AN IMPLEMENTATION FRAMEWORK FOR MOBILE VIRTUAL NETWORK OPERATORS (MVNOs)

Murori Jeremy Arimbi

A thesis submitted in partial fulfillment for the requirements of the award of the degree of Doctor of Philosophy in Information Technology of Masinde Muliro University of Science and Technology

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DECLARATION

This thesis is my original work prepared with no other than the indicated sources and support and has not been presented elsewhere for a degree or any other award

_____ _____

Murori Jeremy Arimbi Date

Reg. No.: SIT/H/14-57471/2016

APPROVALS

The undersigned certify that they have read and hereby recommend for acceptance of Masinde Muliro University of Science and Technology a thesis titled, "An Implementation Framework for Mobile Virtual Network Operators (MVNOs)"

_____ _____

Dr. Daniel Otanga Date

Department of Information Technology

Masinde Muliro University of Science and Technology

_____ _____

Dr. Jasper M. Ondulo Date

Department of Information Technology

Masinde Muliro University of Science and Technology

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DEDICATION

To my Grandchildren: “Strive to give and contribute to mankind no matter how small, it is the very essence of a life well lived”

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Murori J.A.

ABSTRACT

Wireless technology is evolving fast towards Software Defined Networks (SDN) and Network Functions Virtualization (NFV) to a real wireless world and space roaming featuring 5G networks and beyond. Mobile Virtual Network Operator (MVNO) is one sector that is cutting a niche into this new technology. Africa and the developing world has relatively low MVNO market share despite a vibrant mobile industry compared to Europe, North America and Asia Pacific countries. Like Africa, Kenya has a low MVNO market share in a vibrant mobile industry. The MVNO sector in Kenya is not performing. The goal of the study is to assess the status of the MVNO sector in Kenya with the aim of proposing a MVNO conceptual model and implementation conceptual framework for evaluating MVNO performance. The study used both survey and case study strategies to collect qualitative and quantitative data from Kenya MNO industry, MVNO sector, government agencies and the general public in Nairobi Central Business District (CBD) and its environs. Covariance based analysis (CB-SEM) specifically SPSS-AMOS aided by descriptive and inferential statistical tools was used to model, analyze and evaluate the SEM-CFA data set. MVNO conceptual model and MVNO implementation conceptual framework were validated using CFA-SEM methods and Regression Analysis. The study found that, General Public Sourced Barrier Factors, MNO Sourced Barrier Factors, MVNO Sourced Liming Factors, Government Agencies Sourced Limiting Factors, Stakeholders Value Chain Factors and Development Value Chain Factors influenced MVNO performance. The findings from the study, contributes to the performance of MVNOs by improving MVNO's market share, differentiated services, niche markets and exploration of underserved and untapped markets. It further contributes to the body of knowledge by establishing the factors that influence the performance of MVNO in Kenya and developing countries in Africa in general.

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List of abbreviations and acronyms

3GPP	3rd Generation Partnership Project
ABC	Always Best Connected
(A)GFI	(Adjusted) Goodness of Fit
ALIPN	All IP Network
AMOS	Analysis of Moment Structures
API	Application Programming Interface
ARIB	Association of Radio Industries and Businesses
ARPU	Average Revenue per User
ASP	Application Service Providers
ATIS	Automatic Terminal Information Service
AVE	Average Value Explained
BSS	Business Support System
CA	Communications Authority
CAK	Competition Authority of Kenya
CBD	Central Business District
CCSA	China Communications Standards Organization
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CIM	Computational Independent Model
CMIN	Chi Square value (in AMOS)
CRM	Customer Relationship Management
DAB	Digital Audio Broadcasting
DSC	Diameter Signaling Controller
DVB-T	Digital Video Broadcasting -Terrestrial
EFA	Exploratory Factor Analysis
EIF	European Interoperability framework
ETSI	European Telecommunications standard Institute
GEA	Government Enterprise Architecture
GSM	Global System for Mobile
GSMA	GSM Association

IETF	Internet Engineering Task Force
e GIF	e Government Interoperability Framework
EPAN	European Public Administration Network
EPC	Evolved Packet Core
ETSI	European Telecommunication Standards Institute
EU	User Equipment
EU	European Union
E-UTRAN	Evolved UTRAN
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
HLR	Home Location Register
IAMM	Interoperability Assessment Methodology Model
ICT	Information Communications Technology (Authority)
IDL	Interface Definition Language
IEEE	Institute of Electrical and Electronic Engineers
IMS	IP Multimedia Subsystem
IMSI	International Mobile Subscriber Identity
IMT	International Mobile Telecommunication system
IN	Intelligent network
IoE	Internet of Everything
IoT	Internet of Things
ITU	International telecommunications Union
IVR	Interactive Voice Response
KNBS	Kenya National Bureau of Statistics
LCIM	Levels of Conceptual Interoperability Model
LISI	Levels of Information System Interoperability
LIS	Layered Interoperability Score
LTE	Long Term Evolution
M2M	Machine to Machine
MANET	Mobile ad-hoc Network
MDA	Model Driven architecture

MDI	Model Driven Interoperability
MME	Mobility Management Entity
MNC	Mobile Network Code
MNO	Mobile Network Operator
MSC	Mobile Switching Centre
MVNA	Mobile Virtual Network Aggregator
MVNE	Mobile Virtual Network Enabler
MVNO	Mobile Virtual Network Operator
NATO	North Atlantic Treaty Organization
NC3TA	NATO C3 Technical Architecture
NCS	National Communications Secretariat
NFI	Normed Fit Index
NFP	National Facility Provider
NFV	Network Functions Virtualization
NFVI	Network functions Virtualization Infrastructure
(N)NFI	(Non) Normed Fit Index (TLI -Tucker Lewis Index)
OFCOM	Telecom Regulator in UK
OFTA	Office of the Telecommunications Authority (Hong Kong)
OIM	Organizational Interoperability Maturity Model
OOP	Object Oriented Programming
OSA	Open Service architecture
PA	Public Administration
PEST	Political, Economic, Social, Technological
PIM	Platform Independent Model
PSM	Platform Specific Model
QOE	Quality of Experience
QOS	Quality of Service
RAN	Radio Access Network
RMSEA	Root Mean Square Error of Approximation
SACCO	Savings and Credit Cooperative
SAE	System Architecture Evolution

SDI	Semantic–driven interoperability
SDN	Software Defined Networking
SDEPC	Software Defined EPC
SEM	Structural Equation Modeling
SGSN	Serving GPRS Support Node
SLA	Service Level Agreement
SMSC	Serving MSC
SPSS	Statistical Package for the Social Sciences
(S)RMR	(Standardized) Root Mean Square Residual
SSD	Solid State Drive
Telco	Telecommunication Operator
TLI	Tucker Lewis Index
TOGAF	The Open Group Architecture Framework
TPB:	Theory of Planned Behavior
TRA	Theory of Reasoned Action
TTA	Telecommunications Technology Association
TTC	Telecommunications Technology Council
TSDSI	Telecommunications Standards Development Society of India
ULF	Unified Licensing Framework
UTRAN	Universal Terrestrial RAN
VAS	Value Added Service
VLR	Visitor Location Register
VEPC	Virtualized EPC
WLAN	Wireless Local Area Network
WMAN	Wireless Metropolitan Area Network
WPAN	Wireless Personal Area Network

CHAPTER 1: INTRODUCTION

1.1 Overview

This Chapter outlines the background and concept of Mobile Virtual Network Operators/Mobile Virtual Network Enablers (MVNOs/MVNEs) and the reasons for their adoption as a viable technology. It further states the problem statement, aim, objectives and the research questions. Justification, scope and limitations of the study are finally given.

1.1.1 Background Information

In the early 1990s, most telecommunication services were run by Mobile Network Operators (MNOs) and networks were totally closed to other parties. Cost of spectrum licenses and the network infrastructure were high and prohibitive for startups. Frequency spectrum was uniquely dedicated to specific services and not sharable. Demand for introduction of new applications and services proved a heavy burden to existing operators fueling the opening of MNO domains to other parties giving birth to MVNOs [1], [2]. The concept of MVNO) arose in Scandinavia around 1999 with Sense Communication [3] but failed to reach agreements with MNOs by being considered a threat and a business competitor then. However, over the last two decades the MVNO industry globally gained acceptance and grew into a formidable market in excess of 270 million subscriptions by 2018 [67]. Europe has the largest MVNO market while the US is second. Asia Pacific region is third with Hong Kong and Singapore among the world's most competitive mobile markets [19], [160], [161]. In Europe, Germany is the largest MVNO subscriber market followed by the UK. Belgium, Spain, Denmark and the Netherlands are other European hotbeds of MVNO growth. In Africa, the MVNO market is in its infancy; however several MVNO launches have been rolled out with some degree of success, notably in Morocco, Senegal, Cameron, South Africa, Madagascar and Kenya [79]. The MVNO industry in Kenya is embryonic with 9 registered MVNOs in the market. Two closed shop in a span of two years, six are active but struggling and others putting their houses in order. Equitel is the only active MVNO that can be said to be afloat and well [200].

1.1.2 History of MVNOs

An MVNO is a mobile service provider to end-users, who does not own a frequency spectrum and a radio access network-RAN (e.g. GSM, UTRAN, E-UTRAN) but buys such capacity from an MNO. The MVNO may or may not own core network assets {e.g. Home Location Register (HLR), Mobile Switching Centre (MSC) and Gateway GPRS Support Node (GGSN)}.Majority of the core network assets for 4G and 5G have since been evolved and virtualized respectively [148]. MVNO may own mobile network code, SIM card, and operate its own customers and products. The essential network assets of an MVNO are a service delivery platform and a business support system for customer relationship Management (CRM) and billing [2]. MVNOs are all about competition, service differentiation and market segmentation that is pegged on customers, community and market segments. Service differentiation hinges on value addition and innovative products while market segments thrive on untapped/underpenetrated and niche markets and depends on the breadth of the core network platform an MVNO operates and the service level agreements (SLAs) contracted with the host MNO [4]. At a glance, stakeholders who can participate as MVNO are ISPs, cable TV operators, newspaper companies, banks, online brands, supermarkets and any established brands focusing on niche markets un-served by larger MNOs. Understanding and managing technology, device management, billing and cash management rank the highest challenges for MVNOs in that order [5]. In this regard, Mobile Virtual Network Enablers (MVNEs) provide technical consultancy services to MVNOs to bridge the technical gap. MVNEs provide MVNOs with core network and infrastructure elements [5], and solutions for various services, ranging from administrative to operational support. An MVNE acts essentially as an intermediate between the MVNOs and the host MNO and offers publicly available mobile communications services to the MVNO. One of the key design characteristics of future wireless systems is backward and forward interoperability with existing wireless systems and sharing of resources. 5G wireless networks have evolved fast to all real wireless networks and cellular IoT [148] with a proposed progression to 6G and 7G on the drawing boards. Software defined 5G networks and virtualized 5G networks are promising candidates for future MVNOs because multiple tenants will be able to share the same infrastructure and support multi-operator virtualized RAN arrangements [146].

1.1.3 Challenges and Opportunities for MVNOs

Over the past 15 years, MVNOs have helped stimulate competition in the mobile market mainly in Europe, America and Asia Pacific regions by launching innovative services and attractive niche consumer market segments at a lower cost than MNOs [168]. They have introduced unique innovative services that are not in the MNO list, created healthy competition for better services, ventured into market segments that are untapped and underpenetrated and overall improved the mobile market subscription [4]. Survival in saturated developed markets now depends on their ability to adapt to industry trends, leverage innovation and target niche or un-served/underserved consumer segments [131], [168]. In Africa and developing nations, there are a number of opportunities attached to the region. Most of the mobile operators in developing nations are urban and semi-urban based, with very few operators providing services in rural areas [172]. Rural areas are fertile grounds for new markets and products. The market is virgin, less competitive and easier to penetrate. There are also many unique unexplored market segments to venture into [4], [69]. MVNOs have been found to target consumers better; increase reach and scope of mobile offers, reach untapped markets, lower costs and help utilize the network resources more efficiently [166]. Locally in Kenya, there are a number of opportunities for MNOs, MVNOs, Customers and Regulators. MNOs will benefit from the use of underutilized capacity in data and mobile money. Risk sharing would push down operation costs. Better network effectiveness and utilization would be realized by economies of scale through lower operational costs [184], [188], MVNOs would spur growth as they venture into underserved and un-served geographical areas and niche markets. They will have an additional opportunity of developing innovative products and services and exploit online services that cut across the major platforms [183], [188]; they further have the opportunity to add value to MNO products and services for competitive pricing. The MVNO is expected to provide expanded value added products and services to the customer with a wider range of offerings within the wider choice of service providers and cheaper pricing for mobile banking services, data and voice [186], [188]. Communication Authority (CA) of Kenya like other regulators in the world agrees that commercial negotiations and legal enforcement is the best approach to regulate the MVNO sector. They have opted to introduce regulation that forces MNOs to open their networks to MVNOs that regulates at least some aspects of the wholesale agreement between MVNOs and

MNOs. Under the Unified Licence Framework (ULF), the Authority cites improved competition, consumer choice, lower retail prices, innovation, service diversity and more efficient use of scarce spectrum resources as the key welfare enhancing objectives that it needs to nurture in the sector. To this end, CA has assumed the role of facilitation and promotion of competition in the MNO/MVNO industry.

MVNO profit margins have however grown thinner by the day. Half of all MVNOs worldwide are challenged by changing industry dynamics that significantly varies from country to country. MVNO challenges span a range of disciplines namely technical, economic, political, and regulatory among others. Technology is dynamic and changing fast; understanding and keeping up with the changing trends in technology, managing core network devices, billing and cash management rank the highest challenges for MVNOs in that order [5]. Technical and management challenges are solved by engaging MVNEs and MVNAs who act as brokers between MNOs and MVNO. The bilateral relationship between the host MNO and MVNO can be uncertain due to lack of clear policy in developing nations, a situation that is worsened by illiteracy [171]. To this end, regulatory issues and low Average Revenue per User (ARPU) are considered as the key barriers to launching MVNOs, more so in Africa and the Middle East countries. Regulation is a political issue that requires political goodwill, whereas low ARPU is an economic issue that requires national government intervention. Other major economic challenges, holding down developing countries are building proper operation structures for economically disadvantaged geographic areas, lack of electricity, managing natural calamities, such as devastating earthquakes, landslides, and flooding [171]. Subsidy for rural and remote areas that are economically disadvantaged and mitigation of disaster related challenges are a responsibility of national governments. High interconnection rates, mobile number portability (MNP), MNOs resistance to change, policy compliance enforcement and price volatility are cited as legislative regulatory challenges that compromise performance of MVNOs [69], [165], [168]. These are readily addressable at National and Federal government levels. High interconnection rates can prevent MVNOs from offering competitive services, while MVNO resistance to change and MNP are interoperability regulatory issues. At the local level, Kenya does not have a legal provision for telecommunication infrastructure sharing, leaving the MNOs to sign independent partnership

settlements with MVNOs [187]. CA of Kenya has yet to formulate regulations to govern the industry. Currently, there are limited and unclear regulations that govern the MNO/MVNO industry save for general guidelines that act as safeguards to the end users in terms of quality of service, billing and customer care [188]. MVNOs are obligated to provide services within the set Quality of Service parameters and targets as set by MNOs without proper guidelines from the regulator. Entry of MVNOs into the telecom industry was unwelcome; they were seen as advantaged competitors with no license obligations that were set to cannibalize the MNO market share and reduce the client base. There was also a security concern of trusting MVNOs with their core network devices [188]. To penetrate the industry, MVNOs required an effective and efficient marketing plan in order to raise awareness of the uniqueness of their offers [185]. They had also to contend with uncompetitive high interconnection off-net calling rates [188]. Resistance by MNOs, network quality and network capacity were other challenges MVNOs had to face. CA of Kenya had the challenge of forcing the incumbent operators to lower the entry barriers to the market [188] including mobile number portability, price regulation of interconnection and termination fees. It is not clear, whether opportunities and challenges of MVNO and its stakeholders have changed with time; it is a status that needs to be unveiled.

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1.1.4 MVNO Value Chain Environments

MVNO is a business model whose value chain is influenced by 3-environments: the stakeholder environment, the development environment and the Business environment [119] as in fig 1.

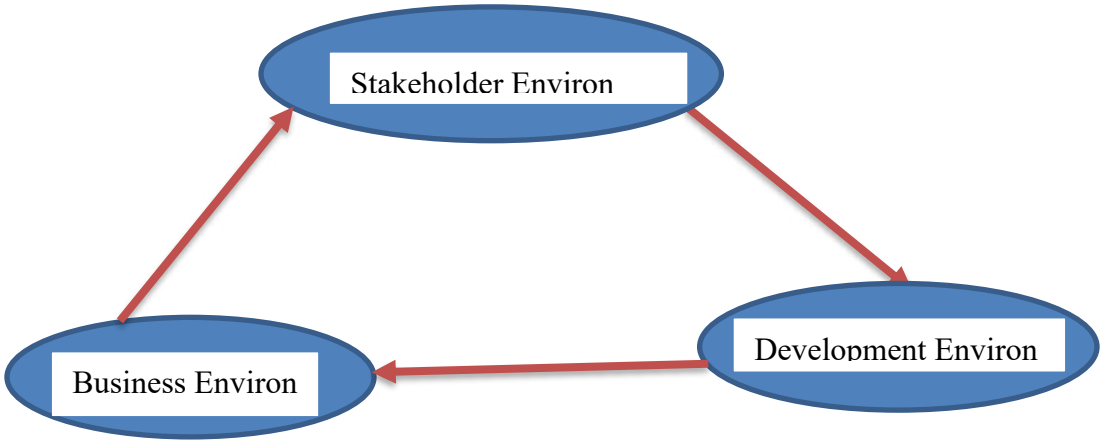


Fig 1: MVNO value chain environments *(Source - 6d-Technologies)*

The stakeholder environment comprise of the General public who serve as customers (wholesalers and profit enablers), MNOs who play the role of spectrum and network infrastructure enablers, Government Agencies who are regulators and Policy enablers and MVNOs who are product and service enablers. The development environment comprises of 4-phases: planning, technical integration, testing and market launch. The third environment is the business environment that is well documented in other studies and is not part of this study.

Table 1: Summary of MVNO Key stakeholders in Kenya and value chain functions

	Stakeholder Category		Role and Value chain	Status/typical Bodies
1	Regulatory and Policy Enablers	International Standardization Bodies	Formulate international regulatory standards and policy for guidance and interoperability purposes	Present – (2) (ITU, 3GPP etc)
		Regional Bodies	Formulate regional regulatory policy in line with international standards for guidance and compliance within cooperating states	Absent - (0)
		National Bodies	Formulate local regulatory policy in line with international and regional standards for guidance and compliance within a country	Present – (2) (CA, ICT Board)
		Private Sector Market stakeholder	Formulate rules to govern their game, oversee and protect their interests	Absent (0)
2	Spectrum & N/W Infrastructure Enablers	MNO	Provides the radio frequency spectrum and essential network infrastructure on which MVNEs, MVNAs, and MVNOs ride on	Present– (4) (Saf, Airtel, Telkom, Jamii Telecom)
3	Technical Enablers (Technical vendors)	MVNEs	Act as a proxy to the MNO by availing core network devices and software to MVNOs. They do not have wholesale agreement with the host MNO and no direct relationship with end-user customers.	Present – (Eferio of Telkom on drawing boards)
		MVNAs	Type of MVNE that has its own wholesale agreement with a host MNO that resells services to multiple MVNOs.	Absent – (0)
		MVNO	True MVNO that does not depend on MVNE or MVNA for its services	Present – (9 but 2 active)
4	Content and Service Enablers	Content and Service Vendors	Package and provide content and services to the MVNOs for distribution	Present – (Many But partially tapped)
5	Profit Enablers	Wholesale distributors and Customers	Provide wholesale and retail distribution channels of the end product to consumers.	Present – (many but partially tapped)

All businesses, experience barriers and challenges in their environments that compromise their performance and growth. Success of a product in the business environment depends on how well it appeals to the initial stakeholders and development environments. MVNO is a business model; as such, the business environment contributes significantly in mitigating Porters 5 forces model [12], PEST analysis external environment, and SWOT analysis strategic tools [181]. It is therefore an essential component of the MVNO framework. The stakeholders environments are informed by collaboration and synergy between them and MVNOs while the development environment is informed by inhouse human resource skills necessary to support the MVNO development stages of planning, technical integration, testing and marketing. A summary of MVNO key stakeholders in Kenya identified in the study and their value chain functions, status and typical bodies are given in table 1.

