of the structural model is the second phase of the PLS-SEM approach, which follows confirmation of the reliability and validity of the construct measures. The structural model and its latent variables represent the stable, theoretically and conceptually established contextual connection between observed data on the input and output sides of the PLS-SEM model (Janadari et al., 2016). Structural modelling is used to assess causal relationships between latent variables and includes multiple regression analysis and path analysis (Nusair & Hua, 2010). To evaluate the structural model, F Joseph et al. (2022) proposed the following five-stage assessments: (1) collinearity issues, (2) path coefficients, (3) coefficient of determination (R^2 value), (4) Effects size of f^2 and (5) predictive relevance (Q^2).

- **Collinearity Issues**

Collinearity issues occur when two or more independent variables are highly correlated with each other (Janadari et al., 2016). A related measure of collinearity is the Variance Inflation Factor (VIF) (Basbeth et al., 2017). Basbeth et al. (2017) also adds that to assess collinearity issues, the VIF values of all predictor constructs in the structural model must be examined. A common value of problematic collinearity may exist if the VIF coefficient is higher than 4 (Janadari et al., 2016), while Diamantopoulos and Siguaw (2006) claim that a VIF value of 3.3 or higher indicates a potential collinearity problem. On the other hand, F Joseph et al. (2022) emphasize that the VIF values in the predictor constructs should be below 5 and preferably below a value of 3 to ensure that collinearity does not have a significant impact on the structural model estimates.

- **Path coefficients**

PLS path modelling uses the bootstrapping technique to test the significance of all path coefficients (Chin, 2010). Efron and Tibshirani (1994) describe bootstrapping as a non-parametric sampling technique that involves repeated random sampling with replacement by the original sample. The path coefficients represent the hypothesised relationships connecting the constructs and help the researcher understand the strength of the relationship between two latent variables (Rahi, 2017). Path coefficients have standardised values approximately between

-1 and +1, with values close to +1 representing a strong positive relationship that is usually statistically significant (Basbeth et al., 2017). When the value of the path coefficient is very low or close to 0, they are usually not significantly different from zero (Basbeth et al., 2017). According to (Rahi, 2017), the path coefficient should reach at least the significance level of 0.05. Furthermore, F Joseph et al. (2022) found that the critical values for significance in the two-tailed test with an error probability of 1 percent ($\alpha=0.01$) and 5 percent ($\alpha=0.05$) are 2.54 and 1.96, respectively. Conversely, the critical value for the significance level of 1 percent ($\alpha=0.01$) and 5 percent ($\alpha=0.05$) in the one-tailed test is 2.33 and 1.645, respectively (F Joseph et al., 2022).

- **Coefficient of determination (R^2 value)**

PLS-SEM analysis evaluates the predictive power of a particular model or construct and determines the standard path coefficient of each relationship between exogenous and endogenous variables using the coefficient of determination (R^2) values of the endogenous variables (Janadari et al., 2016). The coefficient represents the amount of variance in the endogenous constructs explained by all associated exogenous constructs and is calculated as the squared correlation between the actual and predicted value of a given endogenous construct (Basbeth et al., 2017; F Joseph et al., 2022). The R^2 value ranges from 0 to 1, with a higher value indicating higher prediction accuracy (Basbeth et al., 2017). Joe F Hair, Ringle, and Sarstedt (2011) generally consider R^2 values of 0.75, 0.5, and 0.25 for endogenous latent variables to be significant, moderate, and weak, respectively.

- **Effects size of f^2**

The purpose of evaluating the effect size of f^2 is to assess whether exogenous constructs have a significant influence on endogenous constructs (Janadari et al., 2016). The effect size of f^2 can be used to assess whether the omitted construct of the structural model has a significant impact on the endogenous constructs. It is calculated as follows:

$$f^2 = \frac{R^2_{\text{included}} - R^2_{\text{excluded}}}{1 - R^2_{\text{included}}}$$

Here, (R^2 included) and (R^2 excluded) mean the R^2 values of the endogenous latent variables when a selected exogenous variable is included or excluded from the structural model. As a guideline from Cohen (2013), f^2 values of 0.35, 0.15 and 0.02 represent significant, medium and small effect sizes, respectively, while f^2 values below 0.02 indicate no effect.

- **Predictive relevance (Q^2)**

F Joseph et al. (2022) stated that one of the purposes of using PLS-SEM is prediction, so the researcher needs to specify the predictive relevance (Q^2) of the model. The Q^2 represents a measure of how well observed values are reconstructed by the model and its parameters. The Q^2 of the structural model can be evaluated using the non-parametric Stone-Geisser test (Geisser, 1975; F Joseph et al., 2022). The Q^2 value is calculated using the blindfolding method proposed by (Geisser, 1975). Ramayah, Cheah, Chuah, Ting, and Memon (2018) describe the blindfolding method as a resampling technique that systematically deletes and predicts each data point of the indicators in the reflective measurement model of the endogenous construct. Before performing the blindfolding procedure, the omission distance (D) must be selected to any value between 5 and 12 (Chin, 2009). According to Joseph F Hair et al. (2013), Q^2 evaluates not only the values of the model but also the parameter estimates of the model. The Q^2 values greater than zero for a given reflective endogenous construct indicate the predictive relevance of the path model for a given dependent construct (Basbeth et al., 2017).

Summary of Structural Model Evaluation Results

Collinearity Issues Test

Collinearity issues, which arise when two or more independent constructs are highly correlated, were tested using variance inflation factor (VIF) coefficients (Basbeth et al., 2017; Janadari et al., 2016). The relationships of the research constructs and the corresponding VIF coefficient results are shown in Table 5.15. The literature claims that VIF coefficients above 4.0 (Janadari et al., 2016) or above 3.3 (Diamantopoulos & Siguaw, 2006) indicate potential collinearity issues. As shown in Table 5.15, the VIF coefficients range between 1.000 and 1.525, indicating that there are no collinearity issues between the research constructs in the current study.

Table 5.15: Collinearity issues test (VIF coefficients)

Constructs' Relationships	VIF Coefficient
Infrastructure Management => 5G Service Offerings	1.000
Infrastructure Management => Customer Interface	1.409
Infrastructure Management => Financial Aspects	1.494
5G Service Offerings => Customer Interface	1.409
5G Service Offerings => Financial Aspects	1.525
Customer Interface => Financial Aspects	1.308

Path Coefficient Test

Path coefficients are evaluated for their relevance and significance within the structural model. Testing path significance requires the application of bootstrapping routing using the percentile method, with outcome testing and reporting based on the 95% bootstrap confidence interval (F Joseph et al., 2022). Table 5.16 shows the significance results of the path coefficient with the associated parameters: *t*-values, *p*-values, 95% confidence intervals and the standard deviation. According to F Joseph et al. (2022), *p*-values below 0.05 and *t*-values above 1.96 indicate path significance and a strong relationship between two variables.

Table 5.16: Path coefficient and path significance test results

	Path Coefficient	Standard Deviation	<i>t</i> - Values	<i>p</i> -Values	95% Confidence Intervals	Significance (<i>p</i> < 0.05)
5G Service Offerings => Customer Interface	0.297	0.144	2.063	0.042	[0.026, 0.502]	Yes
5G Service Offerings=> Financial Aspects	0.055	0.135	0.405	0.686	[-0.209, 0.251]	No
Customer Interface => Financial Aspects	0.678	0.084	8.110	0.000	[0.511, 0.812]	Yes
Infrastructure Management => 5G Service Offerings	0.539	0.071	7.537	0.000	[0.433, 0.696]	Yes
Infrastructure Management => Customer Interface	0.255	0.115	2.227	0.028	[0.067, 0.473]	Yes
Infrastructure Management => Financial Aspects	0.059	0.12	0.491	0.624	[-0.179, 0.271]	No

Note. *p* = Probability and *t* = Test statistics

Coefficient of Determination (R^2) Test

The coefficient of determination (R^2) values were evaluated to determine the standard path coefficient of each relationship between exogenous and endogenous variables within the structural model (Janadari et al., 2016). In the current study, the exogenous variable was Infrastructure Management, while the endogenous variables were: 5G Service Offerings, Customer Interface and Financial Aspects. Table 5.17 shows the R^2 values of the current study. From the results and according to the observations of F Joseph et al. (2022), Financial Aspect (R^2 value: 0.535) has a moderately strong path significance with Infrastructure Management, while 5G Service Offerings (R^2 value: 0.290) and Customer Interface (R^2 value: 0.235) both seem to have a weak path significance with Infrastructure Management.

Table 5.17: Coefficient of determination (R^2) test results

Endogenous variable	R-square	R-square adjusted
5G Service Offerings	0.290	0.279
Customer Interface	0.235	0.209
Financial Aspects	0.535	0.511

Results of the effect size of f^2

The evaluation of the effect size of f^2 was conducted to assess whether the exogenous construct (Infrastructure Management) has a significant influence on the endogenous constructs (5G Service Offerings, Customer Interface and Financial Aspects). The literature asserts that f^2 values of 0.35, 0.15, and 0.02 represent significant, moderate, and small effect sizes, respectively, while f^2 values below 0.02 indicate no effect. Table 5.18 shows the evaluation results of the f^2 values and the effect sizes of f^2 .

Table 5.18: Results of the effect size of f^2 test

Constructs' Path	f-square	Size Effect
5G Service Offerings => Customer Interface	0.082	Medium
5G Service Offerings => Financial Aspects	0.004	No effect
Customer Interface => Financial Aspects	0.755	Significant
Infrastructure Management => 5G Service Offerings	0.409	Significant
Infrastructure Management => Customer Interface	0.060	Medium
Infrastructure Management => Financial Aspects	0.005	No effect

Predictive Relevance (Q^2) Test

Predictive relevance (Q^2) measures whether the structural model has predictive relevance or not and only applies to endogenous constructs (F Joseph et al., 2022). Q^2 values above zero indicate that all values are well reconstructed and the model has predictive relevance (F Joseph et al., 2022). Furthermore, Q^2 values of 0.02, 0.15, and 0.35 indicate weak, moderate, and strong levels of predictive relevance of each effect (Joseph F Hair et al., 2013). Table 5.19 shows the results of predictive relevance with an omission distance of 7, which is between 5 and 12 as recommended by (Chin, 2009). The results show that all Q^2 values are greater than zero and have moderate predictive relevance for all endogenous constructs in the current study.

Table 5.19: Results of predictive relevance (Q^2) test

Endogenous Construct	Q^2 predict	Degree of Predictive Relevance
5G Service Offerings	0.255	Moderate
Customer Interface	0.140	Moderate
Financial Aspects	0.100	Moderate

5.4.3.3 Original and Final PLS-SEM Models

Before evaluating the measurement and structural models, the original model shown in Figure 5.9 had 20 measurement items in the measurement instruments. These consisted of 5 items for the “Infrastructure Management” construct, 4 items for the “5G Service Offerings” construct, 4 items for the Customer Interface construct and 7 items for the “Financial Aspects” construct. However, when analysing these measurement items, the researcher found that some items were very close and similar to each other. Such items were removed, leaving a total of 14 items in the final model shown in Figure 5.10. Measurement items removed included 3 from the “Infrastructure Management” construct, 2 from the “5G Service Offerings” construct and 1 from the “Financial Aspects” construct.

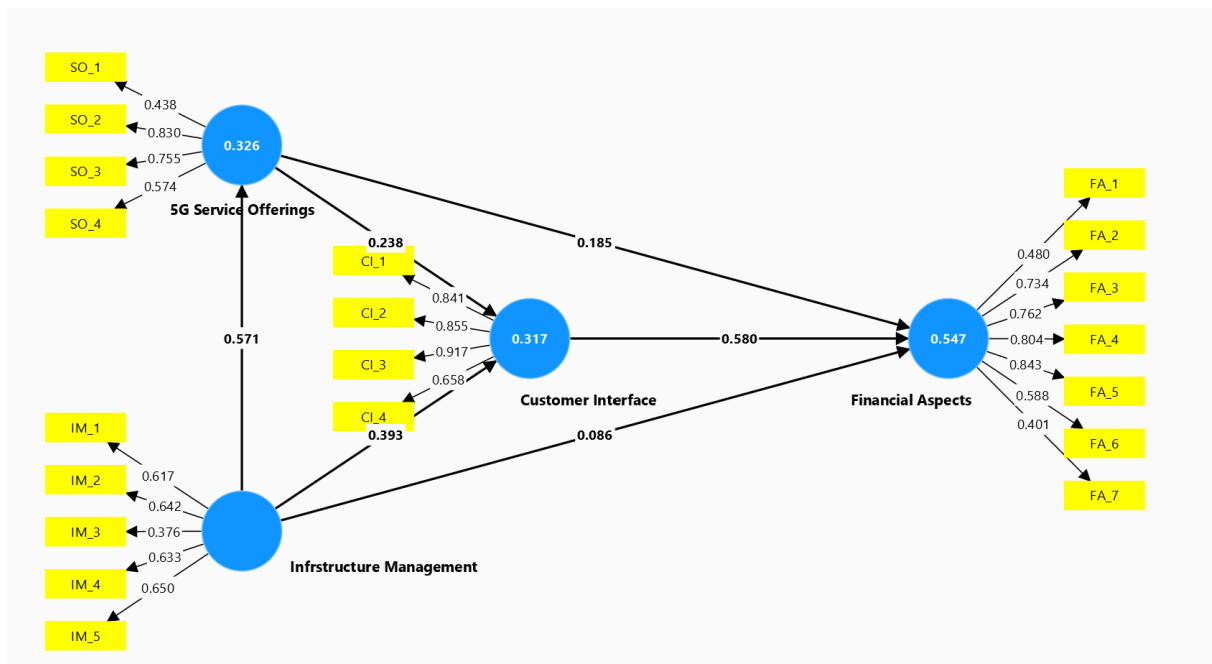


Figure 5.9: Original PLS-SEM Model

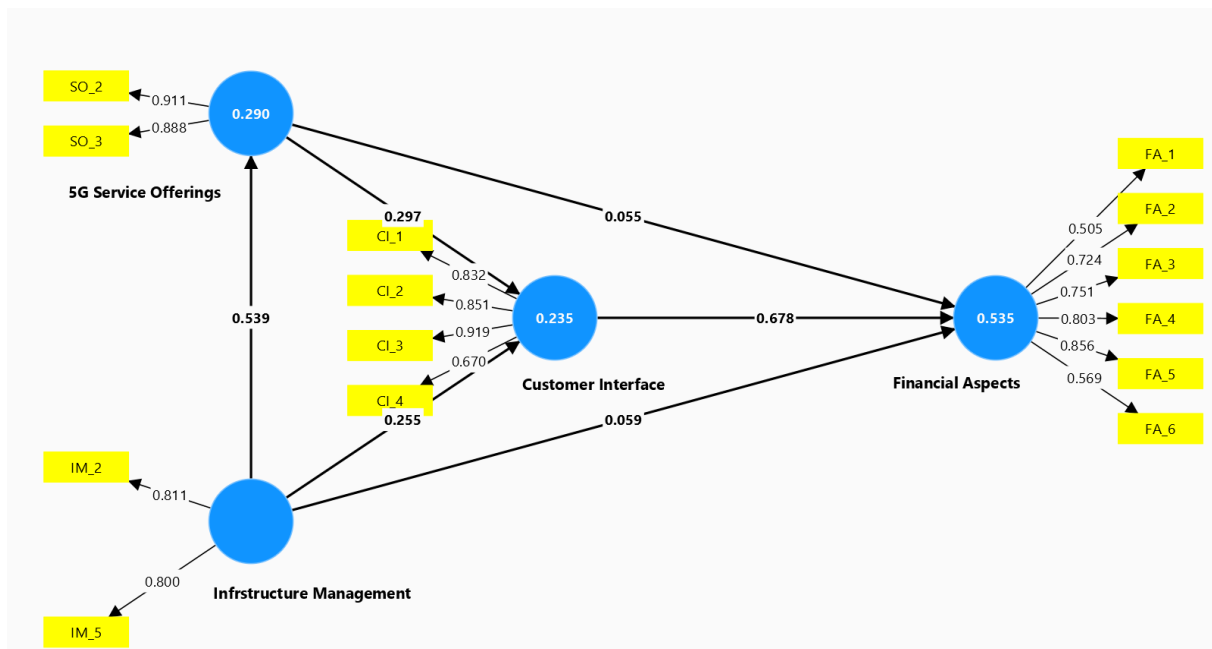


Figure 5.10: Final PLS-SEM Model

5.4.3.4 Hypothesis Testing

After the assessment of the measurement and structural models of the PLS-SEM analysis was completed, the researcher examined the relationships between research constructs through path analysis and hypothesis testing. Nusair and Hua (2010) noted that PL-SEM asserts that certain research constructs directly or indirectly influence certain other research constructs within the model, leading to estimation results that represent how these constructs are related.

When testing hypotheses, path coefficients (β) reflect the nature and strength of the relationships between variables: the higher the β value, the stronger the relationship. To determine whether the hypotheses are supported or not, the β -values, p -values and t -values are analysed within a 95% confidence interval (F Joseph et al., 2022). For the hypothesis to be supported, the following conditions must be met: p -value < 0.05 , t -value > 1.96 and 95% confidence interval. Table 5.20 shows the hypothesis testing results of the current study.

Table 5.20: Hypothesis testing results

Hypothesis & Path	Path Coefficient (β)	t - Values	p -Values	95% Confidence Intervals	Significance ($p < 0.05$)	Test Results
H1: Infrastructure Management => 5G Service Offerings	0.539	7.537	0.000	[0.433, 0.696]	Yes	Supported
H2: Infrastructure Management => Customer Interface	0.255	2.227	0.028	[0.067, 0.473]	Yes	Supported
H3: 5G Service Offerings => Customer Interface	0.297	2.063	0.042	[0.026, 0.502]	Yes	Supported
H4: Customer Interface => Financial Aspects	0.678	8.110	0.000	[0.511, 0.812]	Yes	Supported
H5: Infrastructure Management => Financial Aspects	0.059	0.491	0.624	[-0.179, 0.271]	No	Not supported
H6: 5G Service Offerings => Financial Aspects	0.055	0.405	0.686	[-0.209, 0.251]	No	Not Supported

Note. β = Path coefficient, p = Probability and t = Test statistics

From the results of Table 5.20, four of the six hypotheses are significant and supported. Further analysis is carried out as follows:

H1: There is a significant positive impact of Infrastructure Management (IM) on 5G Service Offerings (SO).

H1 evaluates whether Infrastructure Management significantly and positively affects 5G Service Offerings. The results revealed that Infrastructure Management has a significant and positive impact on 5G Service Offerings ($\beta = 0.539$, $t = 7.537$, $p < 0.05$). Hence H1 was supported.

H2: There is a significant positive impact of Infrastructure Management (IM) on the Customer Interface (CI).

H2 evaluates whether Infrastructure Management significantly and positively affects Customer Interface. The results revealed that Infrastructure Management has a significant and positive impact on Customer Interface ($\beta = 0.255$, $t = 2.227$, $p < 0.05$). Hence H2 was supported.

H3: There is a significant positive influence of 5G Service Offerings (SO) on Customer Interface (CI).

H3 evaluates whether 5G Service Offerings significantly and positively affects Customer Interface. The results revealed that 5G Service Offerings has a significant and positive influence on Customer Interface ($\beta = 0.297$, $t = 2.063$, $p < 0.05$). Hence H3 was supported.

H4: There is a significant positive influence of Customer Interface (CI) on the Financial Aspects (FA).