At a global perspective, Regulatory and Advisory enablers include International bodies, Industry based bodies, Regional bodies, National bodies and Private Sector Market Stakeholders. The bodies may be constituted internationally, regionally and nationally depending on the cooperating entities. International bodies formulate global standards that serve as blue prints to other stakeholders. ITU [74] is an example of an international body in the telecommunications industry among others. Industrial, Federal and National bodies formulate policy in line with the global standards that serve their respective industries and regions. 3GPP [42], IEEE [55] are examples of industry related bodies for cellular networks and emerging technologies respectively while ETSI [127] and EPAN [129] are good examples of regional bodies in the European region. National Bodies formulate local regulatory policy in line with international and regional standards for guidance and compliance within a state. Regional and national intervention is necessary where the market is least likely to provide a timely and useful answer in regard to standards, security, open access and protection of the venerable [167].

In Kenya, Communication Authority (CA) of Kenya and ICT Authority of Kenya [174] are two government agencies that formulate and articulate Communications and ICT policy on behalf of the government among others. The Kenya Information and Communications Act 411A Rev 2012 [189] provides a legal framework that stipulates general regulations for communications, broadcasting and ICT services. Specific regulations targeting individual market sectors are disparate and formulated piecemeal as the need arises. Within the legal framework, CA has

adopted a market structure for telecommunications services under a Unified Licensing Framework (ULF) [190], [158] that is technology neutral. MNOs fall under this framework as National Facility Providers (NFPs), while MVNOs are Application Service Providers within NFPs. This is essentially the CA MNO/MVNO regulatory framework that is supposed to govern the MVNO subsector. The same legal framework has provided the Kenya Information and Communications (Interconnection and provision of fixed links, access and facilities) Regulations 2010 [191] that emphasizes end-to-end connectivity between cooperating entities. The National Payment Systems Regulation, 2014 [193], heralded a formal legal framework for electronic money in Kenya; entrusting CA to formulate the details of its implementation. These two documents constitute CA's MNO/MVNO inter-connection and E-money interoperability frameworks albeit to a limited extent that is still inadequate to govern interconnectivity and interoperability of the MNO/MVNO sectors as established by studies by Analysys Mason [194] and Sterling Capital [195] on Safaricom's dominance and misuse of dominance in the mobile money and mobile communication sectors [194]. The smaller operators have long argued that Safaricom enjoys a dominant position because it accounts for 90 percent of revenues in areas such as mobile money transfer, voice calls and text messages. Safaricom is Kenya's biggest firm by market capitalization and dwarfs the two other operators in the mobile market - Airtel Kenya and Telkom Kenya but Safaricom has consistently rejected the accusations of dominance amid repeated parliamentary petitions for probe of market abuse by rivals. On top of the earlier accusations of dominance, Safaricom's M-Pesa has evolved into a fully-fledged financial service offering loans and savings in conjunction with local banks, plus merchant payment services (Pay bill services, Buy goods till services and Pochi la Biashara). Consumers and small businesses are concerned about high M-Pesa transaction charges where the rents from digital technology are unfairly accruing to Safaricom Plc [199]. The M-pesa platform has overtaken voice to become the biggest revenue earner for Safaricom accounting for about 99.9 percent of the value of mobile money transactions in 2021. It ate into the market of Airtel Money and Telkom's T-Kash reducing them to 0.2 percent and 0.1 percent respectively. To address the problem, M-pesa was separated from Safaricom in January 2023 through the Kenya Information and Communication (Amendment) Bill of 2022 and shared its Pay Bill and Buy Goods infrastructure with Airtel and Telkom - a piecemeal amendment that left agency interoperability maimed till 2024 when it saw the light of day.

The National ICT policy 2020 [192] maps the future of ICTs in Kenya with emphasis on mobile and the knowledge economy, broadband and high speed networks, universal access and infrastructure sharing, interoperability and data sharing with the onus left on CA to develop national policies to regulate the entities in the sectors. CA has yet to formulate these policies. Government Enterprise Architecture (GEA) project [174] by the ICT Authority would be of immense value on interoperability and data sharing. GEA project has rolled out a number of government based services through E-citizen platform some of which are in use currently. The Kenya Vision 2030 [151] is National Blue print for Economic, Social and political Pillars for industrialization and middle income transformation. Science, Technology and innovation (STI) is one of its flagship projects. The Draft National ICT Infrastructure Master Plan 2019-2029 [174] is a draft ICT Industry Infrastructure guideline to realize Vision 2030, as well as the "Big Four" Agenda to specifically streamline the management of the country's ICT infrastructure of undersea cables, the Fibre Optic Cable Backbone (NOFBI), Local Area Networks, wireless networks and data centers. The Kenya National Digital Master Plan 2022-2032 [216] is the latest framework to further streamline ICT human capital and workforce development, Integrated ICT infrastructure and integrated information infrastructure. Private Sector Market Stakeholders formulate rules to govern their game, oversee and protect their interests [175]. There is no official body to lobby on behalf of MVNOs currently. The National ICT policy 2020 [192] and The Kenya National Digital Master Plan 2022-2032 [216] seem to align well with MVNO services and products but there is no regulatory framework to facilitate MVNOs. A summary of legal and regulatory frameworks that are related to the MNO/MVNO sector in Kenya are listed in table 2. From the technical perspective, MVNOs require technical and content enablers. MNOs provide the radio frequency spectrum and essential network infrastructure on which MVNEs, MVNAs, and MVNOs ride on. Safaricom, Airtel and Telkom network operators are supposed to provide these services locally.

Table 2: Legal and Regulatory frameworks related to MNO/MVNO industry in Kenya

	Type of framework	Statement	Target Industries	Comment
1	Legal Frameworks	i) The Kenya Information and Communications (Interconnection and Provision of Fixed Links, Access and Facilities) Regulations, 2010	Information and Communications	General framework for Information & Comms Industry
		ii) The Kenya Information and Communications Act (CAP. 411A–Rev 2011).	Information and Communications	General framework for Information & Comms Industry (Revised 2011)
		iii) Payment Systems Act (No 29 of 2011) & National Payment Systems Regulation, 2014	Money payment systems	General framework for money payment systems
2	Regulatory frameworks	i) The Kenya Information and Communications - Interconnection and Provision of Fixed Links, Access and Facilities) Regulations, 2010	Information and Communication Industry	Interconnection and Provision of Fixed Links, Access and Facilities Regulations, 2010
		ii) Telecommunications Market Structure - Unified Licensing Framework (ULF-2016)	Telecommunications Industry	Unified licensing framework for telecoms industry 2016 (MVNO is an application under URF)
		iii) The National Payment Systems (NPS) Regulations 2017	Banking Industry and financial institutions	NPS Regulations 2017
		iv) The National Payment Systems (NPS) Regulations - Mobile Money Interoperability, 2018	Mobile money Service providers industry	National Mobile money interoperability framework 2018
		v) The National (ICT) Policy Guidelines, 2020	ICT Industry	*ICT Policy Guidelines 2020
		vi)The Kenya National Digital Master Plan 2022-2032 (by Ministry of ICT, Innovation and Youth Affairs)	ICT human capital and workforce development, Integrated ICT infrastructure and Integrated information infrastructure.	Master plan digital programs on infrastructure; Services, Products and Data Management; Skills; Enterprises, Innovation and Business; Policy, Legal and Regulatory; 2021

3	Interoperability Frameworks	i) Mobile money interoperability framework by NPS 2018	Mobile Money Industry	Mobile Money Interoperability framework 2018
		ii) Mobile money interoperability framework by NPS 2018 Amendment 2022	Mobile Money Industry	Mobile money interoperability amendment framework 2022*
4	Government Enterprise Architectures (GEA) Framework	i) Kenya Vision 2030	National Blue print for Economic, Social and political Pillars for industrialization and middle income	Science, Technology and innovation (STI) – June 2008
		ii) Draft National ICT Infrastructure Master Plan 2019-2029 (by ICT Authority)	ICT Industry Infrastructure to realize Vision 2030, as well as the "Big Four" Agenda	Streamline the management of the country's ICT infrastructure of undersea cables, the Fibre Optic Cable Backbone (NOFBI), Local Area Networks, wireless networks and data centers.
		iii) E- Citizen Services	Kenya Government Services	Enterprise Architecture for Government portals (Assorted)

Technical enablers are at three different levels that comprise of MVNEs MVNAs and MVNOs. MVNO is a mobile network operator who does not have his own radio frequency spectrum and network infrastructure but provides services by leasing wireless capacity from MNO, MVNE or MVNA and resells it to consumers at retail prices under its own business brand [2], [4]. An MVNE acts as a proxy to the MNO. It is a telecom solution that avails core network devices to MVNOs. It operates platforms that enable MVNOs to offer mobile telecom services to their customers by connecting them to the MNO. MVNEs do not have a wholesale agreement with the host mobile network operator neither do they have direct relationship with end-user customers [3]. An MVNA is an MVNE that has its own wholesale agreement with a host mobile network operator that resells services to multiple MVNOs. MVNA is a business model while MVNE is a telecom core device solution. MVNE/MVNO is an easier infrastructure for startups to deploy than the MVNA/MVNO in terms of CAPEX and OPEX but MVNA would be a better business venture in the long run in terms of future expansion. Both models are popular in North America,

Europe and Asia Pacific [79], [161]. There are no MVNAs and MVNEs in Kenya however, Eferio Kenya has proposed a MVNE infrastructure that is yet to get into the public domain.
Content enablers package and provide content and services to the MVNOs for distribution. Distribution channels and customers provide the last mile of the MVNO value chain. Proper distribution channels and a loyal customer base are important strategies for MVNO survival. Last mile distribution channels are not fully utilized due to content, service and infrastructure limitations. The five stakeholder enabler categories formed a general basis from which test instruments and constructs were classified for the study.

1.1.5 MVNO Success Cases

The key MVNO players in the world are based in Europe, North America and Asia Pacific. In the US, there is Virgin Mobile, Tracfone Wireless Inc., among others. In Europe, there is Freenet AG in Germany, Polkomtel in Poland, Tesco Mobile Ltd in UK, Telefonica in Spain etc. In Asia Pacific, there are CITIC Telecom International Holding Limited in Hong-Kong and many others [161]. As a quick sample, MVNO in Europe is expected to reach 110.7 million MVNO subscribers at the end of the year 2020; a 15-20% of the total mobile market share. Germany the leading MVNO market in Europe has 3-MNOs and more than 140-MVNOs that boast of 48 million subscribers, accounting for 50% market share [79]. UK the second in line in Europe has 4-MNOs and 104-MVNOs with 13.5 million subscribers that translates to14% of the market share. The US has 4-key MNOs and 133-MVNOs with the MVNO market share of 23 million that translates to about 5% of the market share. Migrant, Roaming and Business are the most popular segments [159].

Asia Pacific (Japan, South Korea, China, Hong Kong) and South East Asia (Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei Darussalam, Vietnam, Lao PDR, Myanmar and Cambodia) have vibrant MVNO market landscapes [163]. The Hong Kong mobile market is saturated with a penetration rate of 200% with 4-main MNOs and a MVNO market share of 17%. Indonesia commands an MVNO market share of 18% with Malaysia at a market share of 15% [162], [163].

In the global MVNO arena, Africa, has relatively low (<1%) MVNO market share compared to the rest of the world [161]. The MVNO industry in Africa is still in its infancy; South Africa, Cameroon, and Senegal are pioneers of the MVNO industry in Africa [165], [69]. A number of other countries like morocco, Kenya, Nigeria, Ghana Egypt have joined the industry. South Africa has 90 million mobile subscribers with an MVNO market share of only 1.7%. Kenya has 49 million mobile subscribers with a MVNOs market share of about 4% (2 million subscribers) [8] that has recently gone down to 2.3% [200]. Finserve Africa Ltd (Equitel) and Money Pay Ltd (Tangaza) are the two noticeable MVNOs in the market currently; Zioncell Kenya Ltd and Sema Mobile Services Ltd closed shop; however there are four new entrants in the market that have not shown significant impact in the MVNO industry [158].

The critical success factors suggested for MVNO include: supportive regulatory policy to facilitate competition, well formulated SLA with core network providers [7], investment on innovative differentiated business services, target on un-served and underpenetrated market segments [4], minimization of CAPEX and OPEX costs, increase of mobile adoption and penetration, increase choice and drive down cost for consumer [165], [69]. It is a general observation that MVNOs target consumers better; they increase reach and scope of mobile offers; they lower costs; and help utilize the network resources more efficiently [166].

1.2 Problem statement

The MVNO market in Europe, North America and Asia Pacific regions is well established with market share levels of 10-20% and above [79], [159], [162], [163]. Africa has a relatively low MVNO market share of <1% compared to the rest of the world [161]. The MVNO industry in Africa is in its infancy; South Africa, Cameroon, and Senegal are pioneers of the industry in the continent with morocco, Kenya, Nigeria, Ghana and Egypt as recent entrants in the market. South Africa boasts of 90 million mobile subscribers with an MVNO market share of only 1.7% [165] - a very low market share indeed. Like South Africa, the Mobile industry in Kenya is vibrant with a subscriber base of 65.5 million and a penetration rate of 129.4%, however the MVNO market share has declined from 4% to 2.3% in 2024 [205]. Of the four initial MVNOs, two closed shop within a span of four years [158]. Entrants in the market in the recent past have

not added value to the market share. An MVNE (Eferio Kenya) was registered in the sector in 2020 but not much has been heard of its activities. Despite a vibrant and mature MNO industry, MVNOs in Kenya were not performing. There is therefore need to assess the status of the sector and establish the main challenges contributing to the nonperformance.

1.3 Objectives

1.3.1 Main Objective

The goal of the study is to assess the status of the MVNO sector in Kenya with the aim of establishing the factors that are retarding the growth of the sector; determine key strategies and develop a framework for MVNO startups, implementation and deployment

1.3.2 Specific Objectives

a) Assess the available MVNO innovative/differentiated services, market segments and their level of utilization.

b) Establish key determinants, facilitators and barriers to the growth of MVNOs

c) Determine key strategies for the implementation of MVNOs

d) Develop an implementation framework for MVNO startups, development and deployment

1.4 Research Questions

i. What is the status of MVNO innovative/differentiated services, market segments and their level of utilization?
ii. What are the key determinants, facilitators and barriers to the growth of MVNOs?
iii. What are the key strategies for the implementation of MVNO?
iv. What design factors would constitute an acceptable implementation framework for MVNO startups, development and deployment

1.5 Justification of the Study

MVNO business models are characterized by differentiated (innovative) services, un-served/underserved market segments and niche markets. The growth of innovative services and niche markets in wireless networks has gradually shifted from MNOs to MVNOs. A vibrant MVNO sector like Germany is a good indicator of a successful MNO mobile industry [79]. This study gives a pointer to what is ailing the MVNO sector in Kenya by identifying barriers that are inhibiting the growth of new entrants into the sector. Barriers that have been encountered in the past in startups, development and deployment stages will be highlighted for the benefit of the incumbent and new entrants in the sector. Adoption of technology is unique to different environments. What works for Europe and Asia might not work for Africa and Kenya. The study brought out unique factors that favour a vibrant MVNO industry in Kenya and Africa in general. Current MVNOs and their mother MNOs seem to be competing on similar services, products and market segments creating unnecessary environment of competition amongst plenty. The study has proposed strategies for suitable MVNO business models, innovative services and un-penetrated/underpenetrated markets segments that are suitable for the sector. Innovative services, products and niche markets would provide customers with better freedom of choice that in turn would provide viable competition and better profit margins without creating unnecessary rivalry. Frameworks are meant to address and mitigate challenges for the smooth running of specific industries. An implementation framework will serve as a blue print and guiding document for MVNOs in terms of regulatory policies and guidelines at the national level by promoting standards, and sharing of data across different MVNOs and MNOs resulting in better utilization of network resources. It will further break business monopoly and promote fair competition in the MNO/MVNO industry. Healthy competition will improve the MVNO market share, higher customer penetration and improve the low ARPU of the industry and in turn the economy. Finally like Kenya, Africa and other parts of the developing world faced with similar MVNO challenges will equally benefit from this study. In a nutshell, the outcome of the study will reinvent the MVNO sector in Kenya by giving it a fulcrum on which to fight its future battles for sustenance and growth.

1.6 Scope of the Study

This study established the factors that were ailing the MVNO sector, assessed the available differentiated services/market segments, determined strategies and developed a framework that would make MVNO startup, development and deployment easier to realize. All the three stages of MVNO development cycle were considered because implementation challenges would arise at any one of the stages. The study was a case study based in Kenya with Nairobi CBD and its environs as the case market and the General public, MNO, MVNO and government agencies as the study environments. Nairobi CBD has the highest concentration of MNO/MVNO outlets and clients compared to any other region in Kenya. It is a business hub both during the day and night. It registers the highest MNO/MVNO business transactions compared to any other urban centres in the country. Nairobi environs border the rural counties that represent rural settings in terms of business transactions. Nairobi CBD and its environs therefore could sufficiently represent the MNO/MVNO market in Kenya for the purpose of this study. Due to the small number of MNOs/MVNOs in Kenya, the case environments included all the MNOs and MVNOs and the relevant government agencies charged with formulation of Information and Communications policy. The MNOs were Safaricom Ltd, Airtel Kenya Ltd and Telkom Kenya Ltd while the MVNOs included; Finserve Africa Ltd (Equitel), Money Pay Ltd (Tangaza), Homeland Media, Eferio Kenya Limited, Jambo Telecom and Jambo Pay. Government agencies included; Communications Authority (CA) of Kenya, ICT Authority, Competition Authority of Kenya (CAK) and National Communications Secretariat (NCS). The target population of the study comprised of managers from MNOs/MVNOs, government agencies and a sample of the general public in Nairobi Central District (CBD) and its environs. It is evident that, the MVNO challenges facing Africa and the developing world are similar to the ones facing Kenya to some extent [68], [69], [130], [161], [165]. As a result, the solution for Kenya could be replicated to serve Africa and other parts of the developing world.

1.7 Assumptions of the study

The study held the assumptions that; the MNO industry in Kenya is mature enough to support MVNOs, MNOs and MVNOs are licensed and operational in Kenya, MNOs/MVNOs and other

telecommunication stakeholders in Kenya were open for interviews and would respond faithfully to the survey questionnaire and interview questions. It also held the assumption that, managers in the target markets were knowledgeable and would authoritatively act and speak on behalf of their respective institutions without contradiction.

1.8 Summary

The preceding chapter discussed the background and concept of MVNO/MVNE/MVNA as emerging technologies of the 21century that are meant to supplement the role of MNOs in the wireless mobile industry. The challenges, opportunities and success cases of the sector together with their key stakeholders were discussed with a view to capturing the disparity of the sector between developed and developing economies with Africa and Kenya as a comparative case study. A problem statement was stated, followed by objectives and research questions. Finally, justification, scope, limitations and assumptions of the study were made.

CHAPTER 2: LITERATURE REVIEW

2.1 Overview

This chapter reviewed the study objectives in the context in which they were addressed in earlier studies. The MVNO/MVNE concept was discussed in the light of emerging technologies as a supplement to MNOs business model. 3GPP open standards were highlighted as the prime mover of forward and backward compatibility of 4G, 5G networks and beyond. The section on related studies discussed previous work related to the study in terms of contributions and deficiencies. Business models and frameworks were discussed as tools of presenting knowledge in research. Evolution of MVNO business models were outlined while interoperability models and regulatory frameworks in public administration were further discussed as essential guiding documents in wireless networks in the light of MNO/MVNOs. MVNO study factors conceptual model, MVNO implementation conceptual framework were given and finally hypotheses and research gap stated.

2.2 A Review of study objectives

There were four objectives in this study. Their review is discussed in the sub-sections that follow.