H4 evaluates whether Customer Interface significantly and positively affects the Financial Aspects. The results revealed that Customer Interface has a significant and positive impact on the Financial Aspects ($\beta = 0.678$, $t = 8.110$, $p < 0.05$). Hence H4 was supported.

H5: There is a significant positive impact of Infrastructure Management (IM) on the Financial Aspects (FA).

H5 evaluates whether Infrastructure Management significantly and positively affects the Financial Aspects. The results revealed that Infrastructure Management has an insignificant impact on the Financial Aspects ($\beta = 0.059$, $t = 0.491$, $p > 0.05$). Hence, H5 was not supported.

H6: There is a significant positive influence of 5G Service Offerings (SO) on the Financial Aspects (FA).

H6 evaluates whether 5G Service Offerings significantly and positively affect the Financial Aspects. The results revealed that 5G Service Offerings have an insignificant impact on the Financial Aspects ($\beta = 0.055$, $t = 0.405$, $p > 0.05$). Hence, H6 was not supported.

5.5 Chapter Summary

This chapter provided the data analysis and research findings of the study. The chapter was divided into three phases. Phase 1 presented the qualitative data analysis based on case study approach with the aim of examining the challenges and constraints of existing business models of mobile operators. Reflexive thematic data analysis was conducted and the emerging themes and sub-themes revealed that existing business models face numerous challenges due to internal factors (occurring within a particular MNO organisation), external factors (occurring from outside the boundaries of the MNO organisation), or a hybrid of both.

In Phase 2, a conceptual business model framework was developed using the themes that emerged from the reflexive thematic data analysis. The four main themes obtained were used to develop the four research constructs of the conceptual framework: Infrastructure Management, 5G Service Offerings, Customer Interface and Financial Aspects. Hypotheses were formulated to determine the strength and significance of relationships between constructs.

In Phase 3, qualitative data analysis was conducted to test the hypotheses developed in Phase 2. This was done using the PSL-SEM analysis approach. Of the six hypothesised relationships, four were found to be significantly supported while two were not supported. In the next chapter, the research findings and results are discussed and key insights are provided.

CHAPTER 6: DISCUSSION OF RESEARCH RESULTS

6.1 Introduction

This chapter presents and discusses the main findings of the research study. In addition, the chapter is considered Phase 4 of the present exploratory sequential mixed-methods research and serves to interpret and discuss the results of the first three phases: Phase 1 (qualitative research), Phase 2 (conceptual framework design) and Phase 3 (quantitative research). The results are discussed with reference to theory and existing literature.

The primary objective of this research study was to design a viable business model framework that mobile operators in Africa can adopt in deploying next-generation communication networks. The secondary objectives included (1) exploring the factors that limit existing business models for mobile operators in facilitating next-generation communications networks, (2) developing a conceptual business model framework for next-generation communication networks, and (3) evaluating the conceptual business model framework for the business viability of mobile operators. The research objectives are achieved by answering the research questions. Accordingly, the data analysis findings investigate the research questions that correlate with the research gap in the literature.

According to the research objectives, this chapter is divided into three main sections: (1) Challenges and constraints of existing business models for mobile operators; (2) Components of the conceptual business model framework; and (3) Statistical research results.

6.2 Challenges and constraints of existing business models for mobile operators

Traditional business models for mobile operators have been market-driven rather than technology-driven. This is primarily because the transition from 2G/3G to 4G represented an evolutionary development rather than a technological shift within the mobile industry (Banda et al., 2022a). Additionally, providing voice services instead of data services is a major source

of revenue for most operators in Africa (Rao & Prasad, 2016). Some of the existing business models before the introduction of 5G networks were outsourced and managed services business models, mobile virtual network operator (MVNO) business models, new market acquisition business models, mobile broadband (MBB) business models, and integrated WLAN-cellular networks business models (Ballon, 2004; Dhir et al., 2020; Obiodu, 2019; Rao & Prasad, 2016). However, these business models have not been able to successfully support the emerging 5G networks due to the disruptive nature of the underlying multi-technology requirements of these networks (Rao & Prasad, 2016). Furthermore, the socio-economic challenges facing Africa have negatively impacted the rapid deployment and adoption of 5G on the continent.

In analysing the challenges and constraints for existing business models for mobile operators, the current study aimed at addressing the following research question:

What factors limit existing business models in enabling next-generation communication networks?

To address the above research question, qualitative data analysis was conducted in MAXQDA24 software (Verbi, 2021) using reflexive thematic analysis (Braun & Clarke, 2019). The main theme that emerged was “*Existing MNOs’ business model challenges and constraints*” and the supporting sub-themes were “*Internal factors*” and “*External factors.*” Internal factors are the challenges and constraints that arise within a specific MNO organisation, while external factors refer to the challenges and constraints that exist outside the boundaries of a particular MNO organisation. It should be noted that some challenges and constraints can be considered as both internal and external factors. The challenges and constraints of existing business models for mobile operators were summarised in Table 5.2 of the previous chapter.

6.2.1 Internal Factors

- *High deployment and operating costs*

The deployment of 5G and its use cases are capital intensive because during network integration, many network nodes need to be replaced or upgraded before the full potential of

5G can be realised. This is a major challenge in the African market where most mobile operators are price sensitive. Furthermore, the investment capital in 5G is substantially high because the equipment and service solutions are significantly more expensive compared to the previous 4G and 3G networks. Since deployment costs are associated with the capital injection, this represents a major challenge, particularly for state-owned operators where capital is not easily accessible. In addition, the challenge of 5G as a new technology is that mobile operators will face high costs of introducing 5G as some equipment manufacturers sell their products and solutions at extremely high prices compared to the previous 4G and 3G technologies. Finally, most operators in Africa incur higher operating costs due to equipment theft, unstable power supply and other socio-economic challenges. Therefore, the high deployment and operational costs faced by mobile operators have a significant impact on their cost structures.

- *Low 5G skills and competences*

As an emerging network technology, the deployment and adoption of 5G requires the cultivation and development of new skills and capabilities within MNO organisations. However, most MNOs face the internal challenge that their employees have inadequate technical skills and competencies for 5G. This is due to low human development indices (HDIs) in most African countries and low investment in research and development by most operators (Adimula et al., 2020; K Okeleke et al., 2019). The low 5G skills and competencies of MNOs' employees significantly impact the key competencies that represent the sub-component of the business model under the infrastructure management component. 5G skills and competencies can be enhanced through partnerships and exchange programs between African operators and their counterparts in developed markets. Therefore, for African operators to rapidly deploy 5G networks, it would be appropriate to consider deploying less advanced stages via secondary innovation suggested by (Q. Xu & Wu, 1991). This will enable African operators to implement 5G cost-effectively within a short period of time.

- *MNOs' readiness issues*

The disruptive nature of 5G for established business models presents mobile operators with a major challenge. Therefore, the lack of preparation and reluctance to embrace the disruptive

nature of 5G without compromising the interests of key stakeholders remains one of the biggest challenges for mobile operators. An MNO's readiness due to lack of preparation or improper strategic planning can significantly impact the key activities of the business model's infrastructure management. Therefore, to remain competitive and contribute to the growth of emerging 5G networks, operators should have the flexibility to rethink their current business model.

- *Inaccurate network planning and dimensioning*

An incorrect approach to network planning and dimensioning by the MNO could lead to one of these two internal challenges: (1) the deployed base stations can hardly transmit mobile traffic and therefore generate only minimal revenue, which affects the revenue model of the business model; or (2) the deployed base stations carry overwhelmingly high mobile traffic and are therefore congested resulting in customer service dissatisfaction, which impacts the customer interface component of the business model. To address such challenges, the business model should consider incorporating scientific principles in network planning and dimensioning.

6.2.2 External Factors

- *Indefinite regulatory frameworks*

Africa's tendency to lag behind in technological advancement can to some extent be attributed to the lack of clearly defined and supportive regulatory frameworks (Suryanegara, 2016). Since the standardisation of 5G, which was followed by mass global rollout, most African countries have not established the necessary policies and regulations that would govern the deployment and adoption of these emerging technologies (Obiodu, 2019). Therefore, the regulatory uncertainties surrounding the deployment of 5G and underlying technologies such as cloud computing, edge computing, IoT, artificial intelligence and machine learning present challenges that extend beyond the boundaries of specific mobile operators. Uncertain regulatory frameworks have a huge impact on the key partnerships (part of infrastructure management) subcomponent of the business model framework, as policymakers and regulators forge strategic partnership with mobile operators (Banda et al., 2022a).

- *Low fibre penetration*

Fibre infrastructure, which predominantly supports the 5G transport network, has low penetration on the African continent (Handforth, 2019). Low fibre penetration significantly impacts the infrastructure management component of the business model framework (DotEcon & Axon, 2018). In addition, the skewed socio-economic imbalance in many African countries leads mobile operators to target wealthy suburbs where fibre infrastructure is available, while ignoring the underdeveloped rural outskirts where fibre infrastructure is almost non-existent. Therefore, limited transmission resources due to low fibre penetration pose a major challenge for most African operators in reinventing their business models in the 5G era.

- *Unreliable and limited power supply*

The energy consumption of 5G hardware equipment is relatively higher than that of previous technologies such as 3G and 4G (ITU-R, 2015). Most Sub-Saharan African countries have been experienced energy deficits over the years, mainly due to industrialisation, urbanisation and population explosion (Kaseke & Hosking, 2013). Moreover Kaseke and Hosking (2013) observed that most rural places in Africa have no electricity at all. The unreliable and limited power supply has resulted in increased operating expenditure (OpEx) for operators as fuel-based generators and expensive batteries are used as backup power sources (K Okeleke et al., 2019). This ultimately has a significant impacts on the cost structures of operators' existing business models (DotEcon & Axon, 2018).

- *Limited spectrum resources*

The limited spectrum availability poses major challenges for new entrants to the mobile communications market, such as micro-operators and private networks that require their own business models (Ahokangas et al., 2019). Regulators and policymakers should closely monitor the allocation and use of limited spectrum resources to ensure that the dominance of incumbent operators is not maintained (Taheribakhsh et al., 2020). Therefore, to meet users' growing and varying demand for services, dynamic and shared spectrum allocation mechanisms should be implemented between traditional mobile operators and new entrants (Mekuria & Mfupe, 2019). As a key resource component of infrastructure management, efficient spectrum allocation and utilisation is crucial for the viability of operators' business models. Regulatory authorities must

therefore ensure in advance that relevant frequencies are retained for telecommunications players. This will avoid delays in the auction process due to disagreements between the industry and the regulator.

- *Exorbitant spectrum prices and licence fees*

The acquisition of spectrum resources and operating licences by operators remains prohibitively expensive due to the enormous prices and fees charged by most regulators in Africa (K Okeleke et al., 2019). Furthermore, spectrum prices and operating licence fees in Africa are largely determined by regulations and policies aimed at maximising revenues for communication regulators and policymakers (Agubor et al., 2021). This may lead to lower investments by operators in the mobile sector and thus in higher service prices for end users. The exorbitant spectrum prices and licence fees have a drastic impact on the operators' cost structures and business models (DotEcon & Axon, 2018). To this end, regulators in Africa need to make policy changes such as allocating relevant spectrum and reducing tariffs to enable faster rollout of 5G.

- *Challenges from over-the-top (OTT) service applications*

The emergence of over-the-top (OTT) service applications (e.g., Facebook and WhatsApp) is impacting the mobile operators' business ecosystem as OTT players can offer these services without owning, leasing or operating the network infrastructure (Rao & Prasad, 2016). Therefore, the impact of OTT service applications, where operators' infrastructure is simply used as a pipe to run OTT services, poses a major challenge to the viability of existing business models. Mobile operators' business models are significantly impacted as their revenues are mainly from traditional mobile data consumption and not from OTT applications (Banda et al., 2022a). Additionally, traditional mobile voice calls and SMS businesses have declined dramatically, resulting in further revenue declines for mobile operators (Rao & Prasad, 2018).

- *Consumers' low digital literacy levels*

The low digital literacy of consumers in most African regions, particularly in rural areas, represents a key challenge for most mobile operators in developing their business models (Ahmad et al., 2024). Although there is relatively high mobile internet coverage in most parts of the continent, most African consumers cannot afford to go online as they lack the necessary

digital skills and knowledge (Radovanović et al., 2020). Therefore, mobile operators should educate consumers about the importance of 5G and the diverse possibilities it offers. This can be achieved through partnership networks with key stakeholders such as local authorities and national governments.

- *Societal issues*

Most radio base stations are deployed in densely populated areas that face socio-economic challenges. Mobile operators face challenges such as limited access to sites during network rollout or network maintenance (Garba et al., 2022). In addition, the implementation of security measures negatively leads to higher OpEx for operators due to equipment theft and vandalism, which impacts the cost structures of the business models. The other challenge for mobile operators is the significant infrastructure investments required given the scepticism about favourable business environments due to political instability in most African countries (Ahmad et al., 2024). Furthermore, 5G has been the subject of misconceptions in many countries, including some in Africa. This has resulted in potential customers expressing concerns about the technology and being hesitant to adopt 5G services once available in their markets (Kenechi Okeleke et al., 2022). One expression of this was the suspected correlation of COVID-19 with 5G mobile technology. Flaherty, Sturm, and Farries (2022) observed that this alleged link was promoted and widely shared on social media during the period 2020 to 2022, often in the form of maps showing the distribution of COVID-19 cases with the installation of 5G towers.

6.2.3 Internal and External (Hybrid) Factors

- *High device prices*

The cost of 5G-supporting devices is extremely high for most users, especially prepaid subscribers. Therefore, device affordability poses a challenge for most users as mass-market 5G-enabled devices are quite expensive. Furthermore, Hatt and Jarich (2020) predict that the cost of 5G devices will remain excessively high for most African consumers for the foreseeable future. This will impact operators' 5G revenues due to low mobile traffic for 5G services. The biggest challenge for device manufacturers in Africa is to produce devices at a low enough

price to gain market share, particularly in the 5G and 4G markets where devices remain extremely expensive for most regional consumers (GSMA, 2023). Some operators are trying to reach the low-income base by making 5G devices affordable by offering monthly contracts, thereby accommodating prepaid subscribers who are the majority of mobile service consumers (Maluleke, Bagula, Ajayi, & Chiaraviglio, 2022).

- *Low device maturity*

Aside from the exorbitant costs, device maturity and availability in Africa are relatively low compared to other regions of the world. Slow network rollout on the continent has resulted in limited availability of 5G-supporting devices as device manufacturers are sceptical about achieving revenue growth in seemingly smaller and immature African markets (K Okeleke et al., 2019). According to Kenechi Okeleke et al. (2022), the adoption of 5G for consumers in Africa will largely depend on the affordability of the devices. Furthermore, Kenechi Okeleke et al. (2022) believe that it is critical for tax authorities to reduce or eliminate import and exercise duties 5G devices to accelerate the transition to enhanced broadband connectivity in Africa. Low device maturity impacts operators' mobile traffic profiles, which ultimately impacts their revenue generation.

- *Limited tower infrastructure space*

Space requirements and tower load capacity pose another major challenge as most towers/masts are already overloaded with antennas and other radio equipment, exceeding the tower utilization factor. In such cases, the operator should recover the existing antennas and replace them with modern 5G-capable antennas, which can be costly. When using Massive MIMO antennas, the problem of limited tower space is exacerbated as the space required would be much larger than traditional antennas (López-Pérez et al., 2022). To this end, Africa is witnessing a new wave of tower deals as operators explore new network infrastructure models and seek further operational efficiencies in the context of the network densification requirements of 5G (Kenechi Okeleke & Joiner, 2023). Mobile operators are now partnering with tower companies who are playing a vital role in the rollout of 5G services in Africa. In addition to managing the tower assets acquired from operators, many of them are also involved

in building new sites, which is crucial for network densification, as well as investing in fibre infrastructure to connect new and existing sites (Kenechi Okeleke et al., 2022). For example, IHS Towers completed the acquisition of a sizeable number of towers from MTN in South Africa, and Airtel Africa has entered into a sale-leaseback agreement with Helios Towers for some of its towers in Madagascar, Malawi, Chad and Gabon (Kenechi Okeleke et al., 2022).

- *Customers value perception issues*

Existing business models of mobile operators have long assumed that customers place value solely on data consumption. However, with the advent of 5G, the perception of customer value has evolved beyond mere data consumption, particularly for enterprise businesses and industry verticals whose goals include value delivery in the form of end-to-end solutions (DotEcon & Axon, 2018). Therefore, existing traditional business models are unable to keep up with this shift in customers' value perception behaviour and hence there is a need to redesign and reinvent existing business models accordingly.

- *Customers readiness issues*

The low levels of customers readiness in adopting 5G is another challenge impacting operators' current business models. According to K Okeleke et al. (2019), market factors such as urbanisation, digital literacy and GDP per capita have contributed to the lack of customer readiness for 5G adoption in Africa. Additionally, as previously outlined, complex issues related to device affordability, device availability, and socio-economic challenges have significantly contributed to customers' unpreparedness for 5G adoption.

6.3 Components of the Conceptual Business Model Framework

A conceptual framework is an analytical tool used to justify the meaning and relevance of the study design by consistently answering the research questions (Adom et al., 2018). It establishes the relationship between concepts by showing theories that influence the research study, thereby providing a theoretical basis for designing the research and interpreting the results (Leshem & Trafford, 2007). Additionally, a conceptual framework includes key process parameters,

defining variables, and cause-effect relationships and can be developed from three sources: experience, literature, and theory (Ravitch & Riggan, 2016).

In the present research, the conceptual business model was developed from the case study insights which were obtained using the reflexive thematic qualitative data analysis proposed by (Braun & Clarke, 2019). Data analysis was carried out in the MAXQDA 24 software (Verbi, 2021). Four main themes emerged from the data analysis: value proposition (business model offerings), customer interface, infrastructure management, and financial aspects. These main themes, sub-themes and associated codes are summarised in Table 5.1 of the previous chapter. In formulating the conceptual business model framework, the study sought to address the following research question:

How can a business model framework be conceptualised and developed for next-generation communication networks?

The themes have been summarised to fit the components of the business model framework: 5G services, customer interface, infrastructure management, and financial aspects as shown in Figure 5.1 of the previous chapter. The following sub-sections discuss the results in the context of the components of the proposed conceptual business model framework.

6.3.1 5G Service Offerings (Value proposition/BM offerings)

5G services describe the value proposition or business model offerings that a mobile operator intends to offer to its customers. This business model component consists of the three main service classes of the 5G technology standards (ITU-R, 2015): (1) *enhanced mobile broadband (eMBB)* services tailored to throughput-sensitive applications such as high-speed broadband access, immersive mobile services, and high-quality video content applications ; (2) *massive machine type (mMTC)* services targeting applications with high device connectivity density such as industrial IoT and commercial IoT applications; and (3) *ultra-reliable low latency communications services (uRLLC)*, intended for low latency (delay) and high reliability

communications, for example mission-critical applications such as industrial automation and remote surgery.

- *Current 5G service offerings*

The interview results showed that operators that have launched and commercialised 5G are offering 5G broadband services in the form of Fixed Wireless Access (FWA) to both residential and commercial customers. All respondents indicated that their respective organisations have implemented 5G as a non-standalone configuration (G. Liu et al., 2020) and that their current service class is the eMBB use case. High-speed mobile and fixed broadband access services are currently the key 5G services that deliver value to customers and capture financial value for mobile operators in Africa.

- *Commercialisation of 5G services*

In terms of steps or changes that mobile operators should consider when commercialising 5G services to industries, government entities and individual customers, interview data suggests several possibilities. A prominent approach is to obtain a clear definition of use cases for specific customer segments by studying and understanding customers' specific technical and business needs. Alliance partnerships with equipment and device manufacturers that have extensive technical experience and expertise can help improve the commercialisation of 5G services. Internal restructuring of the MNO organisation through the creation of units consisting of experts with in-depth knowledge of specific target industries is also a way to successfully commercialise 5G services by mobile operators. Additionally, as African mobile operators commercialise 5G services, they could consider improving the 5G knowledge and skills of their employees through training and exchange programs with operators in regions such as Europe, North America or Asia where 5G has been successfully deployed. Furthermore, mobile operators should be key drivers of digital transformation by actively participating in closing the digital divide in Africa. This can be done in collaboration with local authorities, state governments and non-governmental organisations

- *Proposed initial 5G service offering for mobile operators*

Nine out of ten respondents believe that the eMBB service class is the appropriate entry-level service offering for operators who have just launched their 5G services. This is primarily because the eMBB is seen as a smoother evolution of current 4G mobile broadband services. Therefore, current 4G devices should be able to support 5G eMBB services as long as operators refarm their spectrum accordingly. The other advantage is that providing eMBB services does not necessarily require the costly deployment of the 5G core network, which most African operators cannot currently afford. The other two service classes (mMTC and uRLLC) require complex and specialised use cases that most African operators have not yet developed. In addition, mMTC and uRLLC services require a standalone network configuration, which requires huge capital investments due to the deployment of the costly 5G core network.

6.3.2 Customer Interface

The customer interface of a business model describes the company's target customers, the means of delivering products and services to customers and the relationships a company builds with its customers (Osterwalder & Pigneur, 2004). In the current study, the customer interface component of the proposed conceptual business model framework consists of three sub-components, including: (1) *customer segment*, which describes the customer base to which a mobile operator wants to provide value. These are customers who are attracted to the value proposition. Examples include government agencies, local municipalities, private enterprises and vertical industries, (2) *customer relationships*, which explain the type of connections that a mobile operator establishes between itself and its different customer segments, such as self-service options, personal assistance services, automated services and community-based services, and (3) *distribution channels*, which describe various means that a mobile operator can use to engage with its customers and offer them the value proposition. Examples include contract-based, postpaid-based or prepaid-based channels.

- *Target customers*

In terms of the types of 5G service customers expected to be targeted by mobile operators, the interview results point to vertical industries, particularly the mining, manufacturing and financial sectors. This is primarily driven by the deployment of private 5G networks, which are dedicated local area networks with enhanced characteristics, unified connectivity, optimised services and customised security features in a specific area such as a mining site or factory facility (Wen et al., 2021). To a certain extent, corporate businesses, SMEs and residential/private customers are also being addressed. However, mass markets appear to be the lowest priority for most mobile operators at the moment. This is closely related to low device penetration in the mass-market due to affordability and availability issues.

- *Customer behaviour*

Since the introduction of 5G on some networks, customer behaviour has changed dramatically. Beyond uninterrupted connectivity, customers, particularly across industries, are now demanding end-to-end 5G solutions, unlike the previous 3G and 4G technologies where service demand was primarily focused only on network availability. These demands are primarily triggered by the promises and commitments of the operators that have not yet been fulfilled. For residential and SME customers, mobile data consumption has increased tremendously due to the super-fast speeds and uninterrupted connectivity of 5G technology.

- *Customer relationships*

For most mobile operators, new customers have come primarily from industries such as mining, manufacturing and enterprise businesses. Besides, some operators have experienced an increase in subscriber numbers within existing customer segments, largely due to improved data services delivered over 5G networks. When it comes to building new relationships with existing customers, some operators have seen no changes, while other operators have built new relationships and strengthened existing ones, particularly from the perspective of industrial customers who are benefiting from private 5G networks.

6.3.3 Infrastructure Management

The infrastructure management component of the business model describes how a company solves infrastructural or logistical issues efficiently, with whom and as what type of network enterprise (Osterwalder & Pigneur, 2004). Osterwalder and Pigneur (2010) roughly divide infrastructure management into three sub-components: value configuration, core competence and partner networks.

In the present research study, the infrastructure management component of the conceptual business model framework consisted of four sub-components: (1) *key partners* demonstrating the need for collaborative arrangements with external organisations to effectively deliver and monetize the proposed value. This include equipment vendors, device manufacturers, platform providers, regulatory and policy makers, and other mobile operators; (2) *key resources* describing the resources available to the mobile operator to ensure that value is created and delivered in line with the mobile operator's business objectives. Examples include physical, intellectual, human, financial, spectrum, and site equipment and infrastructure; (3) *key activities* that describe the activities and competencies required to implement the mobile operator's business model. This includes managing partnerships, network design and maintenance, providing mobile services, and supporting technical customer service; and (4) *5G key technologies* which describe the underlying and supporting technologies that a mobile operator must design and implement to ensure that 5G services are created and delivered to intended customers. Key technologies include network slicing, green communications, digital platforms, SDN and NFV, ultra-densification, IoT and D2D communications, and massive MIMO and beamforming.

- *Key partners*

Respondents believe it is important to involve alliance partners in the development and implementation of 5G business models for 5G for various reasons. Some respondents pointed out that involving partners in designing a business model is important because 5G is supported by several underlying technologies such as cloud computing, big data, IoT and to some extent artificial intelligence, which are not necessarily the area of expertise for mobile operators. For

example, when operators partner with certain technology providers such as Amazon, Microsoft or IBM to provide cloud computing services, they bring with them extensive knowledge and expertise as well as infrastructure such as data centres that leverage the operators' design of effective business models. Additionally, device manufacturers are key partners who can play a critical role in price-sensitive markets such as Sub-Saharan Africa by offering devices to consumers at affordable prices, thereby driving 5G adoption.

- *Key activities*

The interview results indicate that most African operators have deployed their 5G networks in non-standalone configuration mode. But even as the global rollout of 5G intensifies, most African operators have yet to deploy the technology, while a significant number are in the pre-commercial testing phase. When it comes to the most cost-effective ways to upgrade from 4G to 5G networks, most operators consider the non-standalone 5G network approach to be the best option for two reasons. Firstly, it enables a smooth and rapid transition from 4G to 5G with minimal configuration changes and secondly, it reduces the huge investment costs associated with deploying the 5G core network. Sharing tower space and infrastructure is considered a key activity in the 5G era, providing an additional revenue stream for mobile operators while reducing operational costs such as energy supply costs and land rates. However, caution is advised when sharing tower space and infrastructure, as incorrect implementation could shift mobile traffic to competitors' networks. Other key activities include extensive sharing of both active (e.g. fibre transport network) and passive (e.g. antennas) resources with other operators. Sharing network resources and infrastructure is beneficial for mobile operators because it reduces both deployment and operational costs.

- *Key resources*

According to the interview responses, it was found that most African operators have relatively sufficient 5G spectrum resources such as 2600 MHz (low-band), 3500 MHz (mid-band) and 26 GHz (high-band), and they have primary operator licences for commercial voice and data services. However, for most operators, acquiring spectrum and the allocation of operating licences remains a challenge for two main reasons. Firstly, the extremely high spectrum prices

and licence fees are a deterrent, especially for new market entrants such as private and micro-operators. These exorbitant prices and fees have a significant impact on operators' cost structures. Secondly, the bureaucratic and complex spectrum auction and licencing process inhibits the rapid rollout of 5G networks. Therefore, regulators in Africa need drastic changes to their policies to ensure expeditious spectrum auction and licence allocation and make associated costs and fees affordable to operators, thereby increasing the pace of 5G deployment on the continent.

- *Key technologies*

The 5G key technologies form a crucial part of the infrastructure management component in the conceptual business model framework of this study. According to the interview results, when it comes to key technologies for 5G, a significant number of operators have deployed at least one of the following technologies: massive MIMO, beamforming, network densification, network slicing, millimetre wave (mmWave) and IoT. This confirms the literature data, as these technologies form the basis of the 5G network architecture. Massive MIMO, beamforming, network densification, and mmWave are considered key drivers in delivering 5G mobile broadband services for more capacity and higher data rates (Ge et al., 2016; Kammoun & Alouini, 2019). Therefore, the use of massive MIMO, beamforming, network densification and mmWave coupled with the non-standalone network configuration is a good reason why most African operators are able to offer entry-level 5G services in the form of eMBB use cases. Furthermore, operators believe that emerging technologies such as network slicing, artificial intelligence, machine learning and IoT, if successfully adopted, can improve operational efficiency and increase productivity within the 5G value chain. Advanced 5G technologies such as digital platforms, software defined networking (SDN), and network function virtualisation (NFV) are beneficial for standalone network configuration, which requires the deployment of a cloud-based 5G core network for end-to-end service solutions (Akyildiz et al., 2016).

6.3.4 Financial Aspects

According to Osterwalder and Pigneur (2004), financial aspects of a business model describes the cost structure, revenue model and the financial sustainability of a company. It consists of two sub-components: cost structure and revenue model (Osterwalder & Pigneur, 2004, 2010). The financial aspects of this study's conceptual business model frameworks outline the capability of a mobile operator to capture and monetise the proposed value delivered to the intended customers. The two parts of the financial aspects in the designed conceptual business model framework are: (1) *cost structure* which sums up the monetary consequences of the means employed in the business model such as fixed costs, variable costs, CapEx and OpEx; and (2) *revenue streams* which describes ways a mobile operator makes money through a variety of revenue flows such as subscription fees, asset leasing/renting, advertisement and partnership revenue sharing.

Interview feedback shows that most operators in Africa have yet to commercialise the 5G services and therefore, have not established 5G cost structures and revenue models. Besides, the few operators with commercial 5G services are still using existing 4G financial models to support basic 5G services which is the eMBB use case.

- *Cost structure*

The majority of interview respondents believe that the development and implementation of the 5G business model leads to changes in the cost structures of mobile operators. In addition, some respondents believe that changes in cost structures need to be incorporated into the design of the business model to make 5G services affordable for consumers. The costs associated with purchasing equipment, deploying network nodes, acquiring spectrum and licencing have a huge impact on capital investment, while costs associated with network maintenance, rentals, energy supply and daily operations significantly impact operators' operational costs. Cost impacts may also arise from global economic volatility, such as the post Covid-19 economic recession, the ongoing war between Ukraine and Russia and the current Middle East conflict, which have resulted in unstable exchange rates, thereby impacting the cost of telecommunications equipment, products and solutions.

Effective ways to minimize these costs and make 5G affordable for end users include: building a range of diversified revenue streams, implementing a revenue-sharing model with partners such as equipment manufacturers, sharing resources and infrastructure with other operators, and initially deploying 5G as a non-standalone configuration. Additionally, the use of new technologies such as IoT, network slicing, artificial intelligence and machine learning can help reduce maintenance-related operational costs.

- *Revenue Streams*

Some interview respondents stated that the deployment of private 5G networks for industrial customers such as mining and manufacturing has created new revenue streams for mobile operators. Other feedback from interviews suggests that the use of FWA for residential and commercial customers represents another additional source of revenue for operators. Other perceived revenue streams include sharing resources and infrastructure with other operators, revenue share models with alliance partners such as OEMs, technology/solution providers and App developers, and diversifying revenue through the provision of digital services such as fintech and insurance services.

It was also pointed out that the deployment of 5G use cases and the lack of product familiarity are some of the challenges in redesigning operators' revenue schemes. This is primarily because the deployment of 5G is done through experimentation to see if the market accepts the offering or to make adjustments if the market does not respond well. Another major challenge in reinventing operators' revenue schemes for 5G is the uncertainties surrounding return on investment (RoI) in less matured African markets.

To maximise their sales and earnings, some operators have redesigned their payment systems and pricing strategies by moving from selling data packages (bundles) to selling broadband capacity (speed) due to customer demands for end-to-end 5G solutions. However, for some operators, no specific changes have been introduced in terms of payment systems or pricing strategies other than the current 4G scenarios. In such cases, operators have simply converted

4G users into 5G users. Therefore, the existing data packages and payment modes have remained the same, only the user profiles have been changed from 4G to 5G.

6.4 Statistical Analysis Results and Research Hypotheses

Statistical analysis is mainly used in quantitative research where numerical data is quantified (Lutabingwa & Auriacombe, 2007). Quantitative data analysis approach is usually associated with finding evidence to either support or reject hypotheses that have been formulated and may include calculations of frequencies and variances among research variables (Dudovskiy, 2018). During statistical analysis, descriptive statistics was used to analyse the demographic data profiles of the sample research participants while inferential statistics was applied during the testing of the formulated hypothesis and in answering the final research question:

How can the designed business model framework have a positive impact on the business viability and sustainability of mobile operators?

In addition, descriptive statistics analysis was conducted in SPSS software while inferential statistics analysis was conducted in SmartPLS software.

6.4.1 Demographic Data Descriptive Results

The descriptive results of the demographic data represented the following characteristics of the research sample: sample response rate, gender of the respondent, position of the respondent in the company, functional area of the respondent's company, and years of experience of the respondent in the mobile industry. Data from Qualtrics were imported into SPSS software for cleaning and descriptive statistical analysis.

Sample response rate

Of the 102 online survey questionnaires distributed for the study, 71 (69.6%) responses were collected. However, of the responses obtained, only 62 (60.8%) were found to be usable for data analysis. Therefore, the usable response rate of the study was 60.8%, as shown in Table

5.4 of the previous chapter. The main challenge of the study was the sample size, which further impacted the response rate. Sample size is more critical in quantitative studies than in qualitative studies (Creswell & Creswell, 2018; Saunders et al., 2019). The sample size for the quantitative part of the study was not as adequate as desired mainly because there are few mobile operators in Africa that have launched and commercialised 5G network services. Additionally, most operators' employees have less knowledge and expertise on 5G as it is still an emerging technology in the African context.

Study participants by gender

The results of demographic data by gender showed that there were 42 male and 20 female participants in the research study, accounting for 67.7% and 32.3% of the sample space, respectively. Therefore, overall, more men than women were sampled. This reflects the perception that the mobile industry, including those championing the deployment and adoption of 5G network technologies, is still male-dominated.

Study participants by position in the company

The demographic data results of the study participants by position in the company revealed that most participants were represented at the middle management level (32.3%) and the junior/employee level (29.0%). A significant number of participants were senior managers (21.0%), while a few were top executives (12.9%). This was to be expected as the majority of mobile operators' employees are at the junior/employee level, middle-management level and to some extent senior management level. These are the position groups where you will find engineers, specialists, senior engineers, principal engineers and project managers who are directly involved in the 5G rollout activities. Participation from top executives was low because mobile operators hold few top leadership positions.

Study participants by functional area in the company

Responses by functional area within the company show that the majority of participants came from the Networks/Technology area (69.4%), followed by the Information Technology (IT) area (17.7%). Other functional areas such as finance, sales/marketing and logistics were hardly represented. As expected, most of the employees responsible for the planning, design, operation

and maintenance, configuration and technical customer support of 5G networks can be found in networks/technical functional areas. The IT functional area was also well represented as the IT staff forms the cornerstone of the organization's internal IT support including the network/technical functional area.

Participants' years of experience in the mobile industry

Sample data on participants' years of experience in the mobile industry showed that the majority of participants had more than 10 years of experience (62.9%). Those with 6 to 10 years of experience accounted for 24.2%, while those with 1 to 5 years of experience accounted for 12.9% of the total sample response. From the results, it can be concluded that operators' employees with more than 10 years of experience were willing to participate in the research survey compared to employees with fewer years of experience. A key reason could be that more experienced employees are likely to be confident enough to answer the survey questions. Additionally, those with more than 10 years of experience have a far better understanding of the evolution of wireless technology from 2G/3G to current 4G/5G technologies. This will enable them to better understand the likely course of 5G and thus assess their willingness to participate in the study.

6.4.2 PLS-SEM Analysis Results

PLS-SEM data analysis was performed in SmartPLS software using inferential statistics. The aim was to design a structural equation model (SEM) for the four research constructs and the associated measures (indicators) and to test the hypothesised paths and relationships between the constructs. In this study, the PLS-SEM design and analysis consisted of three phases: evaluation of the measurement model, evaluation of the structural model, and testing of the formulated hypotheses.

6.4.2.1 Measurement Model Evaluation Results

The PLS-SEM measurement model specifies relationships between the constructs (i.e., latent variables) and the indicators (i.e., measured variables) (Joseph F Hair Jr et al., 2021). A

reflective measurement model approach was chosen in this study. The criteria for evaluating the reflective measurement model included three phases: internal consistency, convergent validity, and discriminant validity (Joe F Hair Jr et al., 2017).

● **Internal consistency Results**

Internal consistency, a quality criterion of a research construct that requires a high level of correlation between indicators of a given construct, was measured using Cronbach's alpha and Composite Reliability (CR) testing methods (Janadari et al., 2016; FHJR Joseph et al., 2010).

Cronbach's Alpha Test Results

The Cronbach's alpha test was conducted to assess the reliability of the scales in the research questionnaire of the study due to its application in measuring and estimating the reliability of multiple item scales (Janadari et al., 2016). A higher value of the Cronbach alpha coefficient indicates a higher reliability of the measurement scale. According to the literature, a scale is considered reliable if the Cronbach alpha coefficient is higher than 0.7 (Joe F Hair et al., 2012), although Nunnally (2014) argues that a Cronbach alpha coefficient between 0.5 and 0.6 is also an acceptable indication of a reliable scale. From the results presented in Table 5.10 "Scale accuracy analysis" of the previous chapter, the Cronbach's alpha coefficient values for the four research constructs: Infrastructure Management, 5G Service Offerings, Customer Interface and Financial Aspects were 0.715, 0.765, 0.836 and 0.798, respectively. Since these values are above the recommended thresholds of 0.6 (Nunnally, 2014) or 0.7 (Joe F Hair et al., 2012), the results of the Cronbach's alpha test confirmed the reliability of the measures used in the current research study.

Composite Reliability (CR) Test Results

The Composite Reliability (CR) test was conducted to evaluate the internal reliability of the measurement instrument (i.e., the survey questionnaire) (Sarstedt et al., 2021). The literature claims that the CR index value must be greater than 0.7 for the CR to be accepted. (Sarstedt et al., 2014). From the results in Table 5.11 "Composite reliability test estimates" in the previous

chapter, the CR index values for the four research constructs: Infrastructure Management, 5G Service Offerings, Customer Interface, and Financial Aspects were 0.787, 0.902, 0.892, and 0.857, respectively. Therefore, the results confirmed the existence of internal reliability for all research constructs in the study.

● Convergent Validity Results

Convergent validity was conducted to determine the extent to which an indicator is positively correlated with an alternative indicator measure of the same construct (Janadari et al., 2016; Schwab, 2013). Convergent validity was conducted by performing the average variance extracted (AVE) test and factor loading test.

Average Variance Extracted (AVE) Test Results

The AVE test results reflected the total variance of all indicators attributable to a particular construct, and therefore indicated the average variance between a construct and its measurements (F Joseph et al., 2022). From the literature Joseph F Hair et al. (2013) claim that an AVE value greater than or equal to 0.5 is acceptable while Fraering and Minor (2006) claim that an AVE value greater than 0.4 indicates that a construct is reliable and valid. From the results provided in Table 5.12 “Average Variance Extracted (AVE) test estimates” of the previous chapter, the AVE test values of the four research constructs: Infrastructure Management, 5G Service Offerings, Customer Interface, and Financial Aspects were 0.649, 0.809, 0.678, and 0.813, respectively. Therefore, the results confirmed the fulfilment of convergent validity for all research constructs in the study.