2.2.1 What is the state of MVNO innovative/differentiated services, market segments and their level of utilization?

There should be a substantial product differentiation and market segmentation between MVNOs and MNOs. MVNOs should venture into value addition and innovative services and underserved/unpenetrated markets segments to avoid service duplication. Typical global segments include Business, Migrant (Ethnic), Retail, Roaming, M2M, Business, Discount, Telecom, Entertainment (Media), Lifestyle, advertising funded, youth, students, elderly, enterprise, health enthusiast, NGO supporters (Charity), financial services among others [4], [67], [134]. Migrant, Roaming and Business are the most popular segments in the US [159].

Discount, niche markets, Data and M2M are prominent in Europe. Differentiated services in the global market may include: Remote management, Security & surveillance, Fleet management, e-Health applications, Sales & payment and Home applications discount, Niche, Retail and Advertising [104]. [105].

A spot check in the Kenyan landscape indicates that services offered and market segments operated by MNOs and MVNOs were literally the same [157], [175]. Value addition and innovation are minimal or completely absent and there were still many un-served/underserved market segments that are yet to be explored creating a need for this study.

2.2.2 What are the key determinants, facilitators and barriers to the growth of MVNOs?

At a glance, a few inhibitor indicators have been documented in LR. Generally, MVNO challenges are technical in nature among other things. Understanding and managing technology, device management, billing and cash management rank the highest challenges for MVNOs in that order [5]. The major issue for developing nations is the formulation and implementation of policies, rules, and regulations [171]. Regulatory issues and low Average Revenue per User (ARPU) have been cited as the key barriers to launching of MVNOs, more so in Africa and Middle East countries [68], [69], [130]. High interconnection rates, resistance by MNOs, lack of national consumer brands (innovative services), lack of Mobile Number Portability (MNP), lack of MVNE/MVNA infrastructure, services and price volatility are other important barriers [69], [165], [168]. Mobile Number Portability (MNP) is a regulatory requirement in Kenya that has not been implemented to the letter due to compliance issues; so is interoperability of mobile money. The playing ground is not level for MNOs and MVNOs; it is more skewed in some than others [194], [195], [157]. There is not a single operational MVNE/MVNA in the Kenyan market to provide technical/business consultancy services for MVNO startups, development and deployment [141], [142], [158]. Well formulated SLA with core network providers, investment on innovative differentiated business services and venture into underpenetrated market segments, increase of mobile adoption and penetration are cited as other factors that facilitate the growth of MVNOs [7]. There is therefore need to establish the prime movers and barriers faced by MVNOs for the purpose of improving their performance and growth.

2.2.3 What are the key strategies for the implementation of MVNO?

The structure of the telecom industry has shifted to an open system of collaboration, communication, and co-ordination; use of standards is therefore a big strategic factor [3], [9], [10], [77], [110], [143]. Properly negotiated service level agreements (SLAs) are a strategic business issue [7]. The critical success factors suggested for MVNO include: supportive regulatory policy to facilitate competition, well formulated SLA with core network providers [7], investment on innovative differentiated business services, target on underpenetrated market segments, minimization of CAPEX, increase of mobile adoption, penetration and choice of services for consumers [165], [69]. Cost leadership, market segmentation and service differentiation are further identified as three generic types of business strategies [12]. The Finish industry looks at the strategies as low price, narrow focus, service differentiation, service reselling and international clustering [4]. MVNO deployment in Asia started with two types of strategies: the growth strategies that targeted consumers and industry and the generic strategies that targeted developed markets for economic growth [178]. Porter's five forces framework (Suppliers, consumer demand, new entrants, substitute products and competitive rivalry) [12] indicate that the mobile telecom industry is attractive for MVNOs in terms of offering new revenue sources. PEST (Political, Economic, Social, Technological) analysis [181], further suggests that most of the external environment factors favour MVNO business model. These were fertile grounds for consideration for suitable strategies for the MVNO sector in Kenya besides other unique features that were unearthed by this study.

2.2.4 What design factors would constitute an acceptable implementation framework for MVNO startups, development and deployment?

Open standards and frameworks have been noted as important elements that facilitate interoperability in systems [10], [26], [42], [59], [60]. Open standards and frameworks prevent design and development of proprietary products and services and allow interoperability of applications from different providers and vendors [14], [62], [63], [137], [138]. Private Sector Market Stakeholders formulate rules to govern their game, oversee and protect their interests. Federal and National governments intervention is necessary where the market is least likely to

provide a timely and useful answer in regard to standards, security, open access and protection of the venerable [154], [158], [167]. MVNOs are expected to deliver services according to national policies defined by each country's telecom regulatory body as well as international standards and practices [171]. MVNO implementation framework should be a guiding standard document meant to mitigate internal and external challenges that inhibit the smooth running of the industry from the point of view of Porter's competitive strategies [12] and PEST's external environment analysis [181]. To this end, the framework should consider but not limited to Political factors, Economic factors, Social factors, Technological factors, Environmental factors and Legal/compliance (PESTEL) factors. Besides, it should include quality factors that have been found to work from earlier studies (LR quality factors). Factors arising from analyzed data should be central in the study and should be included. The existing legal and regulatory frameworks for MVNOs were examined from the local and regional contexts to find out whether they met the threshold based on evolving international practice.

2.3 MVNO/MVNE Concepts

2.3.1 The MVNO Concept

The term MVNO was a technical concept, that has of late assumed many broad oriented definitions among various operators, bodies and authors [70], [71], [72], [73], [74], [75]. An inclusive summary definition of an MVNO is "A network operator who does not have his own radio frequency spectrum and network infrastructure but provides services by leasing wireless capacity from a mobile network operator (MNO) and resells it to consumers at retail prices under its own business brand" [2], [4]. The MVNO may or may not own core network assets such as, home location register (HLR), mobile switching centre (MSC) and gateway GPRS support node (GGSN). MVNO may own mobile network code (MNC), Subscriber Identification Module (SIM) card, and operate its own customers and products.

In terms of the market, Europe represents the largest MVNO market while the US is the second in line [1]. Both markets provide the largest base of MVNO customers but Asia Pacific region is starting to emerge as a third pole of global MVNO activities with Hong Kong and Singapore

among the world's most competitive mobile markets [19],131]. In Europe, Germany remains the largest MVNO subscriber market followed by the UK. Belgium, Spain, Denmark and the Netherlands are hotbeds for MVNO growth [79]. The MVNO market passed the 270 million subscriptions mark by the end of 2018 [67]. MVNOs market in Africa is in its infancy; with several MVNO launches in Morocco, Senegal, Cameron, South Africa, Madagascar and Kenya. Regulatory issues, low Average Revenue per User (ARPU) and high interconnectivity rates are viewed as the main barriers to the launch of MVNOs in Africa [130], Regulatory issues have held back the growth of MVNOs in markets such as the Middle East, Latin America and Africa [68], [69]. Africa is one of the fastest growing markets in the world with Kenya and South Africa posting the highest MVNO penetration.

By April 2024, there were 4-MNOs in Kenya, namely; Safaricom, Airtel, Telkom and Jamii Telecom. Three are 4G compliant except Telkom [8]. The MVNO market is still embryonic with 9 registered MVNOs namely: Zioncell, Sema, Finserve Africa Limited (Equitel), Mobile Pay Limited (Tangaza), Homeland Media, Lycamobile Kenya, JamboPay, Eferio Kenya Limited and Jambo Telecom. Infura Ltd and Hidiga Investment are pending applications awaiting approval. Six MVNOs out of the nine are hosted by Airtel, two by Telkom Kenya Ltd and one by Safaricom Ltd. Of the nine MVNOs, Zioncell Kenya and Sema have closed shop. Homeland Media, Eferio Kenya Ltd and Jambo Telecomms are active but still putting their houses in order. Mobile Pay is active but struggling with compliance issues, while JamboPay is active and the latest MVNO in the market. Equitel is the only MVNO that can be said to be stable and performing. Out of 9-MVNOs registered in Kenya, only two are in the public domain a 22% survival rate that has seen the MVNO market share in Kenya drop from 4% to about 2.3% in the last 4-years [200]. A record of registered MVNOs in Kenya is given in table 3.

MVNOs are about competition, service differentiation and market segmentation [4]. The degree of freedom depends on the breadth of the core network platform it operates and the agreements contracted with the host MNO. The MVNO addresses market segments that are currently underpenetrated by the MNO or not addressed at all, it succeeds in addressing market segments at lower cost than the MNO, and it does not compete on low price, but instead on content or brands. MVNO market segments may be classified by type, by category by business model and

by geographical region [135]. Global market segments by type may take different forms like, Business, Migrant (Ethnic), Retail, Roaming, M2M, Business, Discount, Telecom, Entertainment

Table 3: Record of MVNOs Registration in Kenya *(Source: CA Report statistics/Register 2014 - 2024)*

	MVNO Name	Year of Registration	Host MNO	MVNO Type of services	Mkt share S/B (%)	Status
1	Finserve Africa Limited (Equitel)	April 2014	Airtel	Voice/Data/Mob money Financial	2.3/1.3	Active
2	Mobile Pay (Tangaza)	April 2014	Airtel	Voice/ Data/ Mob Money/ Financial	Insignificant	Active
3	Zioncell Kenya	April 2014	Airtel	Voice /Data	Nil	Obsolete
4	Sema	April 2014	Airtel	Voice/Data	Nil	Obsolete
5	Lycamobile Kenya	November 2015	Airtel	Voice/Data	Insignificant	Active
6	Homeland Media	Feb2016	Airtel	Voice/Data/ Mobile money	Insignificant	Active
7	Eferio Kenya Limited	August 2023	Telkom Kenya	MVNOs & IoT services	Insignificant	Active (MVNE)
8	Jambo Telecom	April 2020	Telkom Kenya	Broadband & N/W provider	Insignificant	Active
9	JamboPay	February 2022	Safaricom	Data/Financial & IoT	Insignificant	Active (Latest MVNO)
		LICENCE UPGRADE MVNO to MNO				
10	Faiba	Dec 2017	Jamii Telecom	VoLTE/Data/SMS 4G Fiber Optic n/w at 700Mhz	N/A	Active Started as MVNO but now MNO
		PENDING REGISTRATIONS				
11	Infura Limited	-	-	-	Nil	Pending
12	Hidiga Invest'nt	-	-	-	Nil	Pending
		UNSUCCESSFUL REGISTRATIONS				
13	Kenya Airways	-	-	-	Nil	Unsuccessful
14	Nakumatt	-	-	-	Nil	Unsuccessful
15	Coop Bank	-	-	-	Nil	Unsuccessful

(Media), Lifestyle, advertising funded, youth, students, elderly, enterprise, health enthusiast, NGO supporters (Charity), financial services among others [4], [67], [134]. Market segmentation by category may take the form of pre-paid and post-paid. Market segmentation by business model includes full MVNO to reseller MVNO. Discount and Niche markets remain the

most popular while Data and M2M Segments will present the highest growth in Europe [79]. M2M communications based on mobile network technology is a new opportunity for MVNO. Many services can be offered like: Remote management, Security & Surveillance, Fleet Management, e-Health Applications, Sales & Payment and Home Applications [104]. Discount, Niche, Retail, Advertising and Brand MVNOs [105] is yet another classification. MVNO's essential network assets are a service delivery platform and a business support system (BSS) for customer relationship management (CRM) and billing [9]. Managing and understanding technology remains one of the fundamental challenges for MVNOs, Most challenging part of launching an MVNO is related to network and IT integration between the operator and the MVNOs. Issues related to technology complexity and cost are largely addressed by MVNEs who act as facilitators between MNOs and MVNOs by providing services in IT/billing and Customer Relationship Management (CRM) software vendors or integrators. Flexibility in both technology and business processes is cited as the most important characteristics for MVNOs if they are to succeed and remain profitable with the role of aggregators becoming virtually indispensable.

A close relationship with the MNO is important for an MVNO's commercial viability From a customer point of view, MVNO is just another MNO [173]. The narrower the relationship gaps between the two, the better the success for the MVNO. Five parameters have been established to find out the gap between MVNOs and MNOs that include: Services Offered, Operational performance, Consumer as a stakeholder, Service provider, and Consumer experience [171].

2.3.2 The MVNE Concept

Mobile Virtual Network Enabler (MVNE) is a relatively recent MVNO type that offers the would-be MVNOs core network and infrastructure elements, and/or solutions for various services, ranging from the provision of core network elements, to ensuring administrative and operational support [3]. An MVNE acts as an intermediary between the MVNOs and the host MNO. MVNEs do not have direct relationship with end-user customers. Its value chain comprises of Technical enablers (hardware and software), Emotional enablers (content and services), spectrum enablers (network operators), physical enablers (POPs) and profit enablers (customers) [4]. There are three common MVNE deployment models in the market; Single

MVNO model, MVNO Aggregator model and Multiple MVNO model [105]. A single MVNO model outsources MVNE platform for its operations but negotiates its own traffic wholesale agreements with the mobile operator MNO directly. The aggregator model again known MVNA (Mobile Virtual Network Aggregator) is a true MVNE that serves several MVNOs. MVNA is a business model that directly interacts with the customers. It negotiates wholesale traffic with MNO and resells it to MVNOs [105]. In the multiple MVNO model, the MVNE platform is owned by a platform vendor or mobile operator himself and services are outsourced to multiple MVNOs.. All the deployment models provide MVNOs with a network service delivery platform and a business support system (BSS) that saves MVNOs the burden of managing technology [9]. MVNE/MVNO systems come in many shades and shapes depending on the type of core network devices owned and standard interfaces used ranging from MVNE/MVNO in a box to virtualized software defined and cloud infrastructure Networks [105], [119], [120], [121]. A single MVNO model is the one practiced in the Kenyan market. MVNE/MVNO deployment models are shown in fig. 2

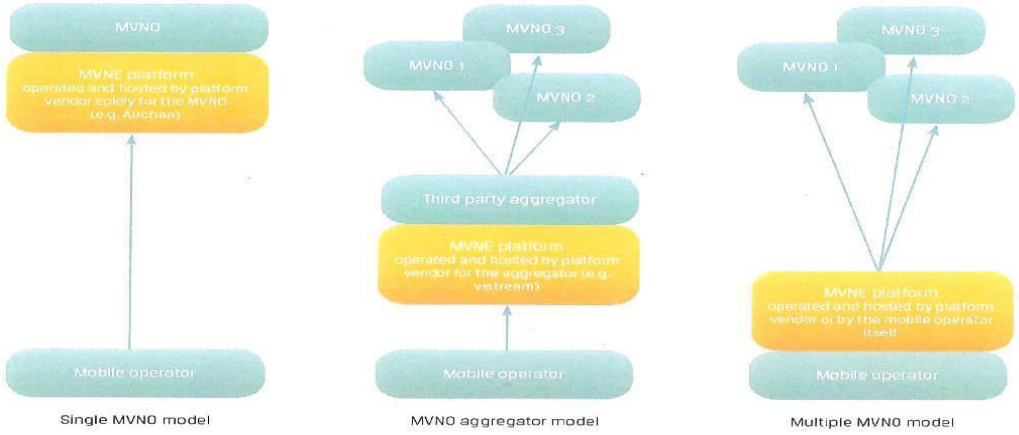


Fig 2. MVNO/MVNE Deployment Models *(Source: Comarch)*

For MVNEs/MVNOs to successfully scale into full MVNOs, they need a virtualized, core network and maximum business flexibility to develop new offers and services and a proper managed customer service and technical assistance [81]. For them to interoperate they need to be supported by standard interfaces like the 3GPP [10], [42]. Majority of the current MVNE/MVNO systems are based on smart devices. 3GPP compliant MVNE platform can

support any variant of MVNO model. 5G Systems riding on 3GPP NFV technology [146] are the latest MVNO models in the market. Single MVNE/MVNO (standalone) models have managed to scale from basic traditional legacy models through smart devices and visualized EPC technologies to MVNA/MVNE supported full MVNOs.

2.3.3 3GPP Open Standards and Future MVNO Networks

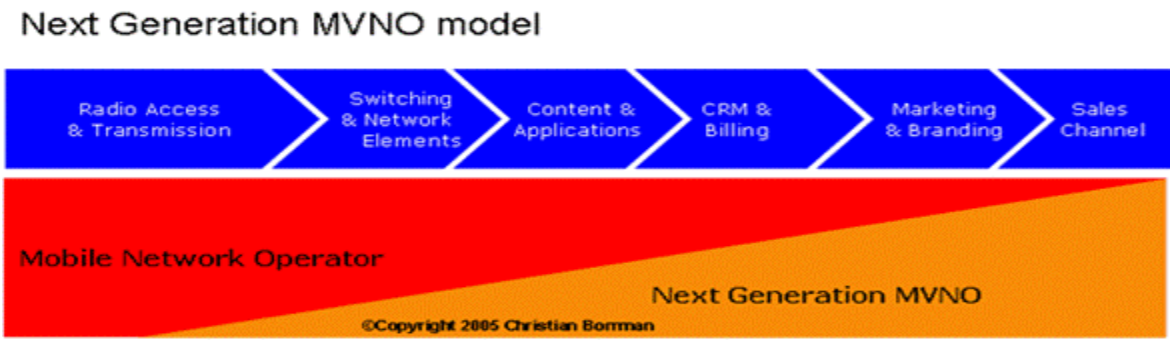
The 3rd Generation Partnership Project (3GPP) is a cellular telecommunications network standard that comprises of seven telecommunications standard development organizations partners (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC) that provide their members with a stable environment to produce the reports and specifications that define 3GPP technologies [123]. Together with other industry players and regulators, 3GPP has helped to align on spectrum, standards and technology. The project covers cellular telecommunications network technologies, including radio access, the core transport network, and service capabilities - including work on codecs, security and quality of service. The specifications also provide hooks for non-radio access to the core network, and for interworking with Wi-Fi networks [123]. 3GPP is the brain child of backward and forward compatibility of wireless LTE technologies. LTE is a 3GPP project that has evolved the 3G UMTS technology towards 4G-LTE mobile network standards and beyond [10]. LTE standards have played the role of integrating different existing wireless network technologies including; WPAN, WLAN, WMAN, MANET, 2G, 2.5G, 3G, satellite, DAB and DVB-T and migrating 4G LTE to 5G [110].

The 3GPP all-IP networks (ALIPN) study started in 2007 and has evolved through a series of specifications namely; Releases 8 to 16 spanning the period 2008 to 2020 respectively and comprising of 3GPP specifications TS23.40, TS23.402, and TS36.300 [123]. 3GPP standards Release 8-14 [143] have successfully supported 4G LTE networks. Releases 15, 16, and 17 are paving way to 5G and future networks from 2020 and beyond. The specification has witnessed GSM/EDGE and UMTS radio networks evolve to GSM EDGE Radio Access Network (GERAN) and Universal Terrestrial Radio Access Network (UTRAN) respectively. UTRAN has further evolved into Evolved Universal Terrestrial Radio Access Network (E-UTRAN) with Evolved Packet Core (EPC) as the core service element that include; System Architecture

Evolution (SAE), Home Subscriber Server (HSS), Mobility Management Entity (MME) and the Policy and Charging Rule Function (PCRF) modules. SAE is the GPRS core network that comprises of Serving Gateway (SGW) and a Packet Data Network (PDN) Gateway (PGW) that supports E-UTRAN, UTRAN, GPRS, UMTS, CDMA, WiFi, WiMax and IP Multimedia Subsystems (IMS). HSS assumes the functions of HLR/VLR/AuC/EIR. PCRF assumes the billing functions and MME is the main signaling module. E-UTRAN and EPC [123] are the backbones of 4G LTE network interoperability. 4G LTE Networks that are 3GPP release 8-14 compliant accommodate variants of MVNO/MVNEs that range from reseller to full MVNO/MVNEs [119], [121]. The 3GPP initiative and other stakeholders, has 5G, 6G and 7G on the drawing boards. 5G will be a unified global standard that brings forth a virtualized infrastructure with a real wireless world [147]. The Virtualized Evolved Packet Core (VEPC) is the basic element of the 5G and combines the Serving Gateway (SGW), the Packet Gateway (PGW), and Mobile Management Entity (MME) as one element. With VEPC an operator can easily create MVNO services, each with its own virtualized MME, SGW, and PGW. M2M and IoT are other virtualized services that are possible for target applications with 5G networks [146]. The 6G is proposed to integrate 5G with satellite networks for global coverage namely; telecommunication satellite networks, earth imaging satellite networks and navigation satellite networks. The 7G mobile networks aim to attain space roaming with uninterrupted access to information anytime and anywhere [147].