Factor Loading Test Results

To complement the findings of the AVE test, convergent validity was conducted by also performing the factor loading test. High factor loadings on a construct indicate that the associated indicators share many similarities captured by the construct and thus represent a high level of convergent validity (F Joseph et al., 2022). The literature review claims that a factor loading value above 0.5 entails the achievement of convergent validity (Anderson & Gerbing, 1988), while F Joseph et al. (2022) recommend a factor loading value above 0.708 as an

indicator of acceptable convergent validity. From the results presented in Table 5.13 “Factor loading test results” of the previous chapter, the factor loading values range from 0.505 to 0.919, which is above the threshold of 0.5 recommended by (Anderson & Gerbing, 1988). This shows that all study indicators load well on their respective constructs. Therefore, the results confirmed that convergent validity was achieved for all indicators and the associated research construct of the study.

● **Discriminant Validity Results**

Discriminant validity assessment was conducted to determine the extent to which a particular construct is uniquely different from other constructs in the model according to empirical standards (F Joseph et al., 2022). The Heterotrait-Monotrait Ratio (HTMT) measurement criterion was used to assess the discriminant validity of the current research study.

The Heterotrait-monotrait ratio (HTMT) Test Results

When assessing discriminant validity, it was imperative to check and confirm whether the correlation between research constructs was less than 1.0, as recommended by (Joseph F Hair et al., 2013). The literature asserts that an HTMT value below 0.9 indicates the achievement of discriminant validity (Henseler et al., 2015). As shown in the results of Table 5.14 “The Heterotrait-monotrait ratio (HTMT) test results” in the previous chapter, all HTMT values are below the recommended threshold of 0.9. Therefore, the results confirm that discriminant validity was achieved for all research constructs in the current study.

The assessment of the HTMT measurement criterion concluded the evaluation of the entire PLS-SEM measurement model. The objectives of all three phases of measurement model evaluation: internal consistency, convergent validity and discriminant validity were achieved. Therefore, the relationships between research constructs and their associated indicators were established as suggested by (Joe F Hair et al., 2012).

6.4.2.2 Structural Model Evaluation Results

The study's structural model was evaluated to determine the relationships between research constructs of the designed PLS-SEM (Joseph F Hair et al., 2013). The model had one exogenous latent variable: Infrastructure Management and three endogenous latent variables: 5G Service Offerings, Customer Interface and Financial Aspects. The structural model was evaluated by performing five measurement tests proposed by (F Joseph et al., 2022): collinearity issues test, path coefficient test, coefficient of determination (R^2) test, effect size of f^2 test, and predictive relevance (Q^2) test.

Collinearity Issues Test Results

Assessment of collinearity issues was performed using the Variance Inflation Factor (VIF) to determine whether two or more independent variables were highly correlated with each other (Basbeth et al., 2017; Janadari et al., 2016). According to the literature reviewed, Janadari et al. (2016) claim that a VIF coefficient above 4.0 indicates potential collinearity issues, while Diamantopoulos and Siguaw (2006) affirm that VIF coefficients above 3.3 indicate the presence of collinearity issues between independent variables. The results from Table 5.15 “Collinearity issues test (VIF coefficients)” of the previous chapter show that the VIF coefficients are between 1.000 and 1.525, which is below the literature threshold. Therefore, it can be concluded that there were no collinearity issues between research constructs in the current study.

Path Coefficient Test Results

The path coefficient test was performed using the bootstrapping technique in SmartPLS software to evaluate the path relevance and significance within the structural model as suggested by (F Joseph et al., 2022). According to F Joseph et al. (2022) and Joseph F Hair et al. (2013): When the path coefficient test is performed with a bootstrap confidence interval of 95%, p -values below 0.05 and t -values above 1.96 indicate path significance and a strong relationship between two constructs. From the results in Table 5.16 “Path coefficients and path significance test results” of the previous chapter, it can be seen that of the six paths of the

structural model in this study, four were significant and had strong relationships between variables: 5G Service Offering => Customer Interface, Customer Interface => Financial Aspects, Infrastructure Management => 5G Service Offerings, and Infrastructure Management => Customer Interface. On the contrary, two paths were not significant and therefore irrelevant: 5G Service Offerings => Financial Aspects and Infrastructure Management => Financial Aspects.

Coefficient of Determination (R^2) Test Results

The coefficient of determination (R^2) test was performed to evaluate the predictive power of the study's structural model by determining the standard path coefficients of each relationship between the exogenous variable (Infrastructure Management) and the endogenous variables (5G Service Offerings, Customer Interface and Financial Aspects), as recommended by (Janadari et al., 2016). From the results in Table 5.17 “Coefficient of determination (R^2) test results” of the previous chapter and according to the recommendations of F Joseph et al. (2022), Financial Aspect (R^2 value: 0.535) had moderately strong path significance with Infrastructure Management, while 5G Service Offerings (R^2 value: 0.290) and Customer Interface (R^2 value: 0.235) both appeared to have weak path significance with Infrastructure Management.

Effect Size of f^2 Test Results

The purpose of conducting the effect size of f^2 was to determine whether the exogenous construct (Infrastructure Management) had a significant influence on endogenous constructs (5G Service Offerings, Customer interface and Financial Aspects) in the structural model of this study, as suggested by (Janadari et al., 2016). The research guideline by Cohen (2013) suggests that f^2 values of 0.35, 0.15, and 0.02 represent significant, medium and small effect sizes, respectively while f^2 values below 0.02 have no practical effect. From the results in Table 5.18 “Results of the effect size of f^2 test” from the previous chapter, it can be seen that the construct paths Customer Interface => Financial Aspects ($f^2 = 0.755$) and Infrastructure Management => 5G Service Offerings ($f^2 = 0.409$) had significant size effects, the construct paths 5G Service Offering => Customer Interface ($f^2 = 0.082$) and Infrastructure Management

=> Customer Interface ($f^2 = 0.060$) had medium size effects, while the construct paths 5G Service Offerings => Financial Aspects ($f^2 = 0.04$) and Infrastructure Management => Financial Aspects ($f^2 = 0.005$) had no size effects.

Predictive Relevance (Q^2) Test Results

The predictive relevance (Q^2) test was the final step in the evaluation process of the study's structural model. The Q^2 assessment was conducted to determine whether the endogenous constructs (5G Service Offerings, Customer Interface and Financial Aspects) of the established structural model had predictive relevance or not as recommended by (F Joseph et al., 2022). The literature claims that Q^2 values of 0.02, 0.15, and 0.35 indicate weak, moderate, and strong levels of predictive relevance of each effect, respectively (Joseph F Hair et al., 2013). The results in Table 5.19 “Results of predictive relevance (Q^2) test” of the previous chapter show that the Q^2 predict values for three endogenous research constructs: 5G service Offerings, Customer Interface and Financial Aspects were 0.255, 0.140 and 0.100, respectively, indicating that all three endogenous research constructs had moderate levels of predictive relevance.

6.4.2.3 Hypothesis Testing Results

The final phase of quantitative data analysis consisted of hypothesis testing, which was conducted after the evaluations of the measurement and structural models of the PLS-SEM analysis were performed using inferential statistics. The research hypotheses formulated during the design of the conceptual business model framework in sub-section 5.3.3 “Conceptual Framework and Hypotheses” of the previous chapter were subjected to numerical testing. Hypothesis testing was conducted to determine whether certain research constructs directly or indirectly influenced other research constructs within the PLS-SEM analysis approach, as noted in (Nusair & Hua, 2010).

During hypothesis testing, path coefficients (β) indicated the nature and strength of relationships between research constructs in the study, with higher β -values indicating stronger relationships (Joseph F Hair et al., 2013). To determine whether a particular hypothesis was supported or not, F Joseph et al. (2022) assert that the β -value (Path coefficient), p -value

(Probability) and t -value (Test statistics) should be analysed within a 95% confidence interval. Specifically, for a hypothesis to be significantly supported, the following numerical conditions had to be met: $p < 0.05$, $t > 1.96$ and 95% confidence interval. From the results presented in Table 5.20 “Hypotheses testing results” of the previous chapter, it can be observed that of the six research hypotheses formulated, four were significantly supported: H1, H2, H3 and H4, while two were not supported: H5 and H6. A detailed summary description of the results of the hypothesis testing results is as follows:

H1: There is a significant positive impact of Infrastructure Management (IM) on 5G Service Offerings (SO).

H1 evaluates whether Infrastructure Management significantly and positively affects 5G Service Offerings. The results revealed that Infrastructure Management has a significant and positive impact on 5G Service Offerings ($\beta = 0.539$, $t = 7.537$, $p < 0.05$). Hence H1 was supported.

Support for H1 shows that underlying infrastructure management is required for 5G services to exist. An important infrastructure management is the 5G deployment and configuration scenario, as 5G can be deployed as either a non-standalone (NSA) or standalone (SA) configuration (G. Liu et al., 2020). The NSA configuration can only offer basic 5G services in the form of eMBB for data-intensive applications, while the SA configuration can offer end-to-end 5G services for all three service classes: eMBB, mMTC and uRLLC. Furthermore, existing technologies such as massive MIMO, beamforming and network densification, as well as new technologies such as network slicing, mmWave, IoT, artificial intelligence and machine learning, are key components of operators’ infrastructure management in the provision 5G services (Banda et al., 2022a). In addition, most African 5G operators have relatively sufficient spectrum resources such as 2600 MHz (low-band), 3500 MHz (mid-band) and 26 GHz (high-band), as well as commercial operating licences to offer entry-level 5G services in the form of eMBB. Another key reason why infrastructure management has a significant positive effect on 5G service offerings is the formation of alliance partnerships with key industry players such as

equipment manufacturers, device manufacturers, technology providers and app developers, who through their extensive knowledge and expertise are able to support operators in delivering high-quality 5G services to customers.

H2: There is a significant positive impact of Infrastructure Management (IM) on the Customer Interface (CI).

H2 evaluates whether Infrastructure Management significantly and positively affects Customer Interface. The results revealed that Infrastructure Management has a significant and positive impact on Customer Interface ($\beta = 0.255$, $t = 2.227$, $p < 0.05$). Hence H2 was supported.

The support of H2 indicates how heavily reliant the customer interface is on infrastructure management. This is evident for vertical industries such as mining, manufacturing and financial sectors that access 5G services via private 5G network infrastructure (Wen et al., 2021). In addition, operators can reach residential or SME customers by leveraging infrastructures such as Fixed Wireless Access (FWA) or Wireless-to-the-x (WTTx). For some operators, the deployment of fibre infrastructure to expand the transport network, particularly in densely populated urban areas, has had a significant impact on increasing the customer base and building new customer relationships. Finally, partnerships between operators and device manufacturers in price-sensitive markets such as Sub-Saharan Africa play a crucial role by offering devices to consumers at affordable prices, thereby fostering 5G adoption and the establishment of new customer relationships.

H3: There is a significant positive influence of 5G Service Offerings (SO) on Customer Interface (CI).

H3 evaluates whether 5G Service Offerings significantly and positively affects Customer Interface. The results revealed that 5G Service Offerings has a significant and positive influence on Customer Interface ($\beta = 0.297$, $t = 2.063$, $p < 0.05$). Hence H3 was supported.

Support for H3 shows that the nature and quality of 5G services provided has a direct and major impact on the customer interface of mobile operators' business model. Based on the qualitative

and quantitative results, it was established that most African operators that have commercialised 5G networks are currently offering eMBB services for data-intensive applications to both commercial and residential customers. This is because most networks are currently based on an NSA configuration, which cannot sufficiently support the other two advanced service classes, mMTC and uRLLC. Besides, mMTC and uRLLC services require complex and specialised use cases that African operators have not yet developed. The other reason is that eMBB is seen as a smoother evolution of the current 4G mobile broadband service and therefore some of the 4G devices can support the 5G eMBB services.

H4: There is a significant positive influence of Customer Interface (CI) on the Financial Aspects (FA).

H4 evaluates whether Customer Interface significantly and positively affects the Financial Aspects. The results revealed that Customer Interface has a significant and positive impact on the Financial Aspects ($\beta = 0.678$, $t = 8.110$, $p < 0.05$). Hence H4 was supported.

The support of H4 confirms that the existing customer interface has a direct and significant impact on the financial aspects of operators, especially on the revenue side. The results of this study suggest that the deployment of private 5G networks for industrial customers such as mining and manufacturing has created new revenue streams for some mobile operators. Additionally, other findings of the study suggest that the use of FWA or WTTx for residential and enterprise customers represents another additional source of income for operators. Finally, the diversification of some operators' revenues by entering new digital markets such as financial services (e.g. fintech) and insurances services has resulted in increased revenue streams. In terms of cost structure, the huge deployment and operational costs required to roll out and maintain a 5G network to serve both new and existing customers have a direct and significant impact on the financial aspects of mobile operators.

H5: There is a significant positive impact of Infrastructure Management (IM) on the Financial Aspects (FA).

H5 evaluates whether Infrastructure Management significantly and positively affects the Financial Aspects. The results revealed that Infrastructure Management has an insignificant impact on the Financial Aspects ($\beta = 0.059$, $t = 0.491$, $p > 0.05$). Hence, H5 was not supported.

The rejection of H5 means that infrastructure management does not have a direct or significant influence on the financial aspects of mobile operators. This means that the presence of infrastructure management does not necessarily lead to changes in financial aspects. Rather, it is the use of the infrastructure by customers that ultimately influences the financial aspects. Therefore, infrastructure management is indirectly related to financial aspects via the customer interface component

H6: There is a significant positive influence of 5G Service Offerings (SO) on the Financial Aspects (FA).

H6 evaluates whether 5G Service Offerings significantly and positively affect the Financial Aspects. The results revealed that 5G Service Offerings have an insignificant impact on the Financial Aspects ($\beta = 0.055$, $t = 0.405$, $p > 0.05$). Hence, H6 was not supported.

The rejection of H6 means that the nature and quality of the 5G services provided do not have a direct and significant influence on the financial aspects of mobile operators. This means that the mere presence of 5G services does not guarantee an impact on financial aspects. Rather, it is the service consumption of customers that ultimately impacts the financial aspects. Therefore, 5G service offerings are indirectly related to financial aspects through the customer interface component.

6.5 Chapter Summary

In summary, this chapter discussed the results of the research study and presented the key insights that were drawn from the findings. First, the chapter discussed qualitative findings from examining factors that limit existing business models in supporting emerging next-generation communications networks. The results of various internal, external and hybrid (internal and

external) factors were discussed. Secondly, qualitative data results from the four business model components of the study were discussed: 5G Service Offerings (Value Proposition/BM Offerings), Customer Interface, Infrastructure Management and Financial Aspects were discussed. Finally, the quantitative results of the statistical analysis of the developed conceptual business model framework as well as the results of the study's hypothesis tests were discussed.

CHAPTER 7: CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter concludes the work with an overview of the main finding of the research study. Conclusions from the present sequential exploratory mixed-methods research are presented. In addition, the chapter highlights the implications of the study, reflection on the research process and the limitations of the study. The chapter concludes by setting an agenda for future research.

7.2 Overview of the Study Objectives

The primary objective of this research study was to design a viable business model framework that mobile operators in Africa can adopt in deploying next-generation communication networks. The secondary objectives included (1) exploring the factors that limit existing business models for mobile operators in facilitating next-generation communication networks, (2) developing a conceptual business model framework for next-generation communication networks, and (3) evaluating the conceptual business model framework for the business viability and sustainability of mobile operators.

The study objectives were achieved by answering the related research questions explored through data analysis findings and correlating the findings with the research gap in the literature.

7.3 The Overall Conclusion of the Study

The overall outcome of the present research study is the development of a business model framework for next-generation communication networks (NGCNs) and mobile operators. The business model for NGCNs applies to established mobile operators focused on 5G and beyond networks for the African market. Detailed conclusions for the three main phases of the study are presented as follows.

7.3.1 Conclusions of Qualitative Study: Phase-1 and Phase-2

For the qualitative study (Phase-1 and Phase-2), the researcher examined the factors that limit existing business models for operators in enabling 5G networks and developed a conceptual business model that can serve as a guide for 5G network operators. To conclude, all main themes and sub-themes of the qualitative data analysis were relevant to both Phase-1 and -2.

- **Limitations of exiting business models**

Based on the results of Phase-1, it can be concluded that most of the factors that make existing business models ineffective come from external rather than internal sources. Furthermore, the study concludes that the key challenges and constraints faced by existing business models for African operators are as follows.

Internal limiting factors: High 5G deployment costs, high 5G operational costs, low 5G knowledge and skills among operators' employees, lack of preparation by operators, and improper network planning and designing.

External limiting factors: Indefinite regulatory frameworks, low fibre penetration on the continent, unreliable and limited power supply, limited spectrum resources, exorbitant spectrum prices and licence fees, competition from OTT players, consumers' low digital literacy levels, high cost of 5G-supporting devices for the majority of consumers, and societal/social-economic issues.

Internal and external (hybrid) limiting factors: high 5G device costs, low 5G device maturity, limited tower infrastructure space, customer value perceptions issues, and customers' readiness issues.

In addition, it can also be concluded that some of the research findings on the above-mentioned limiting factors are supported by the literature: exorbitant spectrum prices (Agubor et al., 2021), high 5G device costs (Hatt & Jarich, 2020), low fibre penetration in Africa (Handforth, 2019), unreliable and limited power supply (Kaseke & Hosking, 2013), societal/social-economic issues (Garba et al., 2022), low 5G knowledge and skills among operators' employees (Adimula et al., 2020) and consumers' low digital literacy levels (Adimula et al., 2020).

● Conceptual Business Model Framework

The current study considers the business model framework from two perspectives in the field of management science: strategic management and technological innovation. The strategic management side focuses on value proposition, value creation, value delivery and value capture activities within the 5G value chain based on profit maximising and competition-based theory (Breuer & Lüdeke-Freund, 2014) and survival-based theory (Magretta, 2002; Sulaiman & Hashim, 2003). The technological innovation perspective views emerging 5G and beyond networks as technology enablers for operators' innovative business models to support 5G and beyond networks. Furthermore, in the African market context, secondary innovation described by G. Xu et al. (2015) is considered as the best option for the adoption of 5G technologies.

The developed business model framework consists of four main components: (1) 5G Service Offerings to support the value proposition, (2) Infrastructure Management to support value creation, (3) Customer Interface to support value delivery, and (4) Financial Aspects to support value capture.

5G Services: This component describes the value proposition or business model offerings that a mobile operator intends to offer to its customers. From the three main service classes standardised by the ITU (ITU-R, 2015) (i.e., eMBB, mMTC and uRLLC), the study concludes that the majority of African operators currently offer only eMBB services to their customers in the form of FWA and WTTx. In addition, the study concludes that the following can contribute to the successful commercialisation of 5G services by operators in Africa: (1) operators' alliance partnerships with key industry players (e.g. equipment and device manufacturers), (2) improving the 5G knowledge and skills of operators' employees through training and exchange programs with their counterparts in developed markets, and (3) active participation of operators in closing the digital divide through digital transformation programs. The study also concludes that eMBB is the best initial service offering that operators should consider. This is because eMBB is considered an entry-level use case for 5G because, unlike more advanced use cases such as mMTC and uRLLC services, it does not require major reconfigurations of the value proposition of current 4G technologies.