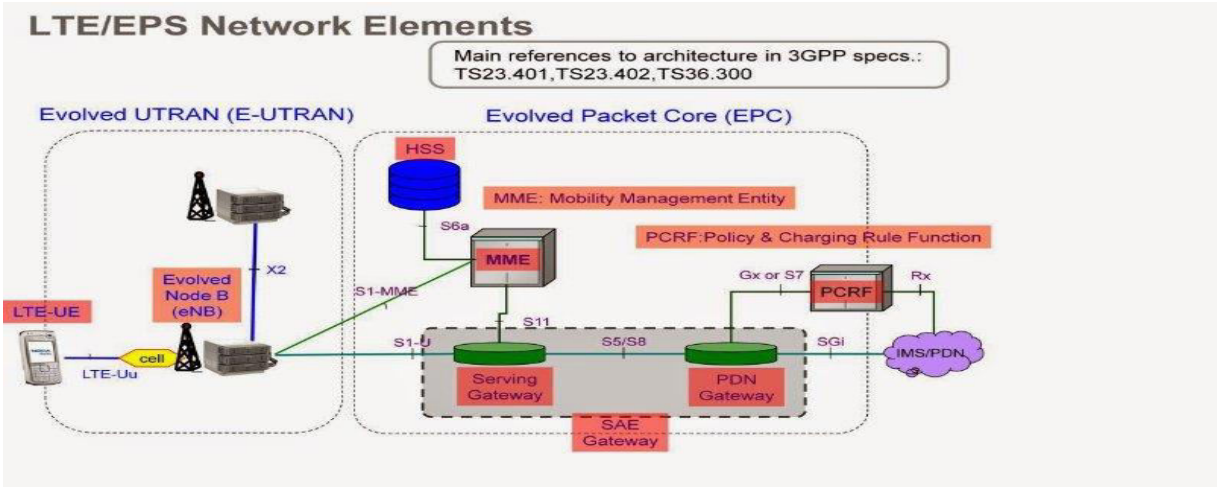
3GPP open standards have reinvented the backward and forward MVNOs/MVNEs LTE designs and EPC virtualized model architectures for the next generation as shown in fig 3. Fig 3a depicts the next generation MVNO model levels that are free of service demarcations unlike the traditional models. Fig 3b is an example of 4G LTE network architecture that has evolved Node B for forward and backward compatibility features and evolved packet core ideal for target and location based services respectively. Fig 3c is a typical example of a 5G network architecture that features an aggregator for forward and backward aggregation and an AIPN Nano Core for specialized network services. The Virtualized Evolved Packet Core (VEPC) and Virtualized AIPN Nano Core are the brain child of 3GPP initiative; they are the basic elements that have revolutionized the future of MVNOs in 4G LTE and 5G networks. 6G/7G networks will take off

from here to realize satellite global coverage and uninterrupted space roaming anytime, anywhere respectively.

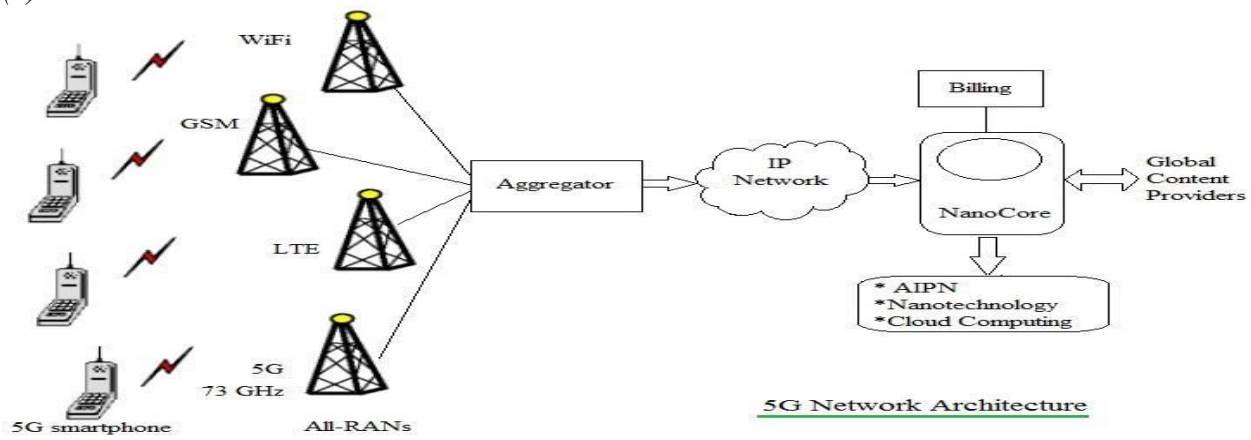


Future MVNO models are flexible in the infrastructure approach

(a)



(b)



(c)

Fig 3: Next Generation MVNO business model and n/w architecture

a. *Next Generation MVNO Business Model (Source: Christian Borrman -2006)*
b. *4G LTE 3GPP EPC Next generation Network architecture (Source: 3GPP Architecture specifications)*
c. *5G Generic network Architecture (Source: RF Wireless world)*

Starlink.com, a subsidiary of Space X and other telecommunications stakeholders (Telesat, Amazon, and Samsung) already have constellations of low earth orbit (LEO) satellites that are providing Internet based services at a comparable quality of 5G networks, however they are not 5G or 6G networks. 6G networks are still in the drawing boards and expected at the turn of the decade (2030) [215]

2.3.4 Forward and Backward MVNO Interoperability Features

The history of networking in the second half of the twentieth century is a story of increasing heterogeneity, as existing networks evolved from analog voice networks to digital voice networks, from circuit-switched to packet-switched networks, from wire -connected to wireless networks, from electronic to optical networks. Wireless networks have evolved through 1G, 2G, 2.5G, 3G, 4G and 5G. 6G and 7G are proposed next generation networks that are next in line. New technologies introduce heterogeneity because it is not possible to install them everywhere at once; instead, they are introduced gradually and interwork with the pre-existing network. Second, the implementation of similar elements from different vendors may differ enough that the elements cannot talk to each other correctly. Third the elements may be able to talk to each other, but they may not deliver the expected service. Interoperability is the only best solution to overcome these problems [101]

Future wireless networks should be an open, all-IP based, seamless connectivity system foreseen as an integrator among all existing, planned and future wireless and wired networks [103]. 4G's major goals are integration and convergence. The former should offer seamless interoperability of different types of wireless networks with the wired backbone. The latter relates to the convergence of different traffic types (e.g. voice, multimedia and data) over a single IP based core network, different technologies. 4G networks support more advanced features than their predecessors. High in the list are service portability, scalability, high data rates, high mobility support, seamless handoff, seamless roaming and QOS. The 4G features are well documented in literature. Convincing solutions have been given for high mobility support [117], [118], seamless handoff [113], [114], [115] and QoS [116]. Portability, seamless roaming, scalability and bandwidth are feasible with 4G technologies. 4G is an all IP packet switched network and

interoperates with existing wireless networks in addition to providing integration across different network topologies as demonstrated by MVNO/MVNE architectures [119], [120], [121].

Interoperability features for heterogeneous 4G networks revolve around re-configurability of network level, the user level or both, and cooperativeness in various communication systems [102]. Reconfigurable interoperability of the heterogeneous 4G system has led to more efficient end-to-end connectivity and service delivery in heterogeneous environments, easier worldwide roaming and dynamic adaptation to regional contexts, enhanced personalization and richer services. At the network level, the reconfigurable interoperability has offered network providers with a possibility to choose between alternative wireless accesses networks at minimal cost. At the user level, the interoperability of the heterogeneous 4G systems has provided more efficient end-to-end connectivity and service delivery in heterogeneous environments, easier global roaming and dynamic adaptation to regional contexts, enhanced personalization and enriched services. Cooperativeness comes to ensure connectivity between all the entities of a network in a consistent manner across all access technologies for any service [103]. The migration towards 4G is compatible with future cloud technologies where network elements could be implemented to provide cloud computing services [106]. Operators with most interest in cloud computing would be the MVNOs because of their CAPEX and (OPEX) startup and operational advantage [107]. 4G is slowly paving way for 5G networks that will benefit the network functions of MVNOs by migrating from dedicated equipment to virtualized EPC (VEPC) [108]. 5G's greatest commercial potential is in high speed broadband. High-speed mobile broadband and massive IoT are leading use cases. Asia Pacific and North America are leaders to commercial launch of 5G services with expected launches in half of the markets by 2020. Trials have been witnessed in North America to South Africa, with switched on commercial networks in South Korea, US, and Qatar to name but a few. Frequency auctions have also been conducted and concluded in markets like Finland, UK, and Italy [159]. 6G and 7G networks are in the drawing boards

Four key challenges for the 4G networks have been cited as; business model challenges; legacy network deployment challenges, scalability challenges, and signaling growth. To address the challenges, network service providers have virtualized the mobile packet core network functions and associated signaling infrastructure. Network Function Virtualization (NFV) and Software

Defined Networking (SDN) architectures allow the operator to manage resources effectively and significantly [133]. Signaling has moved from traditional MAP, SS7 and RADIUS protocols to all-Diameter protocol managed by Diameter Signaling Controller (DSC) [131]. The cheapest route for MVNOs towards 4G services is to partner with a 4G MNO that supports 3GPP TS 29.305 standard for Interworking Function (IWF) for Diameter–MAP. Legacy applications layer protocols like; GSM MAP (Mobile Application Part, GSM CAP (Camel Application Part), ANSI - 41 MAP, ANSI–41 WIN (Wireless Intelligent Network) connect to MNOs for basic and enhanced services. Legacy transport layer protocols like SSL7 for transport and network layer signaling are feasible. Legacy RADIUS (Remote Authentication Dial In User Service) and SOAP (Simple Object Access Protocol) for AAA (Authentications, Authorization and Accounting), policies, operations and administration services are feasible. With this arrangement, full network compatibility between 2G/3G and 4G MVNOs is feasible. DSC backward connectivity for 2G/3G MVNO and 4G MVNO are shown in Fig 7 (a) and (b) in appendix 4 respectively.

Lack of interoperability has been apportioned to business and technical reasons. Businesswise, features that defeat interoperability are viewed as competitive advantage and business monopoly and technically, the lack of or inadequacy of timely standards [99]. Essentially at this age and time, interoperability is not a technical problem as witnessed by 4G and 5G network architectures but more less a regulatory issue.

2.4 Related Studies

2.4.1 Backward to forward frameworks

A number of behavioral models have been used to explain technological adoption and usage of information technology. Such models include the Theory of Reasoned Action (TRA) [16] and its extensions, the Theory of Planned Behavior (TPB) [13], [17], and Technology Acceptance Model (TAM) [18]. In all these models, beliefs and attitudes of individuals towards a certain behavior are determinants of the individual's intention towards the adoption of that behavior. The theories have been applied successfully with some little modification to guide IS technological innovation studies. Authors argue that TRA has been found to be a strong theory for innovation adoption upon a few additions of other variables such as facilitating conditions,

awareness of innovation by users, social pressure and user readiness [176]. It is necessary for marketers and service developers to identify and understand consumers' needs, wants, attitudes and behavioral intentions towards innovative mobile services [15]. MVNOs are emerging technologies that depend on innovative services, and market segments for their success. However these sectors are not properly understood especially in the developing world. The failure of the sector in Africa could be due to intervening conditions that need to be identified and understood to facilitate the adoption of innovative services and market segments. Fit–Viability framework suggests that M-commerce business models are unique to different environments and cultures [19]. Different environments and cultures are influenced to use technology in different ways. Studies have shown that adoption of technology is influenced by geographical factors like rural/urban migration, communication infrastructure, family separation, and technological divide. Close family ties, Community culture, cultural beliefs and practices have also been found to influence adoption and use of mobile technology [177]. Mpesa, the mobile money platform is a case in point that has fanatical patronage in Kenya but the business model will not sell to the rest of the world. Likewise America, Europe and South Asia Pacific countries have vibrant MVNO sectors, while the industry in Africa is ailing. There could be some geographical and cultural factors that may be inhibiting the growth of the MVNO industry in Africa and Kenya in particular that need to be understood.

3GPP is an All IP network (ALIPN) framework that is meant to oversee the backward and forward compatibility of wireless technologies and evolution of the same into the future. Legacy network deployment, Scalability, Signaling and Business models have been cited as main challenges for the 4G networks [131]. 3GPP has integrated different existing wireless network technologies (WPAN, WLAN, WMAN, MANET, 2G, 2.5G, 3G, satellite, DAB, DVB-T) and evolved 3G UMTS technology to 4G (UTRAN, E-UTRAN) and 4G to 5G through Virtualized Evolved Packet Core (VEPC) network devices. Backward legacy network deployment and signaling problems have been solved by use of all-Diameter protocol managed by Diameter Signaling Controller (DSC) [131], while signaling in 5G and beyond has been resolved through Virtualized Evolved Packet Core (VEPC) a feature of Network Function Virtualization (NFV) and Software Defined Evolved Packet Core (SDEPC) a feature of Software Defined Network (SDN) [146], [196]. In addition to resolving signaling problems, the technologies have further

overcome the challenge of wireless network scalability through virtualization of core network devices/cloud computing and software defined core elements. Modern business models hinge on standard interfaces, innovation and value addition as the main ingredients for their success [10], [42]. 3GPP has witnessed variants of MVNO business models evolve from traditional tier model to seamless full MVNO models that are supported by 4G wireless networks [2], [11], [23], [24], [38], [39], [120]. It has further witnessed variants of MVNO/MVNEs that range from reseller to full MVNO/MVNEs [119], [121] with M2M and IoT as other virtualized services that are possible for target applications with 5G networks [146]. 3GPP standards hold very high stake in the development of future wireless networks. 5G is a unified global standard that brings forth a virtualized infrastructure with a real wireless world [147]. The 6G is proposed to integrate 5G with satellite networks for global coverage while the 7G aims to attain space roaming with uninterrupted access to information anytime and anywhere. [10], [119], [121], [123], [143], [146]. It has proved useful to equipment manufacturers and vendors alike, however the rate of the rollout of the specifications is slow and a bottle neck to industry standard implementers; Release 16 on phase 2 of 5G has just been concluded. The standards are appropriate for this study. They spell the latest specifications on future cellular networks and provide useful inputs into the implementation of the MVNO framework.

The European Interoperability framework (EIF) is a regional framework for European member states that provides interoperability solutions in the public administration of European nations. Interoperability frameworks (IFs) are a set of standard specifications that may be used to promote interoperability within collaborating public agencies. Most IFs comprise of technical, semantic and organizational elements. IFs aim at referencing the basic technical specifications and the enterprise architectures (EAs) as tools for achieving interoperability at the organizational level with reference to data, network equipment, software components, business locations and human resources. Unlike technical and semantic interoperability, aspects and characteristics of organizational interoperability for public administrations are much more heterogeneous and varied that they do not have clear guidance; they vary from region to region [127]. Classical Interoperability maturity models (LISI [59], OIM [60,] NC3TA [61], LCIM [62]) are partial with aspects of organizational interoperability missing. EIF is one interoperability framework that has been refined to meet the demands of the changing technology [52], [63]. The EIF [63], EIF

Annex II [124], EPAN [129] and ETSI [127] [128] regulatory bodies and enterprise interoperability frameworks [138], [154], [156], have given organizational interoperability a more prominent berth in terms of defining business goals, modeling business processes and creating collaboration between diverse administrations that wish to exchange information with different internal structures and processes. EIF provides 25 recommendations that serve as guidelines for organizational/administrative interoperability. It gives guidance to public administrations on how to improve governance of their interoperability activities, establish cross-organizational relationships, streamline processes supporting end-to-end digital services, and ensure that existing and new legislation do not compromise interoperability efforts in practice. EIF is a rich framework that looks at public administration from institutional, functional and IT-Service levels. However there is aspect of organizational interoperability that needs to be filled up by enterprise architecture frameworks.

Kenya has just unveiled a National ICT policy 2020 [192] that maps the future of ICTs in Kenya with emphasis on mobile and the knowledge economy, broadband and high speed networks, universal access and infrastructure sharing, interoperability and data sharing with the onus left on CA to develop national policies to regulate the entities in the sectors. The Kenya Information and Communications (Interconnection and Provision of Fixed Links, Access and Facilities) Regulations, 2010 [191] is another policy document spelling out general interconnectivity regulation and guidelines in the sector while the National Payment Systems Regulation, 2014 [193], heralded a formal legal framework for electronic money in Kenya. The two documents touch on interoperability and sharing of information and serve as references in the implementation of an MVNO framework.

2.4.2 Review of Existing MVNO Models and Frameworks

The Schekkerman, Zachman, TOGAF [154] and FEAF [156] Enterprise Architecture (EA) frameworks [137], [138], [155] are more recent frameworks that are better refined to articulate the structure of organizations. EA is a description of an enterprise from an integrated business and IT perspective recognized as a proven instrument to facilitate business/IT alignment [155]. Internet and WWW technologies comprise their core [136]. All the EA frameworks basically

consider business, data/information, applications and Network infrastructure as the main architectural elements. TOGAF framework is iterative in Presently TOGAF is the most cited and widely discussed publication in EA literature, it embodies the modern understanding of EA and is even considered as a *de facto* industry standard in EA practice by some authors. It is an open group standard, technology neutral, reliable and consistent .nature and more technical than the other EAs. It complements but doesn't compete with, other enterprise frameworks. Kenya has a draft Government Enterprise Architecture (GEA) that is yet to be unveiled [142]. IFs and EAs are the building blocks of interoperability in public service initiatives; they were useful in the implementation of the MVNO framework. The United Nations Development Programme (UNDP) e-Government Interoperability Framework (eGIF) [140] is a standard guideline that has helped many developing countries to formulated eGIFs in their nations. The standard provides a concise comparative survey of some selected and a general guidance on implementing an interoperability framework. Common to nearly all eGIFs is the definition of standards to adopt. Slightly less common is the definition of reference architecture to achieve interoperability. A number of African countries (Mozambique, South Africa, Ghana, Namibia, Nigeria, and Rwanda) have embraced the recommendations and produced eGIFs for their countries [139] but not specifically for MVNOs. However the general information was relevant to this study. The MVNO framework by Pham Hai Son [178] and SATRC (South Asia Telecom Regulator Council) Regulatory framework for MVNO by SATRC Group [176] are two closest frameworks to this study.

The MVNO framework by Pham Hai Son [178] for developing countries was of interest to this study. The study considered formulation and implementation of policies rules and regulations as the biggest challenge of MVNO in developing nations. It examines the deployment of MVNOs in developing nations and discusses them in the context of evolving international practice in the telecom market. The main contribution to the literature is developing a regulatory framework for MVNOs in the telecom market based on evolving international practice. The Author looks at the study as a reference document that governments can use to improve their MVNO sectors and create an infrastructure platform for e-government. Pham's proposed framework however is a general MVNO deployment framework for developing nations. SATRC (South Asia Telecom Regulator Council) Regulatory framework for MVNO by SATRC Group [176] is yet another

MVNO regulatory framework resonating well to the aims of this study. The MVNO framework revolves around policy and regulatory aspects of infrastructure sharing among the SATRC countries i.e. formulation of Regulatory framework for MVNOs, ICT regulatory framework for M2M communications and IoT, and Regulatory approaches to enhance broadband experiences. The framework emphasizes opportunities for MVNOs in niche segments mainly in the data driven services such as e-commerce transactions and mobile banking, the enterprise segment, Internet of Things (IoT/M2M and untapped rural markets. SATRC like Africa.is a developing region with similarities in terms of MVNO deployment policy the two regions can share, however the needs and wants may be different on the ground. Secondly, the SATRC MVNO framework came at a time when there were no MVNOs in the SATRC region.

The proposed MVNO implementation framework in this study was informed by existing case studies and markets. For the purpose of an implementation framework for MVNOs in Kenya, no single wide framework was adequate; none captured the needs and aspirations of the sector and mitigated the challenges in the Kenyan landscape. Inputs from a hybrid of tested frameworks, models and collected analyzed data were useful inputs. Institutional, functional and IT-Service views of organizations were considered in the context of MVNO development phases of startups, development and deployment. Strategic, economic, information technology, political/governance, behavioral and Cultural issues that supplement or challenge the adoption and use of MVNO technologies were important elements of consideration in the final product of this study.

In summary, the proposed MVNO framework in this study is not just a deployment regulatory framework but a framework that encompasses implementation of MVNO startups, development and deployment. The framework was informed by the prevailing local practices, international standards/practices and emerging technologies in the wireless networks. The environment of emphasis was developing nations in Africa in general and Kenya in particular. There are some peculiar issues that are unique to Africa and Kenya that may not be found in other developing countries. SATRC and Pam Hai Son MVNO frameworks were forward looking and timely in their environments while Kenya did not have one at all.

Pham Hai framework and SATRC framework, to some extent, resonate well with the findings of this study. A comparison table of the key frameworks recommendations vis-a-vis the findings of this study is given in table 4

Table 4: Comparison of Existing MVNO frameworks vis-a-vis this Study

Framework Name		**Pham Hai Son MVNO Framework (2019)**	**SATRC MVNO Regulatory Framework (2018)**	**MVNO implementation Framework (2024)**
Comparison Areas				
1	Author	(Pham Hai Son. et. al) Elsevier – Utilities Policy Volume. 56, Feb 2019 pp169-180	(SATRC Working Group on Policy, Regulation and Services) 19th Meeting, 13 – 15 December 2018, Islamabad, Pakistan	This Study
2	Title	Governing MVNO in Developing Countries	SATRC Report on Regulatory Framework for MVNO	An Implementation Framework for MVNOs
3	Target Countries	(Developing Countries) Africa, Asia and Latin American countries (India, Nepal, Bangladesh)	(Developing Countries) South Asian Countries (Bangladesh, Bhutan, India, Iran, Pakistan, Sri Lanka)	(Developing Countries) Africa (Kenya)
4	Goal and Focus	Develop a Regulatory framework for MVNO in Developing Nations' Telecom mkt– Create Infrastructure for Deployment of e-Government Services	Report on MVNO Policy, Regulations and Services and Suggestions for improvement - Infrastructure/M2M/ 1oT/Broadband	Develop a Framework for MVNO Startups, Development and Deployment
5	Key contribution	Development of a Regulatory Framework for MVNOs in the Telecom market based on Evolving International Practice	MVNO Regulatory Policy and Infrastructure Sharing	Regulatory framework for MVO Startups, Development and Deployment
6	Specific Contributions	• MVNO to be introduced as a distinct service provider with its own licensing and regulatory framework. • Scale existing framework	• MVNO to be introduced as a distinct service provider with its own licensing and regulatory framework. • MVNO free to choose its business model (Full or hybrid or Thin)	• MVNO to be introduced as a distinct service provider with its own licensing and regulatory framework. • Involve key stakeholders in startup, development and deployment stages of MVNOs

		to suit MVNOs in developing nations • Formulation and implementation of policies rules and regulations big challenge • Upgrade status of telecom service in rural, remote and marginalized areas • Identify steps to involve government in the implementation of the framework • Policy implementation is a slow process and complex • Clear policy to spur fairness and competition • Legal frameworks hard to come by • LSA agreements between MNOs and MVNOS • Dispute Resolution	• Arrangement/ agreement between MNO and MVNO to be driven by market forces. • MVNO to be issued a license under its own tariffs • The license service area of MVNO to be same as that of parent MNO. • Agreement with MNO to be submitted before issue of license to MVNO • No limit on number of MVNOs attached to a MNO. • MNO to pay the spectrum charges for utilization of spectrum by MVNO. • Allocation of Numbers, Number portability, Interconnection with other service providers and roaming to be provided by parent MNO. • Subscribers to be protected on failure of agreement between MNO and MVNO or MVNO quitting service. • No Roll out Obligations for MVNO. • Annual license fees same as that of MNO of the service area. • Restrictions on Mergers and acquisition on similar lines as MNOs. • MVNOs shall be permitted to set up their own network equipment save for RAN • No restrictions on the number of entrants in a service area and number of MVNO parented by an MNO. • MVNOs should be allowed to form an associations to lobby for their rights	• MVNO implementation should adhere to the international standards and practices and National policies • MVNO to be issued a license under its own tariffs but not under a unified license as it is currently • MVNOs shall be permitted to set up their own network equipment save for RAN • MVNOs should be allowed to form an associations to lobby for their rights • Policies from the regulator should be, timely and reviewed often • Compliance and regulation enforcement should be monitored closely • MVNOs should be protected from challenges of existing MNO • The regulator should address any form of unhealthy MNO influence and dominance • Regulator should provide guideline policy for SLA to protect MVNOs • The general public as the key stakeholder should be aware of the existence of MVNOs as mobile service providers and the role they play in the market • Social cultural factors should be mitigated at National and County levels to overcome network limitation • Stakeholders value chain and development value chain are key to MVNO performance • Good business strategy, and finances (CAPEX/OPEX) are key to any startup and deployment

2.5 Models and Theoretical Frameworks

Models and frameworks are foundations on which Knowledge base is represented in research among others things [170]. There are broadly three major types of research models: Qualitative, Quantitative and Hybrid. Models identify basic concepts and describe what the reality is and the conditions by which we can study it. Models use constructs to represent a real world situation, the design problem and its solution space. Models aid problem and solution understanding and frequently represent the connection between problem and solution components enabling exploration of the effects of design decisions and changes in the real world [170]. A theoretical framework is a structure that can hold or support a theory or a research study. The theoretical framework dwells on time tested theories that embody the findings of numerous investigations on how phenomena occur [169]. The conceptual framework on the other hand describes the

relationship between specific variables identified in the study. It also outlines the input, process and output of the whole investigation [169].

2.5.1 MVNO Business Model

Different authors have given different definitions of the business model [28], [29], [30], [31]. A business model is an abstract representation of an organization, be it conceptual, textual, and/or graphical, of all core interrelated architectural, co-operational, and financial arrangements designed and developed by an organization presently and in the future, as well as all core products and/or services the organization offers, or will offer, based on these arrangements that are needed to achieve its strategic goals and objectives. [33], [34]. The business model illustrates the relationships between information systems and business strategy [35]. The structure of the telecom industry is shifting to an open system collaboration, communication, and co-ordination where companies need to reassess their businesses and repackage their business models to cope with the changing times [36]. Developments in the European market and other spheres show an accelerating increase in usage of online communication services (OCS) [112], a paradigm shift from the traditional electronic communication services business model. MVNO business models thrive on value addition on their services rather than standardized interfaces. The 3GPP, Open Service Architecture (OSA) [10], offers such open services for backward and forward compatibility of LTE cellular systems by promoting and opening up the MNO value chain and allowing third parties develop and deploy value added services irrespective of vendor equipment. Besides, 3GPP has gone beyond the forward and backward LTE compatibility to standards that support standalone MVNO business services beyond the 4G networks [146], [147].

Open frameworks and models prevent design and development of proprietary products and services and allow interoperability of applications from different providers and vendors [14]. Such frameworks and models can be refined to suit a variety of situations and environments. Open business models allow ideas to come from any stakeholder and enrich the value network, enabling the innovation that is required for value addition [26]. Ten MVNO critical success factors have been identified with competitive low pricing, innovative services and tariff

packaging leading the pack [40], [41]. The factors can be used to establish the effectiveness of different MVNO models.

Porter's five forces framework (Suppliers, consumer demand, new entrants, substitute products and competitive rivalry) [12] and PEST (Political, Economic, Social, Technological) external factors analysis [181] indicate that the mobile telecom industry is attractive for MVNOs in terms of offering new revenue sources. PEST analysis further suggests that most of the external environment factors favour MVNO business model. Cost leadership, market segmentation and service differentiation are further identified as three generic types of business strategies [12]. The Finish industry looks at the strategies as low price, narrow focus, service differentiation, service reselling and international clustering [4]. MVNO deployment in Asia started with two types of strategies. The growth strategies that targeted consumers and industry and the generic strategies that targeted developed markets for economic growth [178]. The integration of heterogeneous networks is one of the most important features that are needed for the future deployment of new wireless technologies [48].

2.5.2 The Traditional MVNO Value Chain

There is no commonly accepted classification for MVNOs. MVNOs can be classified based on the network components and services owned by the MVNO [4], [5], [11]. To the customer, an MVNO is just another MNO. All the MVNOs deliver their own SIM cards and take care of the branding, marketing, billing and customer care. MVNO classification can be based on technical dependence or services provided. In technical dependence MVNO owns core network devices, in services provided, the argument is that MVNOs are more about customers, community and content than they are technology [6]. Common in both approaches is that the more service creation elements a MVNO has, the more pure or true the MVNO is [4]. In this regard, a number of traditional MVNO business models have been advanced in the literature, ranging from three to five tier models [2], [11]. All the models depict five or six value added services that include; Radio Access and transmission, Switching and Core Network, Applications and services, Customer relationship management (CRM) and billing, Marketing and branding/sales. Four tier models seem to be popular and include; Full MVNO, Enhanced Services MVNO, Services

MVNO and Reseller MVNO. A Full MVNO owns core network devices used for the service provision (e.g. HLR, VLR, (G) MSC, EIR, AuC, (G) SMSC and SGSN). It can issue its own SIM cards, but it does not hold usage rights over the radio frequencies and devices of the core radio access network (e.g. base stations, radio network controllers). An Enhanced Services MVNO (Light MVNO) does not hold any radio access infrastructure and core network. They can issue their own SIM cards and provide value-added services such as voice messages, missed call notifications, virtual private networks (VPN) etc. Services MVNO (Second Brand MVNO) provides CRM and the billing services for the services provided. A Reseller MVNO (Branded MVNO) brands the services through marketing/advertising and reseller the services.

From the MNO's viewpoint, making an agreement with a MVNO is a big strategic issue. Selling network capacity to one or several MVNOs can bring new subscribers and traffic into the network broadening the customer base of incumbent MNOs. Selling of the capacity is also an efficient way of sharing network costs. On the other hand, the entrance of a MVNO in the market becomes a competitor and is likely to lower the prices in the market. Furthermore, the MVNO may enjoy more success than the host MNO. MNOs should thus find the most beneficial and profitable amount of network capacity contracts [7]. This should be based on pricing, customer structure, services and the business strategy of the MVNO

2.5.3 Integrated MVNO Value Chain

The 3rd Generation Partnership Project (3GPP), Open Service Architecture Release (8-14) [10], [42] framework has opened up the field for open source MVNO software solutions. It is the most structured and coordinated initiative of the 4G LTE wireless networks and beyond. To this end, integrated MVNOs of different shades have been created including; the MVNO in a Box [23], [24]; Multi-MNO MVNO model [37]; Always Best Connected model (ABC) [38], [39]; MVNE/MVNO model [119], [120], [121]; NFV and SDN EPC models [108], [146], [196]. 5G has heralded a new era of MVNO business models riding on 3GPP NFV and SDN technologies that have already hit the market [146]. Fig 4 is a summary of MVNO business models and their value added services.

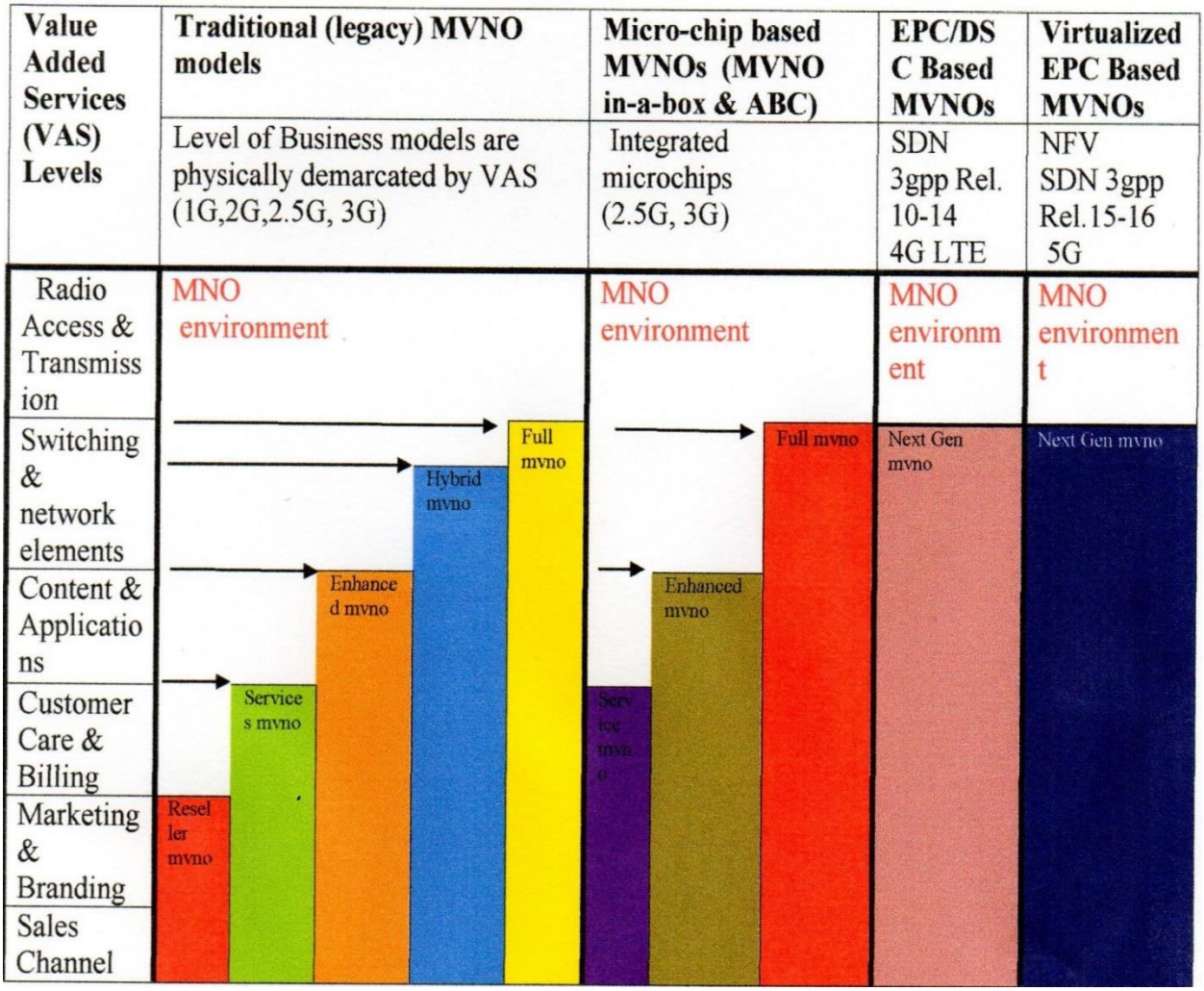


Fig 4: MVNO Business Models and value added services

To summarize, the level of MVNO business model depends on the generation of the MNO network architecture hosting it. MVNO models have globally developed from traditional (legacy) MNO architectures of (1G, 2G, 2.5G and 3G) networks using legacy technologies with services physically demarcated by Value added services (VAS). Over a time, integrated microchips improved the 2.5G and 3G architectures that supported MVNOs in a box whose services were not purely demarcated by VAS. 3GPP, SDN, EPC, and DSC signaling technologies paved way to Evolved Packet Core based networks that supported 4G LTE MVNOs that were free from VAS demarcation. Network Function Virtualization (NFV) further gave rise to Virtualized EPC based MNOs that supported 5G MVNOs free of VAS demarcation. 4G and 5G networks are an initiative of 3GPP LTE and EPC technologies that will see next generation

networks to 6G and 7G. The 6G is proposed to integrate 5G with satellite networks for global coverage while the 7G aims to attain space roaming with uninterrupted access to information anytime and anywhere.

MNOs in Kenya are currently riding on a hybrid of 2G-5G networks depending on the area and geographical region. The highest level of MVNO in the market currently is Enhanced MVNO (Equitel). Existing MVNOs on 4G/5G networks might upgrade to virtualized/EPC technologies that would afford them full MVNO status for target based applications and location services like M2M, IoT and IoE.

2.5.4 Interoperability Maturity Models

Interoperability is founded on open standards, standard devices, standardized protocols and interfaces [3], [9], [77]. Products achieve interoperability with other products by adhering to published standards or by making use of a broker services. Enterprise integration, interoperability and networking are some of the major disciplines that are enabling companies to improve collaboration and communication in the most effective way [53].

Different definitions of interoperability have been advanced in the literature; [51], [55], [57], [58]. Interoperability is the ability of different types of computers, networks, operating systems, applications to work together effectively, without prior communication, in order to exchange information in a useful and meaningful manner [55]. Integration is a means to achieving interoperability. Integration goes beyond interoperability to involve some degree of functional dependence among its components while interoperable systems can function independently. Integration deals with organization issues while interoperability is more of a technical issue. Integrated systems are interoperable but interoperable systems need not be integrated. [57]. Interoperability revolves around three quality criteria of modularity, communications commonality and data commonality [49], [50]. Interoperability promotes principles such as openness, cooperation, reusability, sharing and standardization.

Interoperability issues are of many types and many maturity models have been defined to classify them, namely: LISI [59], OIM [60,] NC3TA [61], LCIM [62] and EIF [63]. Most

interoperability frameworks define a three-layer structure namely; technical, semantic and organizational interoperability [52], [63]. Seamless interoperability is difficult to attain due to different levels of enterprises, different kinds of enterprise applications and varying levels of abstractions of the considered models. A comparison study on maturity models reveals that existing interoperability maturity models (LISI, OIM, LCIM, EIMM) are partial models only dealing with some aspects of the enterprise interoperability domain with models covering all areas of concerns and aspects of the enterprise interoperability still missing [109]. This gap has partially been filled by enterprise architecture frameworks [138], [154], [156].

2.5.5 Organization Regulatory framework

Interoperability encompasses not only mere technical standards and interfaces, but also includes organizational interoperability. Organizational interoperability implies integrating business processes and related data exchange. Organizational interoperability also aims to meet the requirements of the user community by making services available, easily identifiable, accessible and user-focused [124]. It also addresses political, legal, governance and enterprise aspects [128]. Managing the relationship between MNOs and MVNOs is the most crucial component demanding some sort of regulation [152]. To achieve technical interoperability, there are acknowledged standards/protocols; for semantic interoperability, recognized concepts and methods are available. However, aspects and characteristics of organizational interoperability for public administrations are much more heterogeneous and varied that they do not provide similar guidance [127]. The EIF [63], EIF Annex II [124], EPAN [129] and ETSI [127] [128] regional

regulatory bodies and enterprise interoperability frameworks [138], [154], [156], have given organizational interoperability a more prominent berth in terms of defining business goals, modeling business processes and creating collaboration between diverse administrations that wish to exchange information with different internal structures and processes. The EIF and EPAN review documents are key instruments for establishing interoperable digital public services at regional, national and EU (European Union) level. EIF provides 25 recommendations that serve as guidelines for organizational/administrative interoperability. EIF interoperability framework gives guidance, through a set of recommendations, to public administrations on how to improve governance of their interoperability activities, establish cross-organizational

relationships, streamline processes supporting end-to-end digital services, and ensure that existing and new legislation do not compromise interoperability efforts in practice. Modinis Lot 2 project study of interoperability at the local and regional level, recommendations pointed out deficiencies in the current EIF interoperability framework. Technical interoperability and syntactic interoperability are fully developed; semantic interoperability is theoretically developed but practical implementation is a problem; organizational interoperability lack conceptual clarity that leaves room for large scope of interpretation [134]. To this end, a 3 view dimension of organizational interoperability that comprises of functional view, institutional view and IT service view and introduces a business process interoperability layer on top of semantic layer and adds governance (legal & legislation) perspectives vertically is proposed [127].