Customer Interface: This component describes the operator's target customers, the means of delivering 5G services to customers, and the relationships an operator builds with its customers. The study's results analysis concludes that African operators are currently targeting industrial customers, particularly the mining, manufacturing and financial services sectors, with commercial 5G services. This is primarily driven by the use of private 5G networks on customer premises such as mining sites or factories. In addition, the study concludes that corporate businesses, SMEs and residential/private customers are also targeted to some extent by the provision of FWA and WTTx services. The study also concludes that the introduction of 5G has dramatically changed customer behaviour in the following ways: Firstly, beyond uninterrupted connectivity, customers, particularly across various industries, are now demanding end-to-end 5G solutions, unlike before, where demand primarily focused on network availability, and secondly, data consumption for residential and enterprise customers has increased tremendously due to the super-fast speeds and uninterrupted connectivity that come with 5G technology. In terms of customer relationships, it is concluded that mobile operators have established business relationships with their new industrial customers such as mining, manufacturing and business enterprises. Furthermore, the study concludes that new business relationships have emerged between operators and their existing customers, particularly from the perspective of industrial customers who benefit from private 5G networks.

Infrastructure Management: This component describes how a mobile operator solves infrastructural or logistical issues when delivering value to its customers. It consists of four sub-components, namely key partners, key resources, key activities and key technologies.

Regarding key partners, the study concludes that it is critical for operators to involve partners in the development and implementation of 5G business models for two reasons: First, 5G is supported by several underlying technologies such as cloud/edge computing, Big Data, IoT, AI or ML which are not necessarily the operator's areas of expertise. Therefore, engaging technology providers such as Amazon, Microsoft, Google or IBM as partners who have extensive experience in providing services such as cloud/edge computing or infrastructure such as data centres would benefit operators in designing effective business models. Second,

partnerships with device manufacturers can play a key role in price-sensitive African markets by offering consumers 5G-supporting devices at affordable prices, thereby driving 5G adoption on the continent.

In terms of key activities, the study concludes that deploying 5G as a non-standalone (NSA) configuration is the most cost-effective way to upgrade the current 4G to 5G networks for two reasons: First, it enables a smooth and rapid transition from 4G to 5G with minimal configuration changes. Second, it reduces the huge investment costs associated with deploying the 5G core network. The study further concludes that sharing physical infrastructure (e.g. tower space), active resources (e.g. transport networks) and passive resources (e.g. antennas) with other operators is a key activity with substantial benefits such as providing additional revenue streams and reducing CapEx and OpEx for operators.

Regarding key resources, the study concludes that despite the relatively available 5G spectrum resources in most African countries, spectrum acquisition and the issuance of operating licences by regulators remain challenging for two main reasons: First, the extremely high spectrum prices and licence fees are a deterrent, particularly for new market entrants such as private and micro-operators. These exorbitant prices and fees have a significant impact on operators' cost structures. Second, the bureaucratic and complex spectrum auction and licencing process hinders the rapid rollout of 5G networks.

When it comes to key 5G technologies, the study concludes that a significant number of commercial 5G network operators in Africa have deployed at least one of the following 5G technologies: massive MIMO, beamforming, network densification, network slicing, millimetre wave (mmWave) and IoT. In addition, from the analysis results, the researcher concludes that new technologies such as network slicing, AI, ML and IoT, if successfully introduced, can improve operational efficiency and increase productivity within the 5G value chain.

Financial Aspects: This component describes the cost structure, revenue model and financial sustainability of a mobile operator and consists of two sub-components: cost structure and

revenue streams. Based on the research results, it is concluded that the introduction of 5G leads to changes in the cost structures for mobile operators. Additionally, the study concludes that designing effective business models must take into account changes in cost structures to make 5G more affordable for consumers. The study also concludes that 5G networks require huge capital investments, resulting in higher deployment costs that most African operators cannot afford. On the revenue side, the study concludes that the deployment of private 5G networks for industrial customers and FWA for private and corporate customers has created new revenue streams for mobile operators. Furthermore, the study concludes that sharing infrastructure and resources with other service providers as well as creating revenue sharing models with third-party alliance partners represent additional sources of revenue for operators. Finally, it is concluded that revenue diversification through the provision of digital services such as fintech and insurance services contributes to the financial sustainability of mobile operators.

7.3.2 Conclusions of Quantitative Study: Phase-3

In concluding the quantitative findings of Phase-3 of the current research study, four of the six research hypotheses formulated were significantly supported, while two were insignificant and therefore rejected. From the quantitative research results, the study comes to the following conclusions based on the outcome of the hypothesis testing:

- Infrastructure management has a positive and significant impact on a mobile operator's 5G service offerings. Therefore, underlying infrastructure management by an operator is required for 5G services to take effect.
- Infrastructure management has a positive and significant impact on a mobile operator's customer interface. This means that the customer interface relies heavily on an operator's management of the infrastructure.
- 5G service offerings have a positive and significant impact on a mobile operator's customer interface. Therefore, the nature and quality of 5G services provided by a mobile operator have a direct and major impact on the customer interface.

- Customer interface has a positive and significant impact on the financial aspects of a mobile operator. This means that the presence of customer interface has a direct and significant impact on the financial aspects of an operator's business model.
- Infrastructure management does not have a direct or significant impact on the financial aspects of a mobile operator. This means that the presence of infrastructure management does not necessarily impact the financial aspects of a mobile operator.
- 5G service offerings do not have a direct or significant impact on the financial aspects of a mobile operator. This means that the mere presence of 5G services does not guarantee an impact on financial aspects.

7.3.3 Interpretation of Phase 1, 2 and 3

The current research study (1) firstly analysed and understood factors that affect existing business models in facilitating 5G networks deployed by mobile operators. (2) Secondly, the research identified a number of key factors related to 5G technologies and developed a conceptual business model framework based on the underlying relationships between these factors, and (3) finally testified the conceptualised business model framework for 5G network operators. After concluding the three research phases, the final conceptual business model framework is shown in Figure 7.1

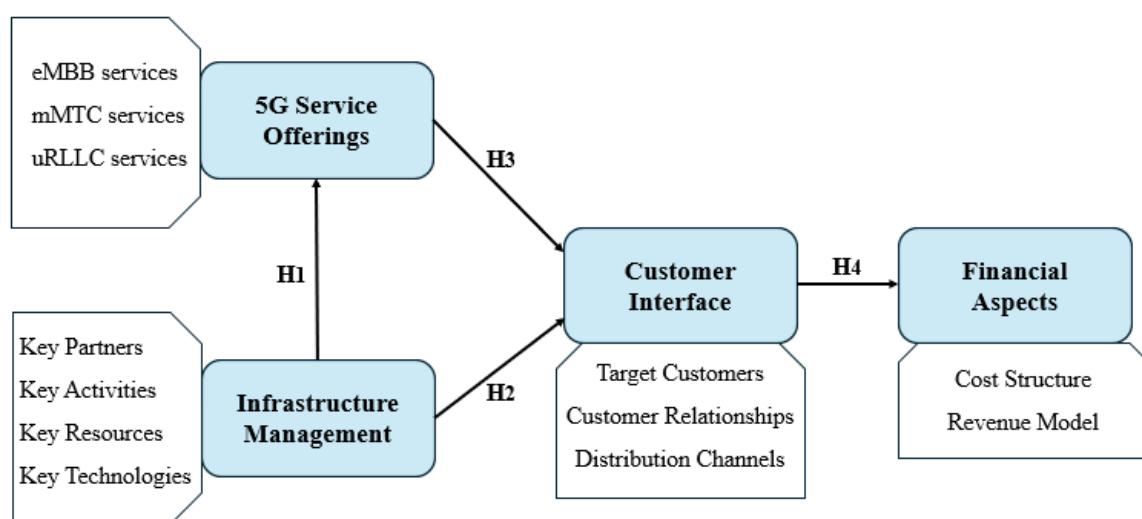


Figure 7.1: Final conceptual business model framework (compiled by researcher)

7.4 Implications and Contributions of the Study

The current research study makes the following theoretical, methodological and practical contributions.

7.4.1 Theoretical and Conceptual Contributions

Theoretically, this research study makes a significant contribution in the context of the African mobile communications market. The study was conducted on employees of well-established mobile operators that have deployed or are in the process of launching 5G network technologies. Previous research indicates the significance of investing in 5G networks especially in developing economies such as sub-Saharan Africa (Campbell et al., 2017a). According to Teece (2010), the business model concept has received little attention within economics and business management study topics. Furthermore, Chesbrough (2010) claims that companies may have extensive investments and processes for exploring new technologies, however they often lack the ability to develop business models that facilitate the new technologies.

The literature suggests that there is a critical link between technological evolution and business model implementation (Schiavi & Behr, 2018). In the context of 5G networks, Banda et al. (2022a) insist that limited research evidence exists on the link between 5G network technologies and the business model concept. Moreover, there is no standardised and acknowledged definition of the business model for 5G and beyond networks. Additionally, the link between 5G and the business model concepts with focus on the African market has not been explored in the literature.

The present study addresses the above research gap. The study investigates and conceptualises business models for 5G and beyond networks for mobile operators in Africa. It links three concepts: business model, 5G networks and management science fields (strategic management and technological innovation) by developing a conceptual framework. The validated conceptual business model framework addresses the main research question: *How can a viable business*

model framework for next-generation communication networks (5G and beyond) be designed to achieve increased economic value for mobile operators in Africa?

Conceptually, the present research study makes an important contribution to research in the African context by exploring the following: (1) Significance of 5G in Africa, (2) 5G key investment beneficiaries within the African market, (3) 5G deployment progress, current status and future forecast, (4) African challenges in 5G deployment, (5) proposed adoption strategy for 5G technologies in Africa, and (6) impact of regulatory policies on 5G deployment. In addition, by exploring the importance of 5G networks as an enabler of business models of mobile operators in Africa, this adds to the contextual knowledge on 5G business model development.

7.4.2 Methodological Contributions

This research study used a sequential exploratory mixed-methods approach. The qualitative part (Phases 1 and 2) of the study was conducted using reflexive thematic analysis (Braun & Clarke, 2019) which was implemented in MAXQDA 24 software. The quantitative part (Phase 3) was conducted using PLS-SEM (Joe F Hair et al., 2012) analysis and was conducted using SPSS and SmartPLS software. This methodological approach significantly contributes to the literature as no previous work has conducted a sequential exploratory mixed-methods study using a combination of such analyses and software according to the researcher's knowledge.

This study was conducted in four phases: Phase 1, exploration and study of mobile operators' existing business models and identification of factors impacting such business models using qualitative methods to formulate case studies. Phase 2, investigating and understanding theoretical constructs and their connections leading to the development of a conceptual framework using the findings from Phase 1. Phase 3, quantitatively testing the conceptualised business model framework using research hypotheses formulated in Phase 2. Phase 4, interpreting and presenting the research findings.

The combination of inductive and deductive approaches in theory development and the application of both interpretivism and post-positivism research philosophies brought a deeper

and detailed understanding of the research problem. This uniquely and significantly positions this study as far as methodological contribution is concerned.

7.4.3 Practical Contributions

In addition to the theoretical and methodological contributions that this study has made, there are practical considerations that could benefit various stakeholders within the 5G value chain and ecosystem. These include practitioners, policy makers and researchers.

- **Practical implications for practitioners**

The output of this study offers several practical implications for practitioners such as top executives, senior managers and project managers of mobile operators. There are various options available when it comes to developing mobile operators' business models. However, most of these options have targeted developed and mature markets (Jones & Comfort, 2020; Patwary et al., 2020; Peppard & Rylander, 2006) where the business environments are different from the African market which is yet to mature. Moreover, most operators are still uncertain of the optimum business model to implement since the business landscape of 5G networks is still new for most markets (Patwary et al., 2020). Therefore, the results of this study provide guidelines to African mobile operators that have launched 5G networks or those considering doing so. The study further brings an understanding of ways of incorporating 5G networks in operators' business model development. In particular, the composition and relationships of the study's four business model components: 5G service offering, customer interface, infrastructure management and financial aspects. Mobile operators that do not have any documented business model or those struggling to develop one can use this research study as a guideline to develop effective, yet unsophisticated 5G business models. Additionally, the significance of the study is that it highlights the importance of developing innovative business models that address the potentially disruptive impact of next-generation networks in an African setting. This will enable mobile network operators to increase their market value, gain competitive advantage and improve the business environment within existing and emerging laws and regulatory policies (Manenti & Scialà, 2013).

● **Practical implications for regulators and policymakers**

The envisioned socio-economic benefits of 5G and beyond networks have received a lot of interests from regulators and policymakers as they are key stakeholders in the mobile communication ecosystem and are likely to be key beneficiaries of 5G network technologies (Manenti & Scialà, 2013). However, most policymakers are facing significant challenges concerning 5G deployment in their respective countries, including Africa (Suryanegara, 2016). As confirmed by some interview participants of the study, Africa has a tendency of trailing behind in terms of technological advancement and in establishing supportive regulatory frameworks. Therefore, even when emerging technologies like 5G are being introduced, most countries are not yet ready to provide regulatory frameworks that govern the introduction and adoption of such technologies. In addition, when it comes to the regulation of OTT content service providers, most African regulators have adopted a reactive rather than a proactive approach. This has been a source of frustrations for mobile operators since the use of operators' infrastructure by OTT services have not been sufficiently regulated as desired by operators.

Another significant implication of this study on the part of regulators and policymakers is the revelation of the bureaucratic and costly processes involved in acquiring spectrum and in issuing of operating licences, especially for new market entrants. The weakness of communications regulators in emerging markets and the lack of an independent research and development arm of the regulators are evident in the allocation of spectrum for 5G services.

7.5 Limitations of the study

All research studies have limitations to a certain extent (Bhakar & Mathur, 2016; Chakanyuka, 2022). According to Price and Murnan (2004), the limitations of the study are those characteristics of the design or methodology that impact or influence the interpretation of the findings from the research investigation. Price and Murnan (2004), further describe limitations as the constraints on the validity, reliability, application to practice, and utility of the findings that result from the selected design or the methodology employed. This research study

encountered the following limitations which impacted the research design, methodology, analysis and results.

- *Sample Size:* The sample size is more critical in quantitative studies than in qualitative studies (Creswell & Creswell, 2018; Saunders et al., 2019). In the current study, the sample size for the quantitative data collection part was not as adequate as desired because there are few well established MNOs in Africa that have deployed or are in the process of deploying next-generation communication networks. Moreover, most MNOs have few employees with expertise in 5G and beyond networks.
- *Lack of prior research study on the topic:* Most of the current literature on business models for next-generation communication networks has been conducted for developed markets rather than for the African market. Henceforth, it was a challenge to identify the scope of work that had so far been done in this area from the African perspective.
- *Timing of the study:* This investigation was conducted during the period when few MNOs in Africa had deployed full-scale 5G and beyond networks. Therefore, data collection period was not quite suitable for most respondents as they did not have solid knowledge on the topic.
- *Data collection process:* The issuance of permission letters from some MNOs to conduct data collection took time and, in some cases, no permission was granted. This delayed the data collection phase of the study. Moreover, in the initial stages of the study, the COVID-19 pandemic did impact the data collection process in terms of logistics.
- *Data collection research instruments:* Some respondents were discreet when answering sensitive questions due to their respective company policies and contractual obligations. This affected the accuracy of the collected data.

7.6 Reflection on the Research Process

In this section, the researcher reflects on the PhD journey and the entire research process by providing some insights into the challenges and successes of the study. The researcher found

the process of data collection and analysis both interesting and challenging. The first challenge was to formulate the research interviews for the qualitative study (Phase 1 and 2) and then design an appropriate survey questionnaire for the quantitative study (Phase 3). After further literature review and consultations with research supervisors, final interview questions and a survey questionnaire were formulated and designed.

The key challenge before starting data collection was the delay or refusal in issuing permission letters by some mobile operators to allow the researcher to conduct data collection from their employees. Furthermore, the response rate during the data collection process was low and slow for both qualitative and quantitative studies. The lesson from these experiences is that the researcher must be persistent and patient in the face of such challenges. In addition, the researcher must politely communicate the academic relevance of the study to selected participants and their representative organisations.

The use of qualitative and quantitative data provided an enrichment and valuable combination for understanding the phenomenon of interest. This was despite the application of different philosophical approaches to the two research methods: interpretivism (qualitative study) and post-positivism (quantitative study). Finally, the findings of this study are relevant not only to academic researchers but also to industry practitioners and policy makers.

7.7 Recommendations for Future Research

The outcome of this research study significantly contributes to the literature on business models and next-generation communication networks in the field of management sciences. Having highlighted the significance and implications of this study alongside the stated limitations, future research will complement this study. The following are the recommendations for future research:

- The time when this research was conducted, few mobile operators in Africa had launched commercial 5G networks. This led to a small sample size, particularly for the quantitative part which is sensitive to sample size. Future research should consider a wider geographical

area by conducting a comparative study between emerging markets and developed markets.

- The present study is from industry perspective. Future research can further explore consumer-perspective on the adoption of 5G and beyond networks. Additionally, since the present research focused primarily on mobile operators that are established within the mobile cellular markets, future work can incorporate other entities such as digital start-ups and SMEs.
- The current study only focused on business models for 5G cellular network providers. Although the impact of the role OTT content providers and other actors has been considered, future research can specifically focus on business model design for OTT content providers within the African contexts and perhaps make comparative cases with the present study.
- The present study considered the business model concepts from both the strategic management and technological innovation management perspectives. Future research can consider other business model areas of research such as organisational theory, e-business, entrepreneurial, marketing, accounting and blue ocean theory.
- Finally, future research should consider advanced forms of business models for mobile operators in Africa. These include Green 5G/6G business models, Integrated 5G-IoT-AI business models and 5G/6G-based Digital Twins business models. In addition, the role of next-generation end-to-end network testbeds for testing business models, as well as the incubation and development of innovative 5G mobile apps and services such as MPESA, can be considered for future research.

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APPENDIX A: RESEARCH INSTRUMENTS

A1: Interview Cover Letter

Invitation to participate in an academic research interview

Thesis Title: Business Models for Next-generation Communication Networks and Mobile Operators in Africa

Dear Sir / Madam,

My name is Laurence Banda and I am PhD student at Wits Business School (WBS), University of the Witwatersrand, Johannesburg. This research study aims to investigate business models for next-generation communication networks (i.e., 5G networks and beyond) and mobile operators in Africa. My project supervisors are Prof. Mjumo Mzyece and Prof. Fisseha Mekuria.

As part of this project, I would like to invite you to take part in an interview. This activity will involve a single interview and will take between 60 and 90 minutes. The interview will be conducted online using either zoom or teams platforms during working hours at your most convenient times. With your permission, I would also like to audio / video record the online interview using a digital device. This recording will be stored in the researcher's academic laptop and only the researcher will have access to this recording. It will be deleted after 6 years.

There will be no personal costs to you if you participate in this project. You will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. Furthermore, your participation in the interview is voluntary and based on your current job position you may be identifiable. I will be using a pseudonym to represent your participation in my final research report. If you experience any form of discomfort at any point in this process, we will stop the interview or resume another time.

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. The data collected from this research project will be stored in the researcher's laptop and will be kept for 6 years. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Yours sincerely,

Researcher:

Laurence Banda, 1855961@students.wits.ac.za

Research Supervisors:

Prof. Mjumo Mzyece, mjumo.mzyece@nwciowa.edu

Prof. Fisseha Mekuria, Fisseha.mekuria@mau.se

A2: Research Interview Schedule



Interview Schedule

PhD thesis on Business Models for Next-generation Communication Networks and Mobile Operators in Africa.

Interview No.	
Position of Interviewee	
Department / Function Area	
Name of Mobile Operator	
Type of Business Model	
Company Ownership	Private/Public/Joint venture/ PPP/ Any other
Major Products/Services	
Date of Interview	

Section A: General Views

1. Do you think we need next-generation (5G) communication networks in Africa? If so, why?
2. How are you adapting your work to changes in the mobile networks industry brought by 5G networks?

3. How are 5-6G networks expected to contribute towards the sustainable digitalization and digital society creation in developing countries?
4. 5-6G networks and associated emerging digital technologies are expected to enhance the process and quality of public and industrial processes across various sectors/industries. Are African MNOs prepared to benefit from this?
5. How can a mobile operator develop a 5G strategy to effectively utilize emerging technologies in the era of 5G and future releases?
6. What challenges do you expect that a mobile operator may face during the introduction of 5G networks?

Section B: Next-generation Communication Networks and the Business Model Concept

i. 5G Key Enabling Technologies

7. Which 5G key enabling technologies has your company employed so far in order to offer current 5G services to the customers?
8. How do new technologies such as Network Slicing (NS), Internet of Things (IoT), and Artificial Intelligence (AI) /Machine Learning (ML) impact mobile operators' business models?
9. Which network solution between non-standalone (NSA) and standalone (SA) has your company deployed so far?

ii. Current Business Models for Mobile Operators

10. What do you understand by the term business model?
11. What are the main challenges and shortcomings of the current business models for mobile operators?

12. In comparison to competitors how would you describe your company's existing business model?

13. How does the introduction of 5G networks change your organisation's current business model?

iii. Customer Interfaces

14. What types of customers do you expect your organisation to target in the era of 5G networks?

15. How will 5G networks change the behaviour of your organisation's customers?

16. Has the introduction of 5G networks led to any new customers for your company? If yes, can you please give examples?

17. Has the introduction of 5G networks by your company led to any new relationships with your existing customers? If so, can you cite a few examples?

iv. 5G Services and Applications

18. In your opinion, which current 5G services deliver value to your customers and capture value for your organisation? Can you cite a few examples?

19. In your view, what are the steps or changes that a mobile operator can take to commercialise 5G services to the vertical industries (e.g., health, logistics, finance, etc.), government and end-users?

20. Which service class: eMMB (ultra-data rates), mMTC (ultra-connection density) or uRLLC (ultra-low latency) do you think is appropriate as the starting point for your organisation?

v. Financial Aspects

21. What kind of payment schemes/pricing strategies has your organisation introduced for 5G services?

22. Did the introduction of 5G networks lead to any new form of revenue schemes? If so, can you mention a few?

23. As per you, please specify any **three** most important challenges while re-inventing revenue schemes of a business model in the era of 5G networks?

24. Do you think the business model for 5G networks leads to any changes in the cost structure for mobile operators? If yes, how can those changes be incorporated to make it affordable for 5G network customers?

vi. Infrastructure Management

25. In your opinion, what is the most cost-effective way for mobile operators to upgrade their 4G networks to 5G networks?

26. Do you think it is correct to involve partners in the development and implementation of business models for 5G networks? If yes, how can they be involved? Please share a few examples if any.

27. Do you think network resources and infrastructure sharing is beneficial to mobile operators who have deployed 5G? If yes, how is it beneficial? Please, give a few examples if any.

28. Which spectrum resources and what type of operating licence does your organisation have for 5G networks?

Thank you so much for your valuable responses. This information will be used purely for academic and research purposes.

A3: Questionnaire Cover Letter

Invitation to participate in an academic research survey questionnaire

Thesis Title: Business Models for Next-generation Communication Networks and Mobile Operators in Africa

Dear Sir / Madam,

My name is Laurence Banda and I am PhD student at Wits Business School (WBS), University of the Witwatersrand, Johannesburg, South Africa. This research study aims to investigate business models for next-generation communication networks (i.e., 5G networks and beyond) and mobile operators in Africa. My research supervisors are Prof. Mjumo Mzyece and Prof. Fisseha Mekuria. As part of this academic research, I would like to invite you to participate in filling a survey questionnaire which will take about 15~20 minutes to complete.

This is purely an academic study. The validity of this study depends on your integrity in filling out the questionnaire honestly. The researcher will ensure that all information collected is confidentially handled; only aggregated data will be used for analysis. No individual or organisational information will be analysed independently or published during the dissemination of findings for this study. If you are willing to participate you can click on the link below which will take you to the questionnaire.

https://wits.eu.qualtrics.com/jfe/form/SV_0Sz3BUEqXiEDVHM

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Contacts

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A4: Research Questionnaire

Research Title: Business Models for Next-generation Communication Networks and Mobile Operators in Africa

SURVEY OPINION

Perceptions of employees on business models for next-generation communications networks (i.e., 5G networks and beyond).

Please answer the following questions by marking appropriate answer(s) with an (X). Your responses will be kept fully confidential and will be strictly used for academic research purpose only.

Section A: General Information

This section seeks your background information. Please indicate your answer by marking (X) on the appropriate box.

1. Please indicate your gender

Male	1
Female	2
Others	3
Prefer not to say	4

2. Please indicate your position occupied in your company

Owner	1
Co-owner	2
Top Executive	3
Senior Manager	4
Middle-level Manager	5
Employee	6
Any other	7

3. Please indicate your functional area in your company

Network Operations/Technical	1
Information Technology (IT)	2
Finance	3
Marketing/Sales	4
Human Resource	5
Purchasing/Supply Chain	6
Logistics	7
Any other	8

4. Please indicate the number of years that you have worked in the mobile communication sector

< 1 year	1
2 – 5	2
5 – 10	3
> 10	4

The questions below will seek your opinions regarding business models for next-generation communication networks and mobile operators in Africa.

Below are statements about: *Infrastructure Management, 5G Service Offerings, Customer Interface and Financial Aspects*. You can indicate the extent to which you agree or disagree with the statement by the corresponding number in the 5-point scale below:

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Please, indicate your answer by marking (X) on the appropriate box.

Section B: Infrastructure Management (MI)

Please indicate to what extent you agree or disagree with each statement regarding the infrastructure management for a mobile operator deploying next-generation communication networks.						
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
		1	2	3	4	5
IM 1	The company has partnered with other network partners (e.g. infrastructure owners, micro operators, mobile virtual network operators, content providers, etc.) in the deployment of next-generation networks.					
IM 2	The network architecture (radio access, backhaul and core network) for next-generation networks is simple and easy to implement when compared to legacy 2G, 3G and 4G networks.					
IM 3	5G technologies will support the digital inclusion and economic empowerment of the disadvantaged communities through innovative digital business start-ups and enterprises.					
IM 4	The company avoids penalties, fines and legal costs for non-compliance with regulations and policies.					
IM 5	The emerging 5G and beyond networks will be able to compete with existing broadband services like WiFi and FTTx in terms of value creation, value delivery and value capture.					

Section C: 5G Service Offerings (Value Proposition/ BM Offerings) (SO)

Please indicate to what extent you agree or disagree with each statement regarding 5G service offerings (value proposition/ BM offerings) for a mobile operator deploying next-generation communication networks.						
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
		1	2	3	4	5
SO 1	The company offers at least one of the three main service classes (i.e. eMBB, mMTC, uRLLC) of next-generation networks.					
SO 2	Customers are generally satisfied with the next-generation service offering by the company.					
SO 3	The response from local governments, public enterprises, private enterprises and other vertical industries regarding the adoption of next-generation services in their daily tasks has been satisfactory.					
SO 4	Multi-service characteristic of next-generation networks poses a challenge to the company’s design of an effective business model.					

Section D: Customer Interface (CI)

Please indicate to what extent you agree or disagree with each statement regarding customer interface for a mobile operator deploying next-generation communication networks.						
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
		1	2	3	4	5
CS 1	Introduction of next-generation networks has resulted in new relationships between the company and the existing customers.					
CS 2	Introduction of next-generation networks has attracted new company's customers from various sectors.					
CS 3	The company's existing distribution channels have been altered since the deployment of next-generation networks.					
CS 4	The company has devised strategies for customer acquisition and customer retention in the era of next-generation networks.					

Section E: Financial Aspects (FA)

Please indicate to what extent you agree or disagree with each statement regarding financial aspects for a mobile operator deploying next-generation communication networks.						
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
		1	2	3	4	5
FA 1	New pricing and charging schemes have been introduced since the adoption of next-generation networks.					
FA 2	Since deploying next-generation networks, the company's return on investment and sales is well above mobile communication industry average.					
FA 3	Since deploying next-generation networks, the company's profit and growth is well above mobile communications industry average.					
FA 4	Since deploying next-generation networks, the company's market share and sales volume growth is well above mobile communications industry average.					
FA 5	In general, there has been overall improvement in company's profitability, after deploying next-generation networks.					
FA 6	There has been overall reduction in the company's network rollout costs, capital expenditure and operational expenditure after deploying next-generation networks.					
FA 7	The current regulatory and operating licence costs are affordable to mobile operators.					

Thank you very much for your participation

APPENDIX B: ETHICS CLEARANCE CERTIFICATE

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG



Research Office

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

CLEARANCE CERTIFICATE

PROTOCOL NUMBER: H21/09/02

PROJECT TITLE

Business Models for Next-generation Communication Networks
and Mobile Operators in Africa

INVESTIGATOR(S)

Mr L Banda

SCHOOL/DEPARTMENT

Wits Business School/

DATE CONSIDERED

17 September 2021

DECISION OF THE COMMITTEE

Approved
Risk Level: Minimal
Two Year Extension

EXPIRY DATE

21 November 2026

DATE

22 November 2021

CHAIRPERSON

(Professor J Watermeyer)

cc: Supervisor : Professor M Mzyece

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **A SIGNED COPY** returned to the Secretary electronically. 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 be contemplated from the research procedure as approved I/we undertake to submit an amendment of the protocol to the Committee. **I/we agree to completion of a regular progress report. For Minimal and Low Risk studies, this is due annually on 31 December. For Medium and High Risk studies, this is due twice annually on 30 June and 31 December.**

Signature

6 / 10 / 2023

Date

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

APPENDIX C: ADDITIONAL QUALITATIVE ANALYSIS RESULTS

C1: Interview Participants Documents

MAXQDA 24

Documents

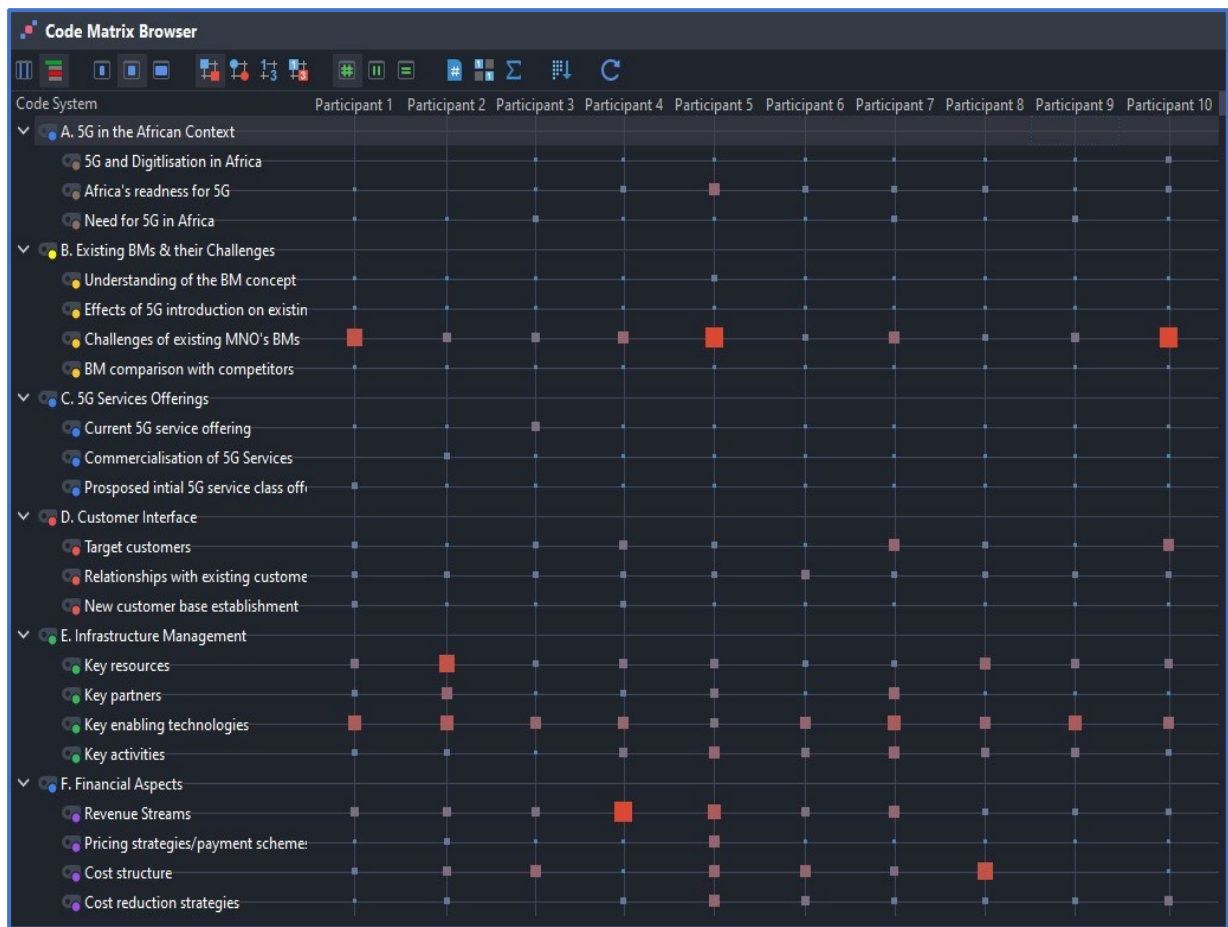
Documents	775
Interview Transcripts	775
Participant 1	72
Participant 2	70
Participant 3	67
Participant 4	81
Participant 5	111
Participant 6	69
Participant 7	78
Participant 8	71
Participant 9	71
Participant 10	85
Audio Interviews	0
Participant 10	0
Participant 9	0
Participant 8	0
Participant 7	0
Participant 6	0
Participant 5	0
Participant 4	0
Participant 3	0
Participant 2	0
Participant 1	0
Sets	0

C2: Research Generated Codes

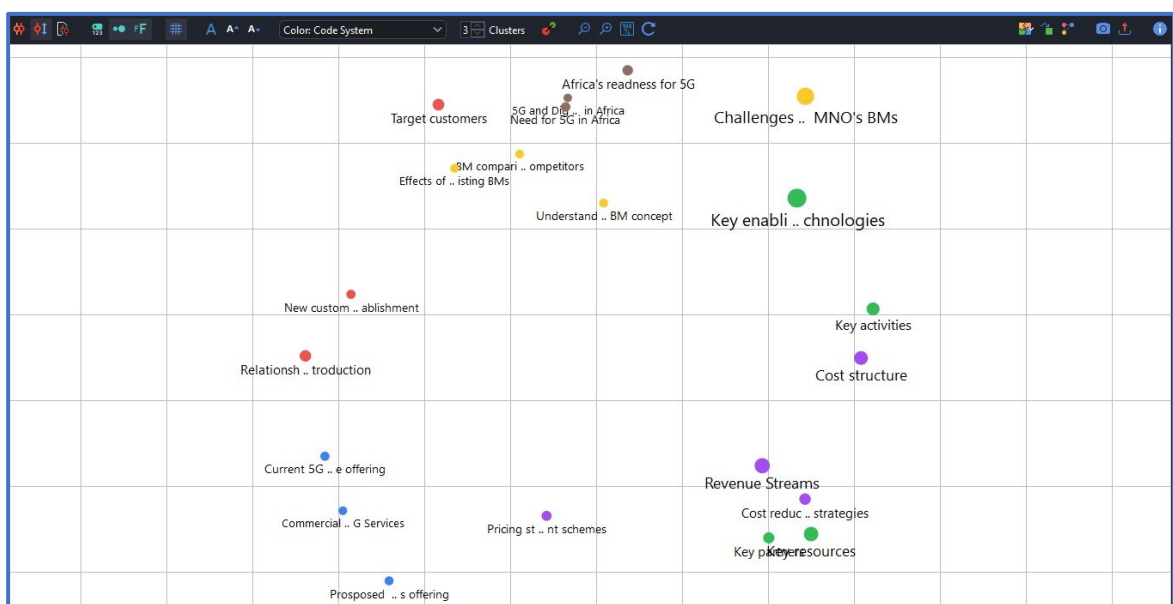
MAXQDA 24

Codes

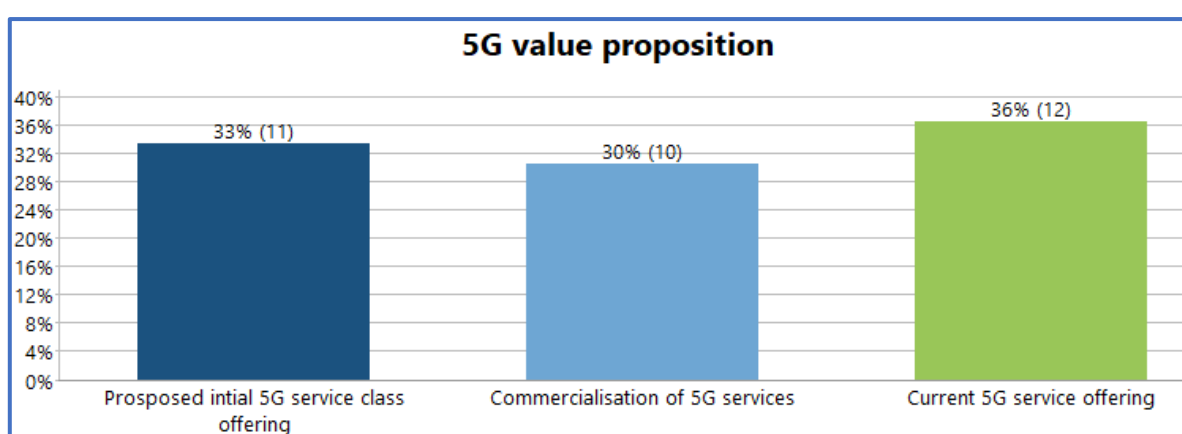
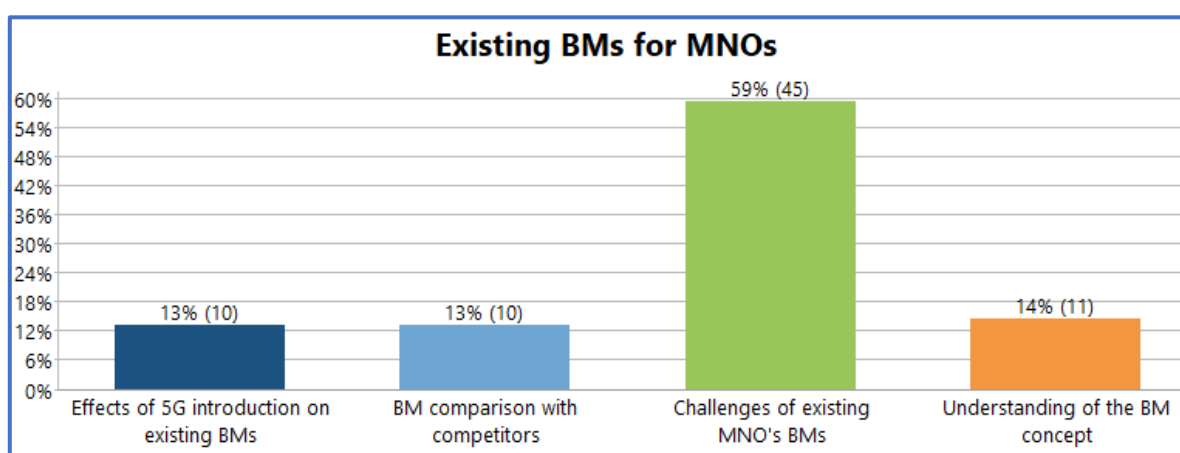
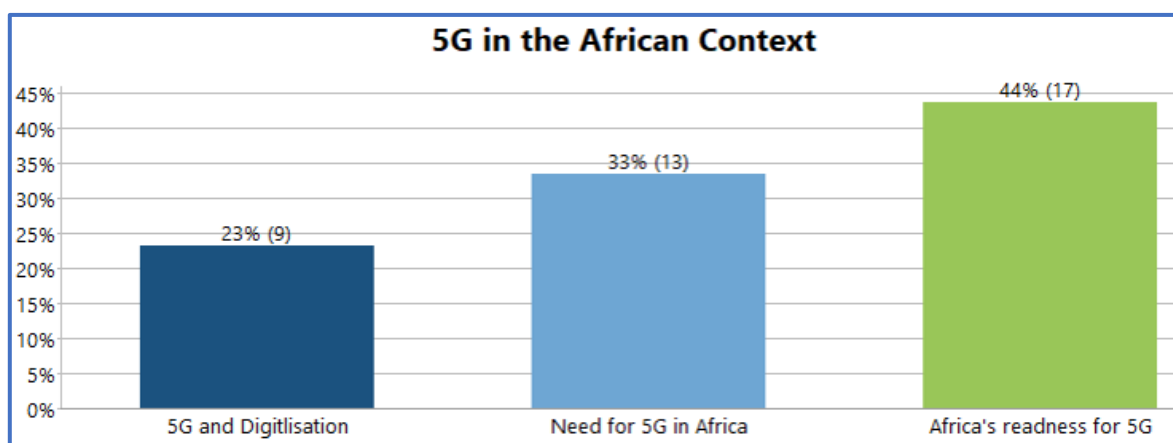
C3: Research Code Matrix Browser