To deliver public services requires cooperation among different public administrations. EIF recommends that public administrations when establishing public service, should base interoperability agreements on existing formalized specifications, or, if they do not exist, cooperate with communities working in the same areas [125]. Organizations involved should formalize cooperation arrangements in interoperability agreements. Agreements should be drafted with sufficient detail to achieve intended aim while leaving each organization, maximum internal autonomy. At legal level, interoperability agreements are rendered specific and binding via legislation or through bilateral and multilateral agreements. At organizational level, interoperability agreements can, for example, take the form of MoUs or SLAs that specify the obligations of each party participating in cross-border business processes. Interoperability agreements at organizational level will define expected levels of service, support/escalation procedures, contact details, etc., referring, when necessary, to underlying agreements at semantic and technical levels. The MNOs of developing nations expect a clear MVNO policy, obligation policy for all MNOs and MVNOs, subsidy for rural and remote places, training, and discussion among stakeholders [171]. Additionally, for an effective MVNO market to emerge and grow, regulation needs to include fair price of use of the network, opportunity of number portability, use of multiple SIM cards and maximum amount of coverage that an MVNO can purchase [153]. Harmonization procedures of a number of thematic areas within service providers should be addressed for interoperability to be a success [126]. Majority of the thematic issues are legislative in nature and best mitigated by national and regional

regulatory bodies in compliance with existing formalized recommendations in their respective regions.

2.5.6 Public Administration Frameworks

Interoperability frameworks (IFs) are a set of standard specifications that include technical, semantic or organizational elements that may be used to promote interoperability within collaborating public agencies. IFs and Enterprise Architectures (EA) are the building blocks of interoperability in public service initiatives [136]. EA is a description of an enterprise from an integrated business and IT perspective recognized as a proven instrument to facilitate business/IT alignment [154]. IFs aim at referencing the basic technical specifications and the enterprise architectures as tools for achieving interoperability at the organizational level with reference to data, network equipment, software components, business locations, human resources etc. Internet and WWW technologies comprise their core with two different structure approaches; OSI-centric, which organizes the standards in layers and POSIX-centric, which organizes the standards around services [136]. A number of EA frameworks have been discussed in the literature including, Business System Planning (BSP) Architecture [155], The Zachman Enterprise Architecture Framework [138], The Schekkerman Architecture [137], The Open Group Architecture Framework (TOGAF) [154] and the Federal Enterprise Architecture Framework (FEAF) [156]. All the EA frameworks basically consider business, data/information, applications and Network infrastructure as the main architectural elements.

Interoperability frameworks can be developed at different levels; local, regional and international depending on the level of the cooperating entities. They could also be based on the services that are meant to be exchanged. Several dozens of interoperability frameworks have been defined all over the world. The UNDP (United Nations Development Programme) [140] provides a concise comparative survey of some selected eGIFs (eGovernment Interoperability Framework) and a general guidance on implementing an interoperability framework. Common to nearly all eGIFs is the definition of standards to adopt. Slightly less common is the definition of reference architecture to achieve interoperability. A number of countries in Africa have taken bold steps in enacting e-government interoperability frameworks. Mozambique [139] South Africa and Ghana

lead the pack with countries like Namibia, Nigeria, Rwanda, just to mention but a few are in their formative stages.

2.5.7 MVNO Interoperability features

Interoperability is one essential factor in 4G, 5G and NextG networks. Future MNOs should adopt the changes in terms of classification and features listed in table 5 and table 6 in line with international standards for the benefit of the MVNOs they host [117], [118]. Some of the problems in the Kenyan environment is organizational interoperability in the mobile money sector where one mobile service provider does not want to share its resources with the other. Other features include lack of efficient spectrum sharing, portability and connectivity issues. Cases of sabotage against MNOs and MVNOs cannot be ruled out.

Table 5: Layers of interoperability classification (source- European Journal of ePractice 2009)

Layer of Interoperability	**Aim**	**Objects**	**Solutions**	**State of Knowledge**
Technical	Technically secure data transfer	Signals	Protocols of data transfer	Fully developed
Syntactic	Processing of received data	Data	Standardized data exchange formats, e.g. XML	Fully developed
Semantic	Processing and interpretation of received data	Information	Common directories, data keys, ontologies	Theoretically developed, but practical implementation problems
Organizational	Automatic linkage of processes among different systems	Processes (workflow)	Architectural models, standardized process elements (e.g. SOA with WSDL, BPML)	Conceptual clarity still lacking, vague concepts with large scope of interpretation

Interoperability in Kenya has been adopted at all layers and more so at the technical, syntactic and semantic levels because of their maturity and international support. Organizational interoperability has taken the form of enterprise architecture frameworks and Government Enterprise Architecture (GEA) projects [174]. The closest Kenya got to an interoperability

framework is through the enactment of Kenya Information and Communications (Interconnection and provision of fixed links, access and facilities) Regulations 2010 [191] that emphasized end-to-end connectivity between cooperating entities and the National Payment Systems Regulation, 2014 legal framework [193] that allowed CA to formulate e-money interoperability framework to facilitate mobile money transfer platforms (Mpesa, Airtel money, Orange money, Equitel, Mobikash and Tangaza).

Table 6: 4G-LTE Interoperability features

Re-configurability features	**Cooperativeness features**
Channel state	End-to-end service such as IP connectivity
Outage probability	Session management
Vertical handover probability	Security
Users' QoS requirements	QoS
Context awareness	High mobility support
Load sharing and distribution	Connectivity issues
Efficient spectrum sharing	Self-organization
Preferred gateway selection	Authentication
Network discovery	Authorization
Congestion control	Accounting
Seamless handoff	Portability
High data rates	Seamless roaming
Scalability	

Kenya recognized the need for mobile money interoperability by encouraging mobile operators to share mobile money infrastructures including agent networks on transparent, fair and non-discriminatory basis [7]. The implementation however has been a bottleneck according to Analysys Mason [194] and Sterling Capital [195] in their studies on dominance and misuse of dominance in the mobile money and mobile communication sectors in Kenya [194].

Besides, Kenya has a National ICT Policy 2020 [192] that maps the future of ICTs in Kenya with emphasis on mobile and the knowledge economy, broadband and high speed networks, universal access and infrastructure sharing, interoperability and data sharing with the onus left on CA to develop national policies to regulate the entities in the sectors. It has also The National ICT Policy Guidelines 2020 [197] that are meant to align the government agenda to Vision 2030, harmonize ICT policies, provide infrastructure and frameworks to support ICTs and leverage international and regional cooperation among others. A National ICT Infrastructure Master Plan 2019 - 2029 [142] and Government Enterprise Architecture (GEA) project [174] by the ICT

Authority are such outfits that have enabled interoperability and data sharing in governments departments in Kenya. GEA project has rolled out many e-government based services through e-citizen digital platforms to the benefit of the citizenry. Interoperability frameworks associated with MNO/MVNO in Kenya are given in table 7.

Table 7: Interoperability frameworks associated with the MNO/MVNO industry in Kenya

	Type of framework	Target institutions and Industries	Architectural Elements	Example IFs
1	Interoperability Maturity models	International Bodies (Information and Communications)	Technical Syntactic Semantic Organizational	LISI, OIM, LCIM, EIMM)
2	Enterprise Architectures (EA)	Regional Bodies Governments Public Enterprises	Network infrastructure Data/Information Applications Business	TOGALF, eGIFs
3	National IFs (Kenya)	Information and Communications Industry	The Kenya Information and Communications -Interconnection and Provision of Fixed Links, Access and Facilities) Regulations, 2010	Legal framework for Interconnection and Provision of Fixed Links, Access and Facilities Regulations, 2010
		Banking Industry and Financial institutions	Payment Systems Act (No 29 of 2011) & National Payment Systems Regulation, 2014	Legal framework for money payment systems
		ICT Industry	Ministry of ICT, Kenya (2016), Kenya National ICT Policy June 2016	ICT Policy 2016
		Banking Industry and financial institutions	The National Payment Systems (NPS) Regulations 2017	The National Payment Systems (NPS) Regulations 2014 Review
		Mobile money industry	The National Payment Systems (NPS) Regulations -Mobile Money Interoperability, 2018	National Mobile money interoperability framework 2018*
		ICT Industry	The National Information Communications and Technology (ICT) Policy Guidelines, 2020	ICT Policy Guidelines 2020
		ICT Industry	The National Information Communications and Technology (ICT) Policy Guidelines, 2020	Align the government agenda to Vision 2030/Region cooperation
		Mobile Money Industry	iii) Mobile money interoperability framework by NPS 2018 Amendment 2022	Mobile money interoperability amendment framework 2022*
3	Government Enterprise Frameworks (GEA)	E-citizen services	National ICT Infrastructure Master Plan	2019 - 2029
		E- Citizen Services	Government Enterprise Architecture (GEA) Framework	Enterprise Architecture for Government Portals

2.6 MVNO Conceptual Model

The MVNO Conceptual model comprises of 3- phases, the input phase of Barriers factors, a mediatory phase of MVNO value chain environments and the output phase of MVNO Performance. The input phase has 4-variables of General Public Awareness Factors, MNO Sourced Barrier Factors, MVNO Sourced Limiting Factors and Government Agencies Sourced Limiting Factors. The mediatory phase of MVNO value chain environment has 2-variables of Stakeholders value chain factors and Development phases value chain factors that interact with the output indirectly through paths a & b and c & d respectively. The mediatory stages represent unforeseen challenges that may arise at any time during the development and deployment stages that might influence both the input and output stages of the system (201). Path [e] is a direct path between the input and the output performance stage that is only influenced by the input variables. The overall performance of the system depends on its inputs and the mediating factors. The MVNO conceptual model is given in fig 5 while an exploded view of the MVNO conceptual study factors model is shown in fig 6.

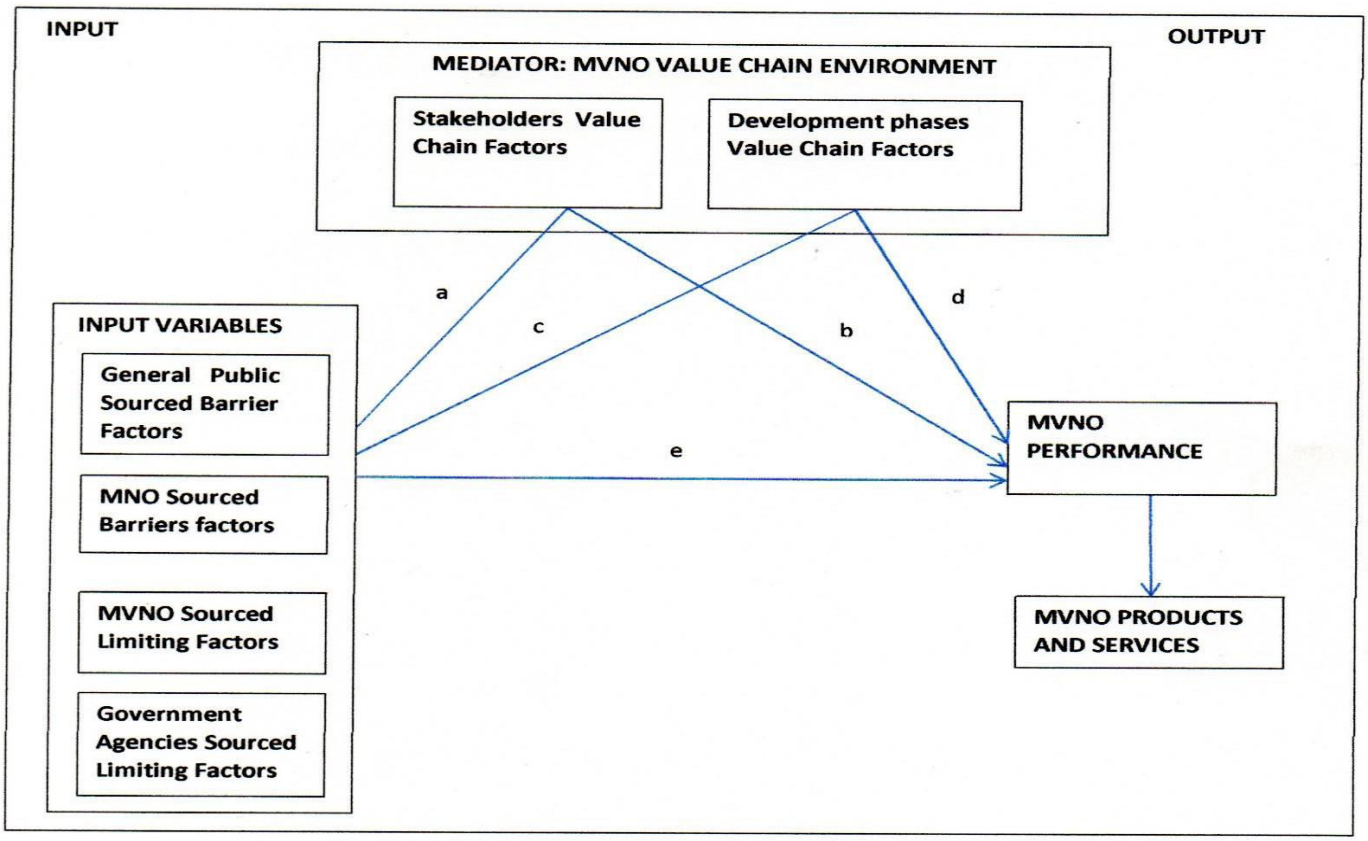


Fig 5: MVNO Conceptual Model

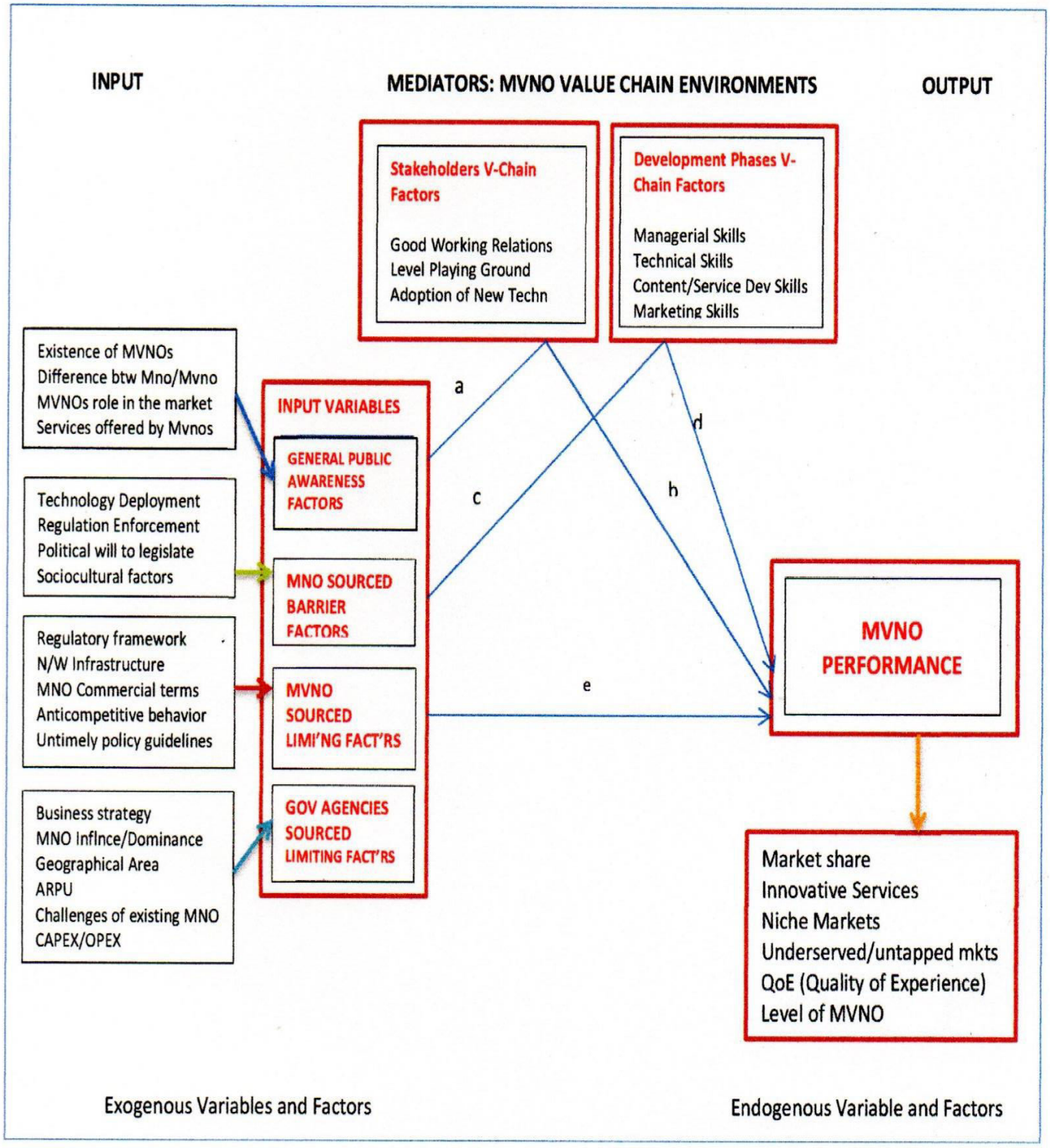


Fig 6: MVNO Study Factors Conceptual model

2.7 MVNO Implementation Conceptual Framework

From a broad perspective, MVNOs interacts with 3-types of environments in its development life cycle, the stakeholder's environment, the development environment, and the business environment. The environments serve as facilitators and limiting agents depending on the prevailing circumstances. Stakeholder's environment is a person or other organizations, an MVNO service provider has a vested interests in the environments for business to exist. The four key stakeholders in the stakeholder environment are; the General Public, MNOs, MVNOs and Government Agencies. These are groups of people or organizations an MVNO works closely with to meet its business goals.

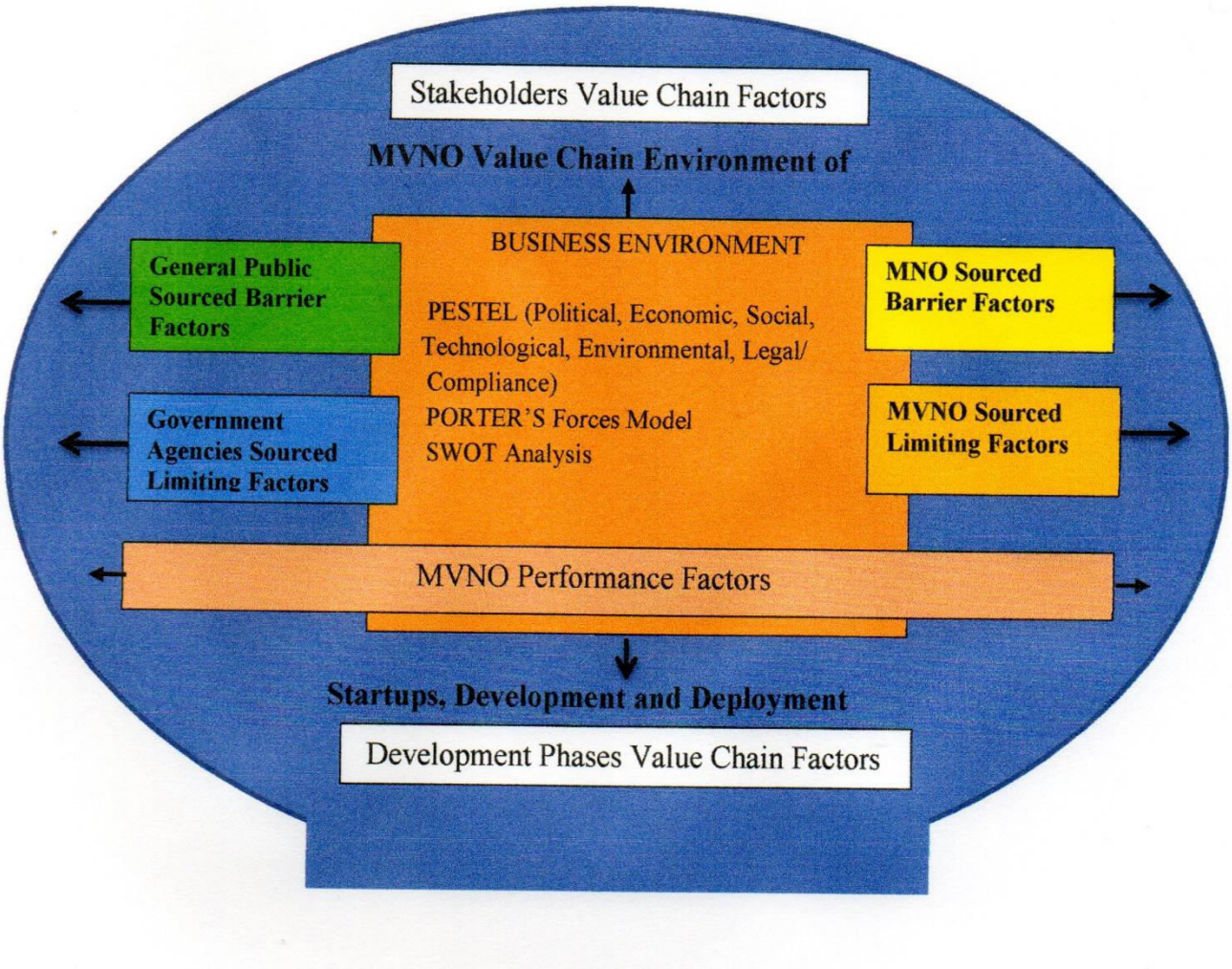


Fig 7: MVNO implementation Conceptual Framework

MVNO development environment is influenced by the value addition provided by stakeholders on one hand and in-house value addition on development phases on the other hand. That's what the study refers to as Stakeholders Value Chain and Development Phases Value Chain respectively that form Mediator variables of the conceptual model. Stakeholder's value chain comprises of three indicators, namely; Good working relations, Level playing ground and Adoption of new technologies while Development Phases Value chain has four indicators namely; Managerial skills, Technical skills, Content/service development skill and Marketing skills. Management and technical personnel skills are essential at every stage of MVNO development cycle (startup, development and deployment).