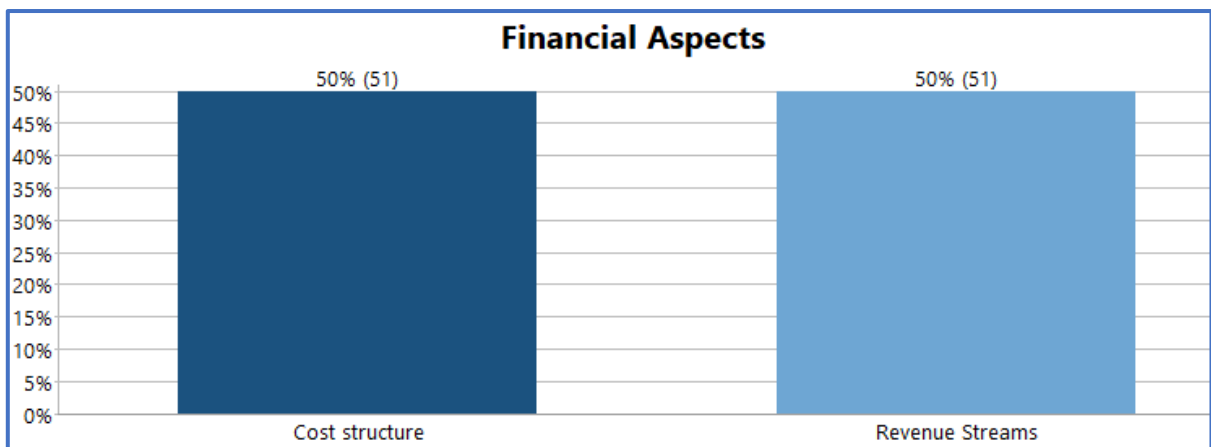
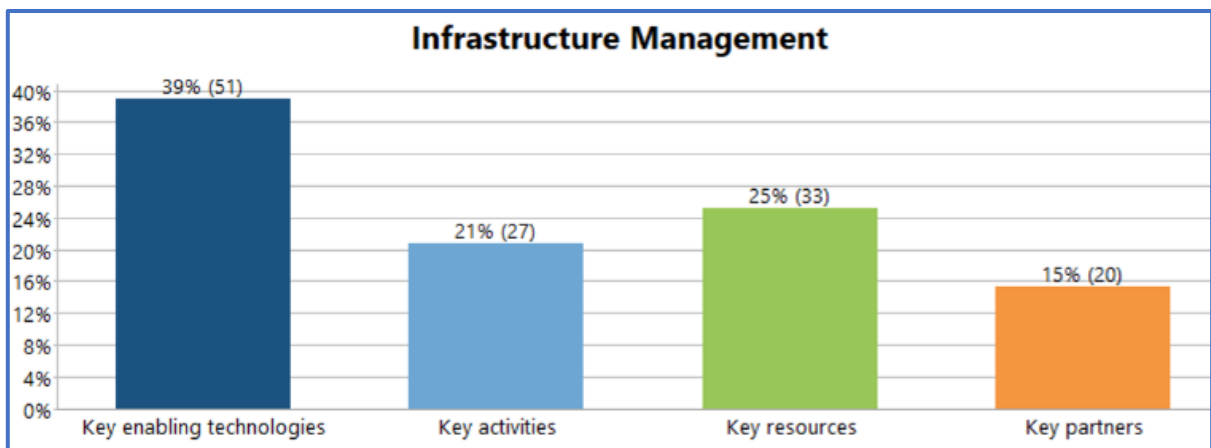
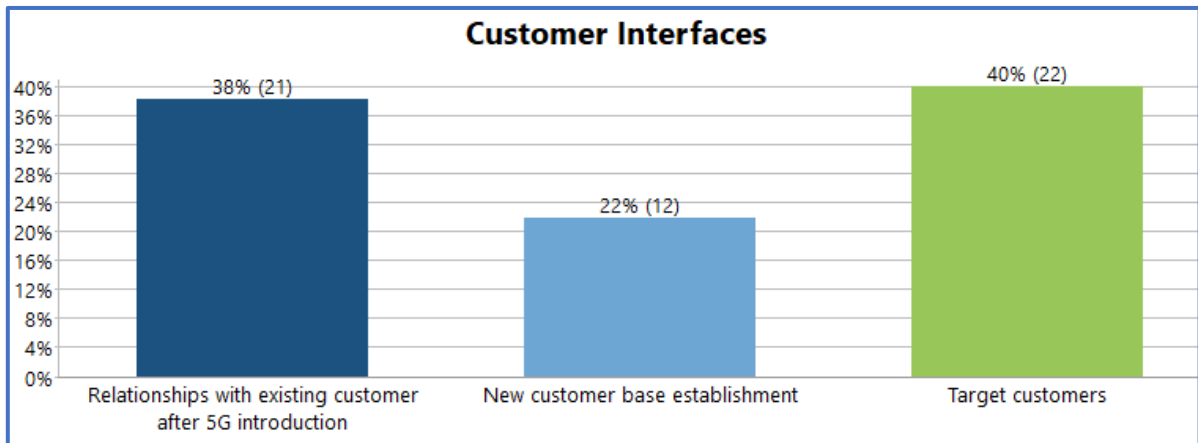


C3: Research Code Map



C4: Sub-code Statistics



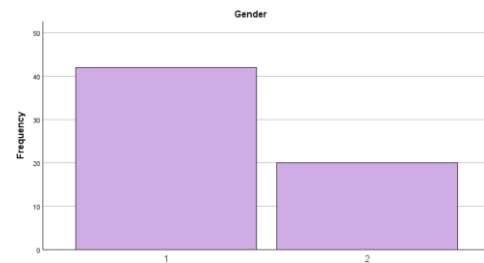


APPENDIX D: ADDITIONAL QUANTITATIVE ANALYSIS RESULTS

D1: Descriptive Statistics – Frequencies

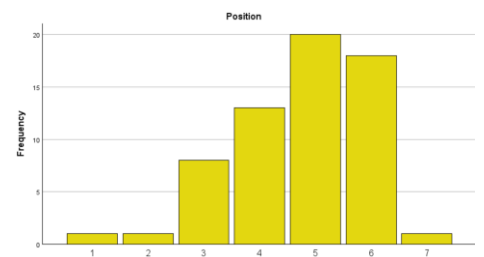
● Gender

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	42	67.7	67.7	67.7
	2	20	32.3	32.3	100.0
	Total	62	100.0	100.0	



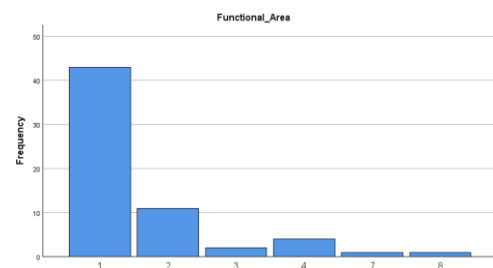
● Position in the Company

Position					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	1.6	1.6	1.6
	2	1	1.6	1.6	3.2
	3	8	12.9	12.9	16.1
	4	13	21.0	21.0	37.1
	5	20	32.3	32.3	69.4
	6	18	29.0	29.0	98.4
	7	1	1.6	1.6	100.0
	Total	62	100.0	100.0	



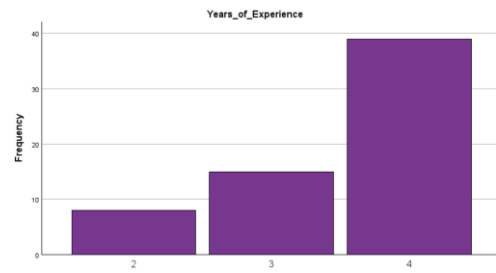
● Functional Area

Functional_Area					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	43	69.4	69.4	69.4
	2	11	17.7	17.7	87.1
	3	2	3.2	3.2	90.3
	4	4	6.5	6.5	96.8
	7	1	1.6	1.6	98.4
	8	1	1.6	1.6	100.0
	Total	62	100.0	100.0	



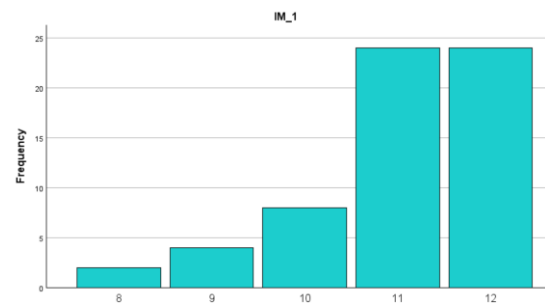
- Years of Experience

Years_of_Experience					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	8	12.9	12.9	12.9
	3	15	24.2	24.2	37.1
	4	39	62.9	62.9	100.0
	Total	62	100.0	100.0	

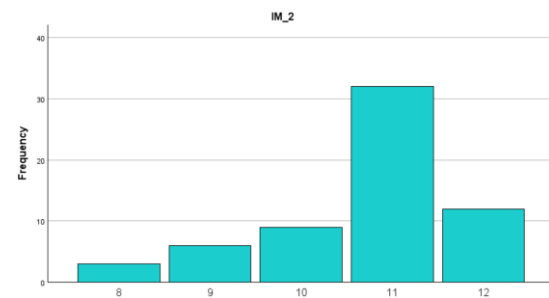


- Infrastructure Management (IM)

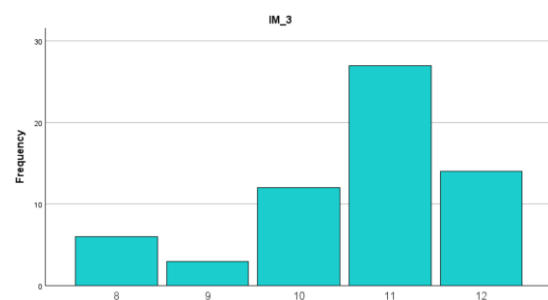
IM_1					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	8	2	3.2	3.2	3.2
	9	4	6.5	6.5	9.7
	10	8	12.9	12.9	22.6
	11	24	38.7	38.7	61.3
	12	24	38.7	38.7	100.0
	Total	62	100.0	100.0	



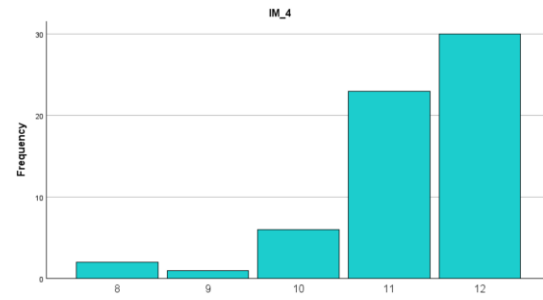
IM_2					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	8	3	4.8	4.8	4.8
	9	6	9.7	9.7	14.5
	10	9	14.5	14.5	29.0
	11	32	51.6	51.6	80.6
	12	12	19.4	19.4	100.0
	Total	62	100.0	100.0	



IM_3					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	8	6	9.7	9.7	9.7
	9	3	4.8	4.8	14.5
	10	12	19.4	19.4	33.9
	11	27	43.5	43.5	77.4
	12	14	22.6	22.6	100.0
	Total	62	100.0	100.0	



IM_4					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	8	2	3.2	3.2	3.2
	9	1	1.6	1.6	4.8
	10	6	9.7	9.7	14.5
	11	23	37.1	37.1	51.6
	12	30	48.4	48.4	100.0
Total		62	100.0	100.0	

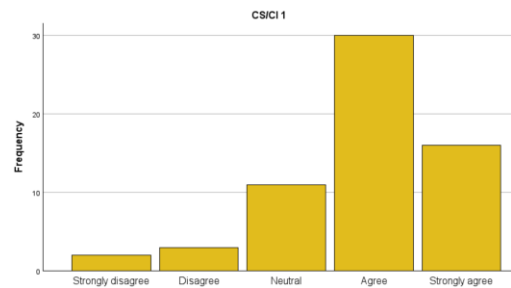


IM_5					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	8	3	4.8	4.8	4.8
	9	22	35.5	35.5	40.3
	10	16	25.8	25.8	66.1
	11	16	25.8	25.8	91.9
	12	5	8.1	8.1	100.0
Total		62	100.0	100.0	

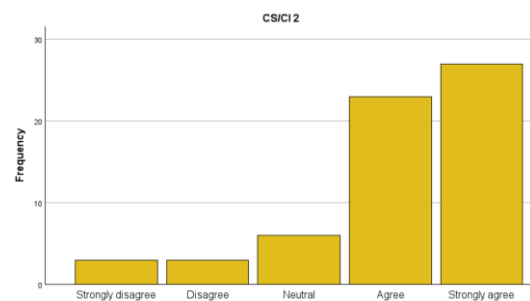


- **Customer Segment/Customer Interface (CS/CI)**

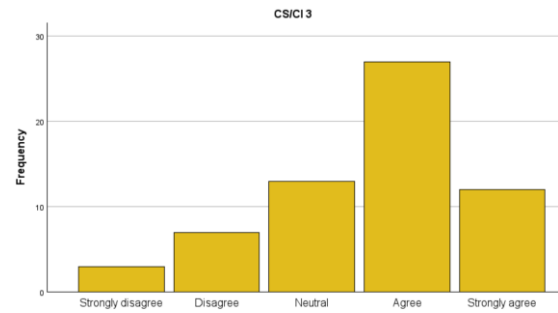
CS/CI 1					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	3.2	3.2	3.2
	Disagree	3	4.8	4.8	8.1
	Neutral	11	17.7	17.7	25.8
	Agree	30	48.4	48.4	74.2
	Strongly agree	16	25.8	25.8	100.0
Total		62	100.0	100.0	



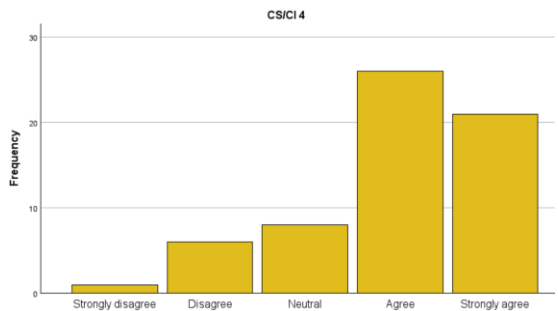
CS/CI 2					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	4.8	4.8	4.8
	Disagree	3	4.8	4.8	9.7
	Neutral	6	9.7	9.7	19.4
	Agree	23	37.1	37.1	56.5
	Strongly agree	27	43.5	43.5	100.0
Total		62	100.0	100.0	



CS/CI 3					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	4.8	4.8	4.8
	Disagree	7	11.3	11.3	16.1
	Neutral	13	21.0	21.0	37.1
	Agree	27	43.5	43.5	80.6
	Strongly agree	12	19.4	19.4	100.0
	Total	62	100.0	100.0	

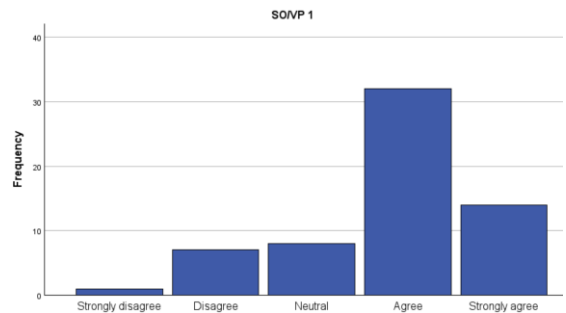


CS/CI 4					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.6	1.6	1.6
	Disagree	6	9.7	9.7	11.3
	Neutral	8	12.9	12.9	24.2
	Agree	26	41.9	41.9	66.1
	Strongly agree	21	33.9	33.9	100.0
	Total	62	100.0	100.0	

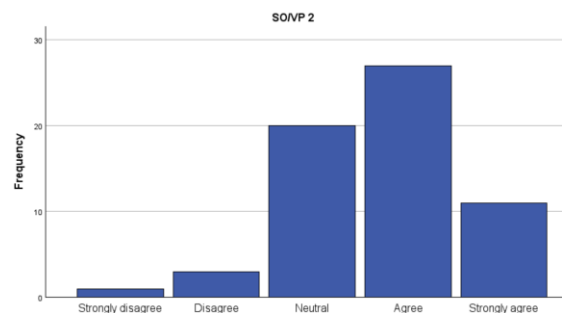


- Service Offerings/Value Proposition (SO/VP)

SO/VP 1					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.6	1.6	1.6
	Disagree	7	11.3	11.3	12.9
	Neutral	8	12.9	12.9	25.8
	Agree	32	51.6	51.6	77.4
	Strongly agree	14	22.6	22.6	100.0
	Total	62	100.0	100.0	