The Business Environment starts once the product is launched in the market. This environment is well documented by Porter's five forces framework [12] and PEST analysis [181]. PEST components and complementally strategic tools play an important role in every business aspect. MVNO is a business model with no exception. The business environment is one area that has been studied extensively and is not part of this study. However PEST and its extensions are broader components of the MVNO business model and they were components of the implementation framework. The MVNO implementation conceptual framework is shown in fig 7, while fig 8 captures PEST components application, and complementary strategic tools.

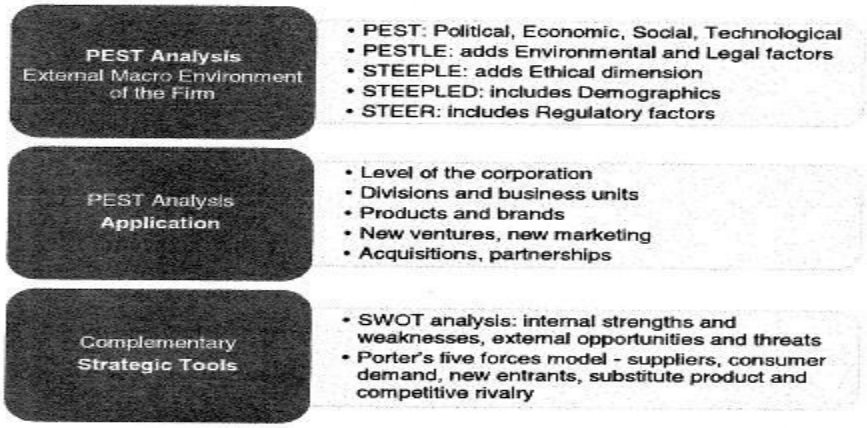


Fig 8: PEST components, application, and complementary strategic tools.

Overall study factors therefore were sourced from 7-categories of test instruments; the stakeholder's development environments of General public, MNOs, MVNOs, Government Agencies, Interview Protocol, observation Protocol and LR Quality factors listed below:

i. General public (dataset sourced barrier factors)
ii. MNO (dataset sourced barrier factors)
iii. MVNO (dataset sourced limiting factors)
iv. Government Agencies (dataset sourced limiting factors)
v. Interview Protocol (Interview protocol sourced barrier factors)
vi. Observation Protocol (Observation Protocol sourced barrier factors)
vii. LR Quality factors (LR sourced barrier factors)

2.8 Hypothesis – (Direct and Indirect Hypotheses)

Referring to the MVNO conceptual model in fig 5, 4-direct hypotheses were stated from the inner structural model that comprise of exogenous and endogenous variables:

H_1: MNO barrier factors have a significant effect on MVNO performance
H_2: MVNO limiting factors have a significant effect on MVNO performance
H_3: Government Agencies limiting factors have a significant effect on MVNO performance
H_4: General public barrier factors have a significant effect on MVNO performance

Referring to the MVNO study factors conceptual model in fig 6, 19-indirect hypotheses were formulated from the exogenous variables of the outer measurement model and 6-indirect hypotheses from the endogenous variable of the outer measurement model. They were listed down under their respective direct hypothesis.

H_1: MNO barrier factors have a significant effect on MVNO performance

i. ***Ho1:*** Technology integration and deployment knowhow does not have a significant effect on MNO barrier factors

Ha1: Technology integration and deployment knowhow has a significant effect on MNO barrier factors

ii. ***Ho2:*** *Regulation enforcement does not have a significant effect on* MNO barrier factors

Ho2: *Regulation enforcement has a significant effect on* MNO barrier factors

iii. ***Ho3:*** Government political will to legislate does not have a significant effect on MNO barrier factors

Ha3: Government political will to legislate has a significant effect on MNO barrier factors

iv. ***Ho4:*** Sociocultural factors do not have a significant effect on MNO barrier factors

Ha4: Sociocultural factors have a significant effect on MNO barrier factors

H_2: MVNO limiting factors have a significant effect on MVNO performance

v. ***Ho5:*** Separate regulatory framework and policies for MVNOs will not have a significant effect on MVNO limiting factors

Ha5: Separate regulatory framework and policies for MVNOs will have a significant effect on MVNO limiting factors

vi. ***Ho6:*** *MNO network infrastructure coverage does not have a significant effect on* MVNO limiting factors

Ha6**:** *MNO network infrastructure coverage has a significant effect on* MVNO limiting factors

vii. ***Ho7:*** MNO commercial terms do not have a significant effect on MVNO limiting factors

Ha7: MNO commercial terms have a significant effect on MVNO limiting factors

viii. ***Ho8:*** MNO anti-competitive behavior does not have a significant effect on MVNO limiting factors

Ha8: MNO anti-competitive behavior has a significant effect on MVNO limiting factors

ix. ***Ho9:*** Timely formulation of policy/guidelines by the regulator does not have a significant effect on MVNO limiting factors

Ha9: Timely formulation of policy/guidelines by the regulator has a significant effect on MVNO limiting factors

H_3: Government Agencies limiting factors have a significant effect on MVNO performance

x. ***Ho10:*** Clear business strategy does not have a significant effect on Government Agencies limiting factors

Ha10: Clear business strategy has a significant effect on Government Agencies limiting factors

xi. ***Ho11:*** MNO influence and dominance does not have a significant effect on Government Agencies limiting factors

Ha11: MNO influence and dominance has a significant effect on Government Agencies limiting factors

xii. ***Ho12:*** Geographical area of operation (urban/rural/marginalized) does not have significant effect on Government Agencies limiting factors

Ha12: Geographical area of operation (urban/rural/marginalized) has a significant effect on Government Agencies limiting factors

xiii. ***Ho13:*** ARPU does not have a significant effect on Government Agencies limiting factors

Ha13: ARPU has a significant effect on Government Agencies limiting factors

xiv. ***Ho14:*** Challenges of existing MNO sector do not have a significant effect on Government Agencies limiting factors

Ha14: Challenges of existing MNO sector have a significant effect on Government Agencies limiting factors

xv. ***Ho15:*** CAPEX/OPEX do not have a significant effect on Government Agencies limiting factors

Ha15: CAPEX/OPEX have a significant effect on the Government Agencies limiting factors

H_4: General public barrier factors have a significant effect on MVNO performance

xvi. ***Ho16:*** Lack of awareness of the existence of MVNOs does not have a significant effect on General public barrier factors

Ha16: Lack of awareness of the existence of MVNOs has a significant effect on General public barrier factors

xvii. ***Ho17:*** Lack of awareness of the difference between MNOs and MVNOs does not have a significant effect on General public barrier factors

Ha17: Lack of awareness of the difference between MNOs and MVNOs has a significant effect on General public barrier factors

xviii. ***Ho18:*** Lack of awareness of what MVNOs do in the Kenyan market has no significant effect on General public barrier factors

Ha18: Lack of awareness of what MVNOs do in the Kenyan market has a significant effect on General public barrier factors

xix. ***Ho19:*** Lack of awareness of the services offered by MVNOs does not have a significant effect on General public barrier factors

Ha19: Lack of awareness of the services offered by MVNOs has a significant effect on General public barrier factors

H_5: MVNO performance quality factors (MVNOPFS) have a significant effect on MVNO Performance

Ha20: Size of the market share (MVNOPF1) has a significant effect on MVNO performance (MVNOPFS)

Ha21: Differentiated services (MVNOPF2) has a significant effect on MVNO performance (MVNOPFS)

Ha22: Number of niche markets (MVNOPF3) has a significance effect on MVNO performance (MVNOPFS)

Ha23: Penetration of underserved/untapped markets (MVNOPF4) has a significant effect on MVNO performance (MVNOPFS)

Ha24: QoE (MVNOPF5) has a significant effect on MVNO performance (MVNOPFS)

Ha25: Level of the MVNO (MVNOPF6) has a significant effect on MVNO performance (MVNOPFS)

2.9 Mediator Hypothesis

The MVNO value chain environments had two mediators; Stakeholders value chain factors (SVCFS) and Development phases value chain factors (DVCFS). 8-Hypothesis for mediating factors were formulated as follows:

H6: Stakeholders value chain factors (SVCFS) and Development phases value chain factors (DVCFS) have mediating effect on MNO barrier factors, MVNO limiting factors, Government agencies liming factors and General public awareness factors on MVNO performance factors (MVNOPFS)

Ha26: The effect of MNO barriers factors on MVNO performance is mediated by stakeholders' value chain factors of good working relationship, level playing ground and adoption of new technologies

Ha27: The effect of MVNO limiting factors on MVNO performance is mediated by stakeholders' value chain factors of good working relationship, level playing ground and adoption of new technologies.

Ha28: The effect of Government Agencies limiting factors on MVNO performance is mediated by stakeholders' value chain factors of good working relationship, level playing ground and adoption of new technologies.

Ha29: The effect of General public awareness factors on MVNO performance is mediated by stakeholders V-chain factors of good working relationship, level playing ground and adoption of new technologies.

Ha30: The effect of MNO barriers factors on MVNO performance is mediated by development phase value chain factors of managerial skills, technical skills, Content/service development skills and marketing skills.

Ha31: The effect of MVNO limiting factors on MVNO performance is mediated by development phase value chain factors of managerial skills, technical skills, Content/service development skills and marketing skills.

Ha32: The effect of Government agency limiting factors on MVNO performance is mediated by development phase value chain factors of managerial skills, technical skills, Content/service development skills and marketing skills.

Ha33: The effect of general public awareness on MVNO performance is mediated by development phase value chain factors of managerial skills, technical skills, Content/service development skills and marketing skills

2.10 Research Gap

Africa, has relatively low MVNO market share (<1%) compared to 10-20% in developed regions in the world [161]. The MVNO market share in South Africa is 1.7% despite a vibrant mobile market of 90m [165]. The MVNO market share in Kenya is low (4%) despite a vibrant mobile industry of 49m mobile users and a penetration rate of 106%. Two out of the 4 - pioneer MVNOs in Kenya wound up within a period of 4 years. The third MVNO operator is performing dismally, leaving only one potential MVNO player in the Kenyan MVNO market [158]. There are 4-newly registered MVNOs in the last 3 years whose impact has not been felt in the market and two pending applications? There is one proposed MVNE in the market but its operations are not in the public domain. The MVNO sectors in Africa and Kenya are not performing. There is therefore need to establish the reasons for the nonperformance.

Behavioral models suggest that our beliefs and practices influence adoption and use of technology [13], [17], [18]. Fit–Viability framework further suggests that M-commerce business models are unique to different environments and cultures [19]. Adoption and use of technology is influenced by geographical factors like rural/urban migration, Close family ties, Community culture, cultural beliefs and practices [177]. Africa and Kenya is a melting pot of cultures. It would be of interest to establish peculiar cultural factors that are a barrier to the growth of the MVNO sector.

Open standards, regulatory frameworks and models prevent design and development of proprietary products and services and allow interoperability of applications from different providers and vendors and also facilitate startups, development, and deployment of systems [14]. Regulatory issues have held back the growth of MVNOs in markets such as the Middle East, Latin America and Africa [69], [30]. Phan Hai Son MVNO framework for developing Asian countries [171] is a general MVNO deployment framework that does not touch on startup and development, while .SATRC framework for MVNOs [176] is a deployment framework limited to infrastructure sharing among SATRC Group countries, however both frameworks resonate well with the study. The proposed framework in this study is an implementation framework for MVNO startups, development and deployment. The regulatory framework supposed to support

the MVNO industry in Kenya [189], [190], [192], [193] is either inadequate or missing altogether and needs to be reexamined.

MVNO business models hinge on differentiated (innovative) services, segmented/niche market, value addition, un-served/underserved market segments and cost leadership [10], [42]. MVNOs in Africa and Kenya seem to be competing on the same products and market segments. It is not clear why innovative/differentiated services are missing in the MVNO market in Kenya besides penetration of untapped/underserved and niche markets. These are questions that need to be answered by the study to help unearth the challenges ailing the sector.

The EIF maturity model [63], TOGAF Enterprise Architecture framework [154], UNDP eGIF implementation guidelines [140], 3GPP standards [10], [143 [146], [147], existing guidelines and policy documents on information and communications industry in Kenya [141], [142], [189], [190], [191], [192], [193], [197] and the analyzed data will come hardy in the development and implementation of MVNO framework for the study.

2.11 Summary

Kenya MVNO sector is not performing despite vibrant MNO mobile networks. There is therefore need to establish what key factors were contributing to the nonperformance. Adoption and use of technology is unique to different cultures and environments. What is it about Africa and Kenya in particular, affects the growth of MVNO industry? Open standards, regulatory frameworks and models prevent design and development of proprietary products and services and facilitate startups, development and deployment. There are no clear indicators that Kenya has an adequate regulatory framework to oversee its MVNO sector. MVNO implementation conceptual framework proposed in the study may help alleviated the problem faced by the ailing MVNO sector in Kenya

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Overview

This chapter gives an overview of the methods and strategies that were used to gather the research data and the techniques used to analyze the data with relevant justification of the same. An account of the research philosophy and design was given. Approaches to theory and development, methodological choice and strategies of inquiry underpinning the study were outlined based on Mark Saunders' Research Onion Diagram [180]. The chapter further discussed location of the study, data collection procedures, target population, the sample size, test instruments, software and hardware tools in addition to data analysis methods. Pertinent ethical issues touching on the integrity of the study were finally given.

3.2 Research Philosophy

Research philosophy is a system of beliefs and assumptions about development of knowledge that comprise of research paradigms of ontology, epistemology and axiology [180]. Ontology philosophy hinges on philosophical worldview of Objectivism, Constructivism and Pragmatism and makes us aware of the nature of reality, how the world operates, and composition of society and how the society impacts on its surroundings. It clears the difference between realities and how we perceive reality and makes us understand how the behavior of people is influenced - it hinges on the realities we encounter in our research (ontological assumptions). Epistemology philosophy hinges on philosophical worldview of Positivism, critical Realism and Interpretivism that tries to find the acceptable knowledge (epistemological assumptions) and addresses the facts according to that knowledge; mostly appropriate for scientific study [218]. Axiology philosophy hinges on Ethics and Aesthetics that helps us learn how our own values and opinions impact the collection and analysis of our research (axiological assumptions). The study of MVNOs in Kenya is a technological, scientific study whose data source is likely to change with the times as the social behavior of the people it is meant to impact changes**.** It therefore partly hinged on ontological worldview that embraces pragmatism research philosophy; that leans towards constructivism philosophy. Constructivism believes that social actors create social phenomena

that may change the view of the past to accommodate the future. The study of MVNOs is also an emerging technology in the world (Africa/Kenya) included where its existence is not well understood and could therefore be supported by research questions that are tested against accepted knowledge. The study therefore also hinges on epistemological worldview that embraces positivism philosophy. Positivism supports hypotheses (or research questions) that could be tested against accepted knowledge. Ethical issues played a critical role during data collection stages that invoked philosophical worldview of axiology. This study was therefore supported by both ontological, epistemological and axiological worldviews of constructivism, positivism and ethical philosophies respectively that hinge on a pragmatic approach of the first layer of Saunders research onion [180].

The MVNOs sector in Kenya is therefore multifaceted and called for mixed method of research where both quantitative and qualitative data collection and analysis methods were used. The research valued flexibility and adaptability in methodology and research design. It was meant to inform action, improve and bridge theory and practice as well as scientific and social methods of knowledge creation. The research overall hinged on pragmatism philosophy paradigm [218]

3.3 Research Design

Research design provides a direction for collecting and analyzing data in a given study [180]. A research study design can be exploratory, descriptive, and explanatory or mixed depending on the purpose of the research. The study of MVNOs in Kenya was a cross-sectional research that used survey and case study strategies. It was a technological study whose data source was likely to change with the times as the social behavior of the people it was meant to impact changed. On one hand, the study used hypotheses (research questions) that were tested against accepted knowledge while on the other; MVNOs were perceived as emerging technology (phenomenon) that was meant to impact on its users differently with consequences that needed to be established and understood. The research study therefore used mixed methods of qualitative and quantitative research approaches. Qualitative because it was partly exploratory; MVNOs were emerging business models that needed to be assessed and understood through interviews, observations and content analysis. Quantitative because it was partly descriptive; there was need to get the picture of the situation as it unfolded where a questionnaire was used to sample the MVNO market. Both

deductive and inductive development approaches were used because of the quantitative and qualitative nature of the data that was collected. The choice for the triangulation of data was based on mixed methods of questionnaires, interviews, observations, and documentary analysis. Thematic analysis was used to analyze qualitative data while descriptive and inferential statistical tools and CB-SEM structural methods were used to analyze and validate quantitative data. Findings from analyzed data and information derived from standard frameworks and models were used to develop an implementation framework for MVNOs.

3.3.1 Research Study Sequence

To achieve the final product of the study, the objectives were realized in the sequence shown in figure 9. Objective (a) was partly answered from the LR content and the analyzed data. Analyzed data met the threshold of objective (b). Objective (c) was partly answered from the LR content and the analyzed data. EIF interoperability maturity framework [63], TOGAF Enterprise Architecture framework [154], UNDP eGIF implementation guidelines [140], 3GPP standards [10], [142], [143], [146], [147], SATRC MVNO framework [176] and proposed Developing Nations MVNO Framework by Pham [178] among others offered useful insights into the final product of the study. Kenya National ICT Policy [141], [179, [142], Draft National ICT Infrastructure Master Plan (2019-2029) [174], Kenya Vision 2030 [151], Communications Authority of Kenya Regulatory Policy and other relevant policy documents from other arms of Government, were referenced for any useful information. Inputs from frameworks, international/regional standards, Government policy documents and findings from analyzed data were used to develop an implementation framework for MVNOs to satisfy objective (d).