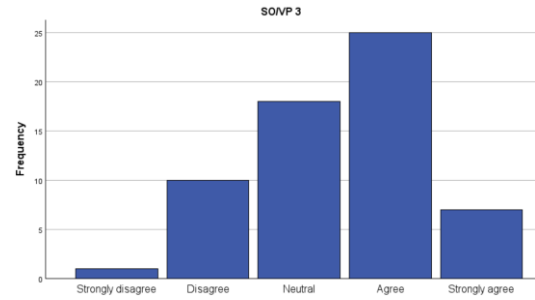


SO/VP 2					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.6	1.6	1.6
	Disagree	3	4.8	4.8	6.5
	Neutral	20	32.3	32.3	38.7
	Agree	27	43.5	43.5	82.3
	Strongly agree	11	17.7	17.7	100.0
	Total	62	100.0	100.0	



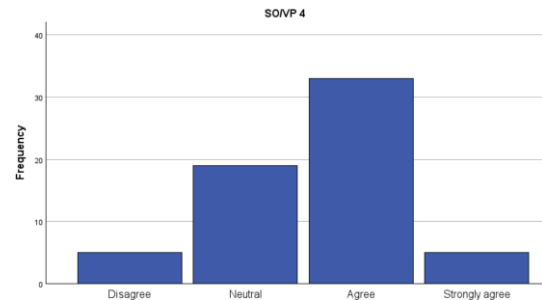
SO/VP 3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.6	1.6	1.6
	Disagree	10	16.1	16.4	18.0
	Neutral	18	29.0	29.5	47.5
	Agree	25	40.3	41.0	88.5
	Strongly agree	7	11.3	11.5	100.0
	Total	61	98.4	100.0	
Missing	System	1	1.6		
Total		62	100.0		



SO/VP 4

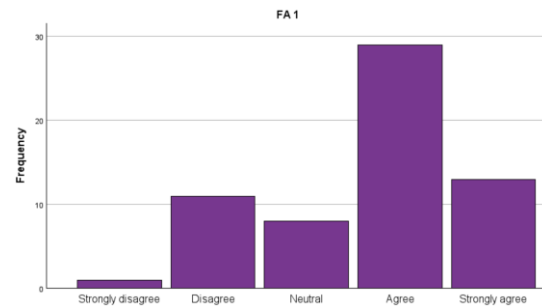
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	5	8.1	8.1	8.1
	Neutral	19	30.6	30.6	38.7
	Agree	33	53.2	53.2	91.9
	Strongly agree	5	8.1	8.1	100.0
	Total	62	100.0	100.0	



- Financial Aspects (FA)

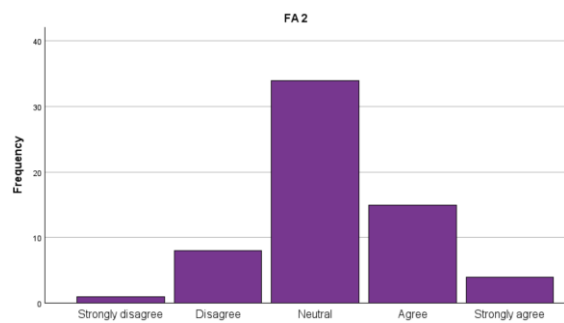
FA 1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.6	1.6	1.6
	Disagree	11	17.7	17.7	19.4
	Neutral	8	12.9	12.9	32.3
	Agree	29	46.8	46.8	79.0
	Strongly agree	13	21.0	21.0	100.0
	Total	62	100.0	100.0	

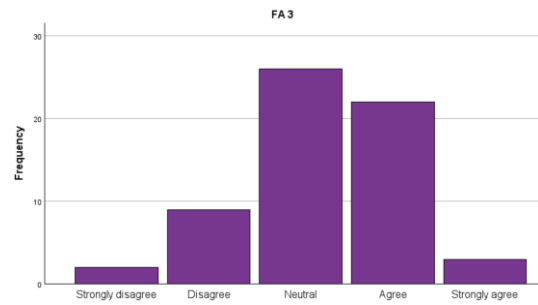


FA 2

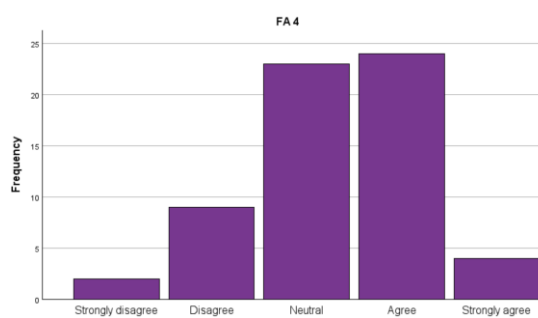
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.6	1.6	1.6
	Disagree	8	12.9	12.9	14.5
	Neutral	34	54.8	54.8	69.4
	Agree	15	24.2	24.2	93.5
	Strongly agree	4	6.5	6.5	100.0
	Total	62	100.0	100.0	



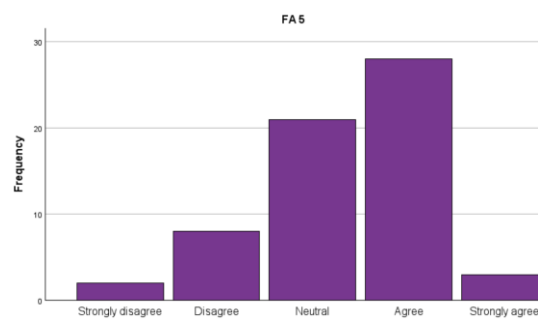
FA 3					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	3.2	3.2	3.2
	Disagree	9	14.5	14.5	17.7
	Neutral	26	41.9	41.9	59.7
	Agree	22	35.5	35.5	95.2
	Strongly agree	3	4.8	4.8	100.0
Total		62	100.0	100.0	



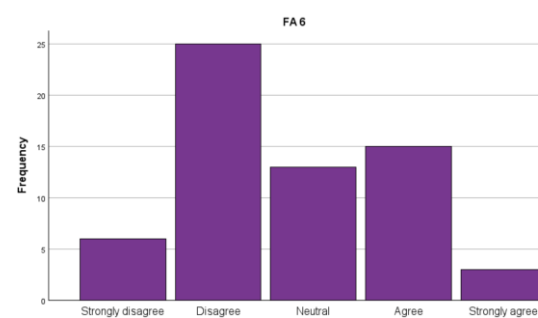
FA 4					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	3.2	3.2	3.2
	Disagree	9	14.5	14.5	17.7
	Neutral	23	37.1	37.1	54.8
	Agree	24	38.7	38.7	93.5
	Strongly agree	4	6.5	6.5	100.0
Total		62	100.0	100.0	



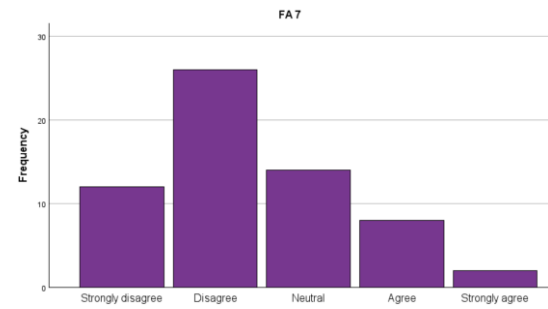
FA 5					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	3.2	3.2	3.2
	Disagree	8	12.9	12.9	16.1
	Neutral	21	33.9	33.9	50.0
	Agree	28	45.2	45.2	95.2
	Strongly agree	3	4.8	4.8	100.0
Total		62	100.0	100.0	



FA 6					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	6	9.7	9.7	9.7
	Disagree	25	40.3	40.3	50.0
	Neutral	13	21.0	21.0	71.0
	Agree	15	24.2	24.2	95.2
	Strongly agree	3	4.8	4.8	100.0
Total		62	100.0	100.0	



FA 7					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	12	19.4	19.4	19.4
	Disagree	26	41.9	41.9	61.3
	Neutral	14	22.6	22.6	83.9
	Agree	8	12.9	12.9	96.8
	Strongly agree	2	3.2	3.2	100.0
Total		62	100.0	100.0	



D2: Descriptive Statistics - Descriptives

- **Gender**

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Gender	62	1	2	1.32	.471	.222
Valid N (listwise)	62					

- **Position in the Company**

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Position	62	1	7	4.74	1.200	1.441
Valid N (listwise)	62					

- **Functional Area**

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Functional_Area	62	1	8	1.65	1.368	1.872
Valid N (listwise)	62					

- **Years of Experience**

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Years_of_Experience	62	2	4	3.50	.719	.516
Valid N (listwise)	62					

- **Infrastructure Management (IM)**

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
IM_1	62	8	12	11.03	1.040	1.081
IM_2	62	8	12	10.71	1.046	1.095
IM_3	62	8	12	10.65	1.175	1.380
IM_4	62	8	12	11.26	.940	.883
IM_5	62	8	12	9.97	1.071	1.146
Valid N (listwise)	62					

- **Customer Segment/Customer Interface (CS/CI)**

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
CI_1	62	8	12	10.89	.960	.921
CI_2	62	8	12	11.10	1.082	1.171
CI_3	62	8	12	10.61	1.077	1.159
CI_4	62	8	12	10.97	1.008	1.015
Valid N (listwise)	62					

- **Service Offerings/Value Proposition (SO/VP)**

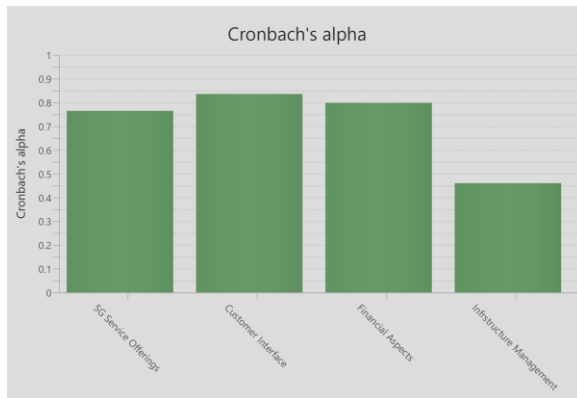
	N	Minimum	Maximum	Mean	Std. Deviation	Variance
SO_1	62	8	12	10.82	.967	.935
SO_2	62	8	12	10.71	.876	.767
SO_3	61	8	12	10.44	.958	.917
SO_4	62	9	12	10.61	.754	.569
Valid N (listwise)	61					

- **Financial Aspects (FA)**

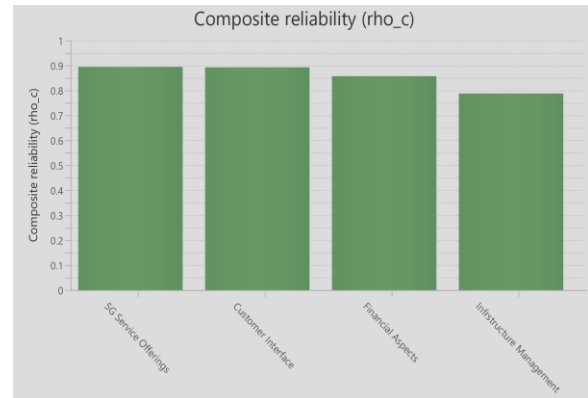
	N	Minimum	Maximum	Mean	Std. Deviation	Variance
FA_1	62	8	12	10.68	1.052	1.107
FA_2	62	8	12	10.21	.813	.660
FA_3	62	8	12	10.24	.881	.777
FA_4	62	8	12	10.31	.916	.839
FA_5	62	8	12	10.35	.889	.790
FA_6	62	8	12	9.74	1.085	1.178
FA_7	62	8	12	9.39	1.046	1.094
Valid N (listwise)	62					

D3: Inferential Statistics – Measurement Model

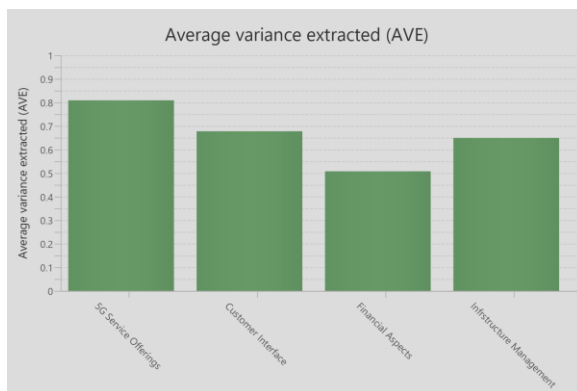
Cronbach's Alpha Test



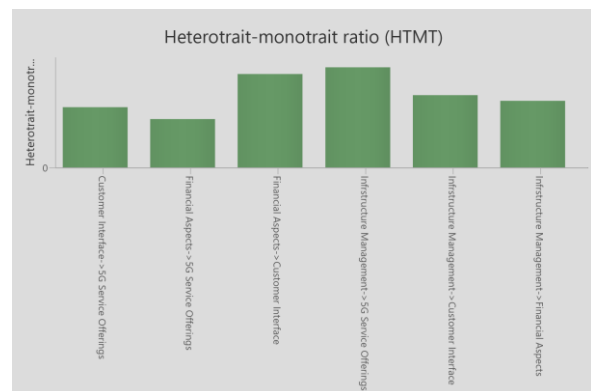
Composite Reliability Test



AVE Test



HTMT Test



Outer/Factor Loading Test

Outer loadings - List	
	Outer loadings
CI_1 <- Customer Interface	0.832
CI_2 <- Customer Interface	0.851
CI_3 <- Customer Interface	0.919
CI_4 <- Customer Interface	0.670
FA_1 <- Financial Aspects	0.505
FA_2 <- Financial Aspects	0.724
FA_3 <- Financial Aspects	0.751
FA_4 <- Financial Aspects	0.803
FA_5 <- Financial Aspects	0.856
FA_6 <- Financial Aspects	0.569
IM_2 <- Infrastructure Management	0.811
IM_5 <- Infrastructure Management	0.800
SO_2 <- 5G Service Offerings	0.911
SO_3 <- 5G Service Offerings	0.888

Cross Loading Test

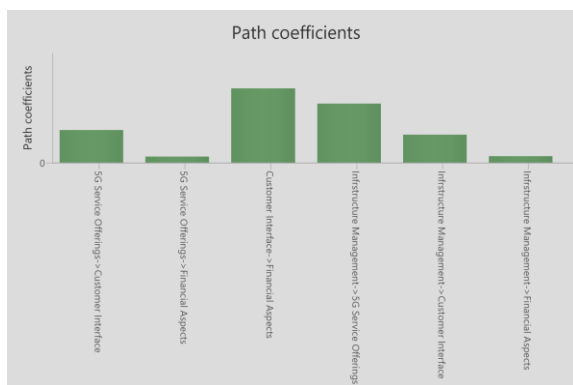
Discriminant validity - Cross loadings				
	5G Service Offerings	Customer Interface	Financial Aspects	Infrastructure Management
CI_1	0.287	0.832	0.581	0.411
CI_2	0.326	0.851	0.633	0.177
CI_3	0.375	0.919	0.659	0.487
CI_4	0.450	0.670	0.506	0.262
FA_1	0.238	0.546	0.505	0.142
FA_2	0.270	0.407	0.724	0.228
FA_3	0.206	0.426	0.751	0.247
FA_4	0.194	0.534	0.803	0.273
FA_5	0.498	0.704	0.856	0.369
FA_6	0.064	0.327	0.569	0.299
IM_2	0.395	0.414	0.283	0.811
IM_5	0.475	0.253	0.314	0.800
SO_2	0.911	0.417	0.391	0.484
SO_3	0.888	0.362	0.289	0.486

D4: Inferential Statistics – Structural Model

Collinearity Issues Test Results

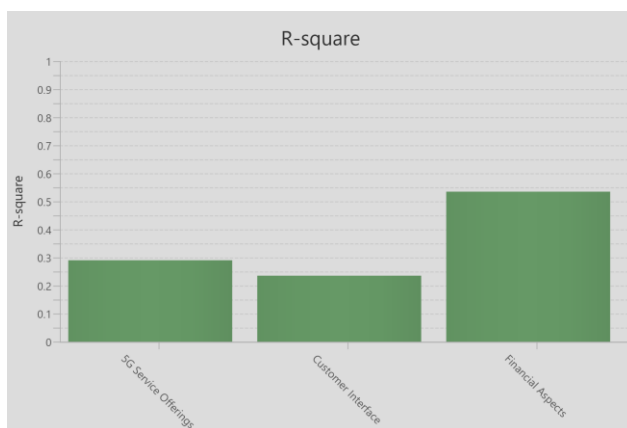
Collinearity statistics (VIF) - Inner model - Matrix				
	5G Service Offerings	Customer Interface	Financial Aspects	Infrastructure Management
5G Service Offerings		1.409	1.525	
Customer Interface			1.308	
Financial Aspects				
Infrastructure Management	1.000	1.409	1.494	

Path Coefficients Test Results



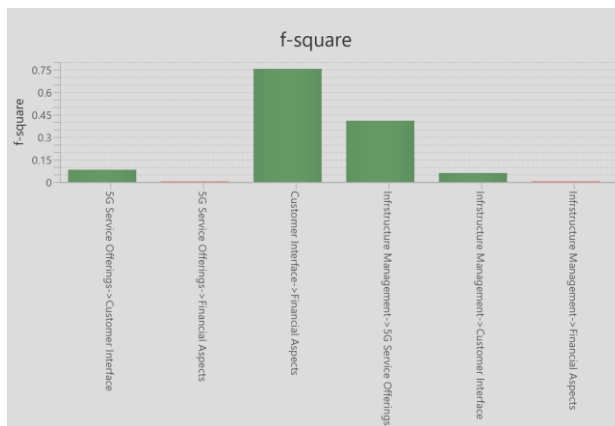
Path coefficients - List	
	Path coefficients
5G Service Offerings -> Customer Interface	0.297
5G Service Offerings -> Financial Aspects	0.055
Customer Interface -> Financial Aspects	0.678
Infrastructure Management -> 5G Service Offerings	0.539
Infrastructure Management -> Customer Interface	0.255
Infrastructure Management -> Financial Aspects	0.059

Coefficient of Determination (R^2) Test Results



R-square - Overview		
	R-square	R-square adjusted
5G Service Offerings	0.290	0.279
Customer Interface	0.235	0.209
Financial Aspects	0.535	0.511

Effect Size of f^2 Test Results



f-square - List

	f-square
5G Service Offerings -> Customer Interface	0.082
5G Service Offerings -> Financial Aspects	0.004
Customer Interface -> Financial Aspects	0.755
Infrastructure Management -> 5G Service Offerings	0.409
Infrastructure Management -> Customer Interface	0.060
Infrastructure Management -> Financial Aspects	0.005

Q-Square Test Results

PLSpredict LV summary - PLS-SEM				
	Q ² predict	RMSE	MAE	
5G Service Offerings	0.255	0.900	0.709	
Customer Interface	0.140	0.974	0.748	
Financial Aspects	0.100	0.996	0.754	

Hypothesis Testing Parameters

Path coefficients - Mean, STDEV, T values, p values						Copy to Excel/Word	Copy to R
	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O /STDEV)	P values		
5G Service Offerings -> Customer Interface	0.297	0.283	0.144	2.063	0.042		
5G Service Offerings -> Financial Aspects	0.055	0.055	0.135	0.405	0.686		
Customer Interface -> Financial Aspects	0.678	0.694	0.084	8.110	0.000		
Infrastructure Management -> 5G Service Offerings	0.539	0.569	0.071	7.537	0.000		
Infrastructure Management -> Customer Interface	0.255	0.260	0.115	2.227	0.028		
Infrastructure Management -> Financial Aspects	0.059	0.055	0.120	0.491	0.624		