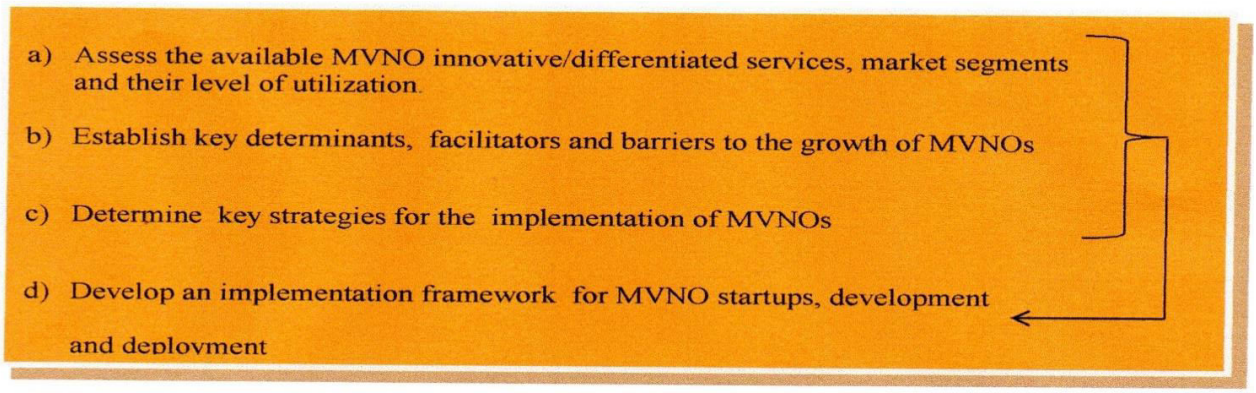


Fig 9: Sequence for implementing research study objectives

3.3.2 Location of Study

This research was conducted in Nairobi County and its environs with Kenya as the case market and MNO/MVNOs as the study environments. Nairobi CBD was chosen to represent an urban setting and its environs a semi-urban and rural setting respectively. The assumption was that Nairobi CBD and its environs was an urban/rural setting with the highest concentration of mobile phone users and transactional services by day than any other region in Kenya. Starehe Sub-County is the business hub of Nairobi and was chosen to represent the CBD. Kasarani Sub-County was chosen to represent a semi-urban setting. It is the largest Sub-County in Nairobi and shares boundaries with most of Nairobi Sub-Counties and rural Counties. It is also the second most populous sub county to Embakasi. Ruiru Sub-County in Kiambu was chosen to represent a rural setting. It is the closest sub-county to Nairobi; the most densely populated and shares its boundary with most of Nairobi sub-counties.

3.3.3 Data Gathering Methods

This research study used quantitative and qualitative mixed methods of data collection. A questionnaire was designed as a test instrument for quantitative data while interview/observation protocols and content analysis of LR formed the basis for qualitative data.

The questionnaire was used to capture the opinion of the general public and senior managers of MNOs, MVNOs and Government Agencies. The opinion poll on the general public sought to establish the awareness and subscription of MVNO in Nairobi County and its environs while that of senior managers of organizations sought to establish their opinion on the status of the MVNO sector at a national level. Public survey was conducted manually by assigning three research assistants to the poll designated areas of CBD, semi-urban and rural settings while MNOs, MVNOs and Governments Agency senior managers were polled and interviewed electronically by the main researcher. Permission to administer questionnaires was sought from the respective organizations prior to the survey.

Interviews and observations formed the basis of qualitative data. They were conducted on senior managers of MVNOs, MNO and government agencies affiliated to the sector to establish the status and level of alignment of MVNOs to research questions. Observations were conducted on all the MVNOs and MNOs to establish the nature of network infrastructure they hold, regulatory policy that governs their operations and services/markets that they operate. Interviews and observations were conducted by the main researcher himself. Permission to conduct the interviews and make observations was sought from the respective organizations, after which interview/observation protocol documents were communicated and a date for the interview/observation agreed on. Interviews were conducted electronically through zoom meetings. Observations were partially manual and through content analysis.

3.3.4 Piloting

To ensure that the test instrument was clear and pertinent to the study, a pilot survey was conducted on 20-respondents in Meru town and its environs in the month of May, 2020 comprising of 4 regional managers and 16 respondents from the general public (6 Urban, 6 Semi-urban and 4 rural) representing all the 4-location categories of interest except Government Agencies from which the actual data was supposed to be collected. All the test instruments were improved in structure and content. Typological and grammatical errors were fixed. Ambiguous statements were restructured for clarity and the flow sequence of questions improved. Besides, two unique issues came out strongly at this stage; first, technical and product managers were the right managers to target for interviews in the Telcos and second, dominance by Safaricom in the MNO industry was real.

3.4 Target Population

This study targeted four categories of the population; the general public, MNO operators, MVNO operators and Government Agencies. Each of the target population was required to respond to a questionnaire, an interview or both. Observations were made on pertinent issues in areas of interest where possible as the survey was carried out within the target population.

3.4.1 Questionnaire Target population

A survey was conducted on the general public, all the MNOs, all the MVNOs and four Government Agencies to gather opinion on the MVNO sector from an urban, semi-urban and rural setting. Nairobi CBD (Starehe constituency) and its environs were chosen for the survey because of its central location and high penetration of mobile phone users and activities during the day. Kasarani Sub County in Nairobi County and Ruiru Sub County in Kiambu County were chosen as semi-urban and rural settings for the study respectively. Kasarani is the second populous sub county in Nairobi and stretches to the outskirts of Nairobi to border Kiambu County in the North and Machakos County in the East. It is a blend of all classes of city residents. Ruiru is the most populous Sub County in Kiambu County and borders Nairobi County in the North. It is a true representative of a rural setting. Based on the 2019 census [182], the population ratio of CBD (Starehe Sub County), Kasarani and Ruiru Sub Counties is 210,423 to 780,656 to 371,111, translating to a ratio of 16:57:27.respectively. From the population ratios and Cochran equation [149], the sample size for the CBD, Kasarani and Ruiru location settings were determined. The general public responded to sections A2 of the questionnaire while, senior managers from MNOs, MVNOs, Government Agencies and their respective staff responded to sections A_3, A_4 and A_5 of the questionnaire respectively. Apart from Government Agencies and Senior managers, Agency outlets for individual organizations (MNO and MVNO) served as a source for respondents with respect to staff within the category locations (Urban, Suburban and Rural)

3.4.2 Interview target groups

Interviews targeted at least one senior manager in all the MVNOs (Finserve Africa Ltd - Equitel, Mobile Pay Ltd – Tangaza and Eferio Kenya Ltd, all the MNOs (Safaricom, Airtel Kenya and Telkom Ltd) and four government agencies (CA, NCS, CAK and ICT Authority). The targeted government agencies were charged with the responsibility of policy formulation, Compliance and enforcement. Senior technical and product managers with good understanding of the organization operations were targeted in each organization together with their staff. Individual interviews were preferred to group interviews for ease of appointments and collaborative data.

3.4.3 Observation target areas

Observations were made on all the operational MVNOs (Finserve Africa - Equitel and Mobile Pay Ltd - Tangaza and Eferio Kenya) and all the MNOs (Safaricom, Airtel Kenya and Telkom Ltd) to establish the level of network infrastructure, core network devices and use of standards, Quality of services, market segments and network penetration Any useful documents, records and images were noted.

3.5 Sample Size

3.5.1 Questionnaire sample size

Kenya has an MVNO subscriber base of about 2.168 million [8]. Out of the registered MVNO subscribers, it was a requirement to know the sample size (Nr) that satisfied a given confidence level at an acceptable margin of error (degree of precision) (d) from the proportion of the population (p) that operated in Nairobi CBD (Starehe Sub County) and its environs

The sample size Nr by Cochran [149] is given by:

$Nr = (Z)^2pq/d^2$ eqn. (3.1)

Where;

Nr = required sample size

Z = abscissa of the normal curve at desired confidence level (e.g. 1.962 at 95% confidence level)

p = proportion of the population having the characteristic

d = Margin of error

q = 1- p

This was a preliminary study and no data was available on the proportion on the Nairobi CBD and its environs, the worst case scenario was assumed and (p) was set at 0.5 (therefore q = 1- 0.5 = 0.5). The study was ready to accept a margin of error of ± 5%, so (d) was set at 0.05.

$Nr = (1.96)^2x0.5x0.5/0.05^2 = 385$ Respondents.

A minimum of 385 respondents were required for this survey. The population ratio of Kasarani Sub County, Ruiru Sub County and CBD (Starehe Sub County) was 57:27:16 respectively. This

translated to a questionnaire sample size ratio of 220:105:60 (385 respondents) that was rounded up to 400. A minimum of 220 questionnaires were administered in Kasarani semi-rural setting, 110 in Ruiru rural setting and 70 in the CBD respectively. Senior managers of MNOs, MVNOs Government Agencies and their staff responded to sections A3, A4 and A5 of the questionnaire respectively. 400 respondents in all were sampled to capture the opinion on MVNO and related organizations. All the three MNOs (Safaricom, Airtel and Telkom) were sampled to establish their role and involvement with MVNOs. All operational MVNOs (Equitel, Tangaza and Eferio Kenya) were sampled to establish their relationship with host MNOs, service offerings, market segments and level of operation. Four government agencies (CA, ICT Authority, NCS and CAK) were sampled to establish their roles in policy formulation, compliance, licensing and enforcement. Probability cluster sampling was preferred for the General Public while non-probability purposeful sampling was used for MNOs, MVNOs and Government Agencies.

3.5.2 Interview sample size

A senior manager in each of the five MVNOs (Finserve Africa Ltd-Equitel and Mobile Money Pay-Tangaza, Homeland Media, Eferio Kenya, Jambo Telecoms), a manager in each of the three MNOs (Safaricom, Airtel Kenya and Telcom) and a manager in each of the four Government Agencies were interviewed. The assumption here was, senior managers bore the highest responsibility to provide accurate representative views of the organization. Twelve (12) managers in all were interviewed

3.5.3 Observation Sample size

Like the interviews, observations were made on 3-MNOs, 5-MVNOs and 4 government agencies. A top manager in each of the institutions helped in the observation process to fill in the gaps for collaborative purposes. 12 institutions in all were subjected to observation in 6-key areas of Radio Access Network infrastructure, Core network devices, regulatory policy, innovative services, market segments and their level of utilization.

3.6 Data Gathering Instruments

The test instrument comprised of a questionnaire, an interview protocol an observation protocol and SEM-CFA analysis questionnaire labeled as sections A1, A2, A3 and A4 respectively in Appendix A. The questionnaire had 6 sub-sections and a total of 60 questions. A1-0, captured location categories of the respondents; Section A1-1, registered the demographics of all the respondents; Section A1-2, captured public opinion on MVNO awareness; Section A1-3, was devoted to MNO senior managers and their staff; Section A1-4, addressed MVNO senior managers and their staff, while section A1-5, targeted Government Agencies tasked with formulation and enforcement of policy and regulation of ICT and telecommunications sectors. The interview protocol in Section A2 comprised of 13 open ended questions that were aligned to the study research questions on which interviews were conducted. The Observation Protocol in Section A3 considered three thematic areas of network/core device infrastructure, regulatory policy and services/market segments on which observations were made. Section A4 was a Likert scale questionnaire that was retrieved from the main questionnaire for the purpose of SEM-CFA data analysis.

3.6.1 Questionnaire

The questionnaire comprised of 6 sections of 60 composite single ended and 5-level Likert scale questions that took 15 minutes to complete. Single ended questions required a YES or NO response or listing. 5-level Likert scale was chosen because, measurement of interest revolved around nominal, ordinal, interval, or ratio data. The questionnaire was subjected to a pilot survey in Meru Town in June 2020 prior to final administration and tested for internal reliability using Cronbach's Alpha method [150].. The questionnaires for the general public were administered manually by 3-research assistants in Nairobi CBD and its environs in the months of July/August 2020, while the senior manager questionnaires were administered electronically by the main researcher in the month of September 2020. The questionnaire research instrument is shown in Appendix A1 sections A1-0 to A1-5.

3.6.2 Interview protocol

Interview protocol comprised of 13 open ended questions that were pegged on inquiry based conversation aligned to the study research questions in four thematic areas namely: current status of the MVNO sector, MVNO challenges, Regulatory framework in the MNO/MVNO industry and the way forward for future MVNOs. The interview protocol was subjected to a pilot survey in Meru town at Safaricom, Airtel, Telkom and Equitel regional offices in June 2020 before they were administered. The protocol took 20 minutes to complete. Interviews were conducted in the months of July/August 2020 in Nairobi County by the researcher himself. The data captured formed the content for thematic analysis. The interview protocol is given in appendix 1, section B.

3.6.3 Observation Protocol

Observation protocol revolved around three thematic areas of network/core device infrastructure, regulatory policy, services/market segments of the mother MNOs and the MVNOs. Observations were made to establish the nature of standard devices used, coverage area and the quality of services. Available Regulatory policy documents were noted. Differentiated services/market segments offered by the MVNO were noted. Any useful data in form of documents, artifacts, recordings and photographs were examined and noted. The observation protocol was piloted at Safaricom, Airtel, Telkom and Equitel regional offices in Meru town in June 2020 before they were administered in Nairobi County. Observations were made by the researcher himself in the months of July/August 2020. Data collected formed the content for thematic analysis. The observation protocol is given in Appendix 1, Section C.

3.6.4 Survey Response Rate

In the context of this study, response rate was taken as the ratio of the actual respondents to the targeted (expected) sample size. Survey research response rates vary depending on the type of survey research used (descriptive, exploratory and casual). Response rates of 5% - 100% have been recorded, with 50% or higher considered excellent and 5% -30% more typical. Published

research suggests a benchmark of approximately 35%–40% and an average of about 50 percent. The survey in this study was both descriptive and exploratory and a response rate of 40% and above was good enough for analysis [198]. Out of a target population of 400 respondents, 350 questionnaires were returned; corresponding to response rate of 87.50%. After data screening and cleaning, 155 responses were found suitable for compilation into a data set and subsequent analysis translating into an overall response rate of 44.29%. The response rates for the individual survey categories were as follows: MNOs recorded a response rate of 49.41%; out of the three MNOs, one declined to participate in the survey at the HQ level, reason being the questionnaire was considered borderline confidential. Another assumed MNO operator declined to participate in the survey. It could not be established whether the operator was an MNO or an MVNO. It was excluded from the list of either group in this study. MVNOs recorded a response rate of 43.48 %. Out of the four MVNOs, three MVNOs participated partially because they were not fully operational. The response rate for Government Agencies was 40.00%, two agencies participated partially due to lack of pertinent data. The general public recorded 43.00% response rate. All the individual survey categories recorded response rates of 40% and above, a threshold that is considered good enough for data analysis purposes [198]. The 155 sample size also met the threshold for SEM – CFA analysis that recommends a sample size of 100-200, [204]. There were seven (7) constructs that guided data collection. It is recommended, at least 3-indicators be used to measure the constructs [203], [204]. The actual indicators for the individual constructs ranged from 3-6 and met the construct /indicator threshold.

3.6.5 Data compilation and coding

Collected raw data was compiled into three categories before coding namely: quantitative data from the questionnaire and qualitative data from interviews and observation respectively. Quantitative data was further grouped into 7-variables together with their factors according to their source as; General Public, MNOs, MVNOs, Government Agencies, MVNO performance and 2-mediator variables. Likewise, qualitative data was compiled through a series of iterative stages that finally culminated into themes suitable for interview and observation thematic frameworks. Quantitative data and qualitative thematic frameworks were merged into their respective variables to form the study quality factors. The data was then coded using IBM SPSS

Version 21 to form the SEM-CFA data set for evaluation and analysis. SPSS Version 21 was specifically chosen because it incorporated SEM-CFA Amos that was subsequently used to evaluate the study models. After coding, the data set was cleaned by removing outliers, system errors, irrelevant and duplicate values. Logically inconsistent data were removed and missing values filled in.

3.7 Assessment of Test Instruments

Prior to data analysis, it was necessary to test the instrument for construct reliability and validity. The model fitness, Hypothesis and moderation/mediations effects needed to be tested as well. Construct reliability measures the extent to which indicators of a latent construct are internally consistent in their measurement and that the indicators measure the true value, while validity is the degree to which a test instrument measures what it claims to measure. Validity is achieved when the Fitness Indices for a construct achieves the required level. Cronbach's Alpha (α) was used to measure internal consistency of the test instrument while Regression Analysis methods and Structural Equation Modeling (SEM-CFA Amos) techniques were used to test for validity, hypothesis, model fitness and moderation/mediation effects. All the techniques are incorporated in the SPSS software.

3.7.1 Reliability Assessment

Cronbach's Alpha Split–Half and Alpha (α) are the two most commonly used methods for measuring reliability (internal consistency) of a test instrument [150]. Cronbach's Alpha (α) and SEM-CFA Amos are the two methods that were used to assess reliability in this study. The applications are directly incorporated in SPSS package. Cronbach's Alpha value (α) of >6, considers data under test to be consistent otherwise inconsistent [202]. Some literature accommodate lower (α) values of >6 [213]. The method works best for Likert scale type questions. The more the number of constructs and factors/indicators in the test instrument, the higher the reliability of the instrument. The test instrument under test comprised of a dataset of seven (7) constructs with a total of 32-indicators, namely: General public Awareness four (4) indicators, MNO Sourced Barriers four (4) indicators, MVNO Sourced Limiting factors five (5)

indicators, Government Agencies Sourced limiting factors six (6) indicators, MVNO Performance factors six (6) indicators, MVNO Stakeholders Value Chain factors three (3) indicators and Development phases value Chain four (4) indicators. There are three criteria for the assessment of reliability for a measurement model: Internal indicator reliability, Construct reliability and Composite reliability.

Internal indicator Reliability: measures the true value of internal consistency of an item or indicator that is considered to be error free and part of a latent construct. A Cronbach's Alpha value of (≥ 0.6) is acceptable.

Construct Reliability (CR): measures the extent to which indicators of a latent construct are internally consistent in their measurement and that the indicators measure the true value and are error free. A threshold Alpha value of (≥ 0.6) is acceptable.

Composite Reliability (CoR): estimates the extent to which a set of latent construct indicators share in their measurement of a construct. A threshold Alpha value of (≥ 0.6) is acceptable

3.7.2 Validity Assessment

Four types of assessment were carried out on validity on the measurement model; Average Variance Extracted (AVE), Construct validity, Convergent validity, Discriminant validity and Model validation. CFA by AMOS was hardy in these assessments [202], [203].

Average Variance Extracted (AVE): Indicates the average percentage of variation explained by the measuring items for a latent construct that is given by:

$AVE=\sum K^2/n$ eqtn 2

Where K = factor loading of each item

n = number of items in the model

Conversely, AVE value can be computed directly from structural model estimates using AMOS. AVE value of (≥ 0.5) is acceptable.

Construct Validity (CV): Is the degree to which a test measures what it claims, or purports, to be measuring. This validity is achieved when the Fitness Indices for a

construct achieved the required level (table 23a).

Convergent Validity (CoV): Is achieved when all items in a measurement model are statistically significant.

Discriminant Validity (DV): Is achieved when the measurement model is free from redundant items. It is also established when the correlation between each pair of latent exogenous construct is less than 0.85 and the square root of AVE (√AVE – diagonal construct correlation values) in the Master Validity table 28 [213].are higher than the correlation between the respective rows and columns.

Model validation is established when the fitness indices for the constructs are achieved or when all the items in the measurement model are statistically significant

3.7.3 Hypothesis Testing

There were 4-direct and 25 -indirect hypotheses formulated in this study. In addition, there were 8-mediation hypotheses to be established as well. The direct hypotheses (Conceptual model hypotheses) could be established indirectly using Multivariate Regression methods test based on level of significance (< 0.05) on one tailed tests. Because of their bigger number, the indirect hypotheses were established using CFA structural model estimates (factor loadings). Use of structural model estimates on the model fit was ideal because the test was performed on the final product. The two different methods of testing served as a means of validation of the hypotheses test results.

3.8 Data Analysis Methods

3.8.1 Overview

Two types of data were collected for analysis in this research study; qualitative and quantitative data. Qualitative data included interviews, observations and literature review content. While quantitative data was derived from questionnaires. Thematic and content analysis methods were used to analyze data from interviews, observations and literature review content while descriptive and inferential statistical tools (Measures of central tendency, dispersion and dependency) were used to analyze quantitative data using IBM SPSS 21 package. Structural

Equation Modeling (SEM) and Confirmatory Factor Analysis (CFA) AMOS were used to model, evaluate the proposed measurement models and validate the hypothesis. Regression method was used as an alternative method for analysis and validation purposes

3.8.2 Modeling in SEM

In Structural Equation modeling (SEM), researchers basically choose between a covariance based analysis (CB-SEM) and variance based method, referred to as partial least squares (PLS-SEM) [207], [208]. The main advantages of CB-SEM compared to other techniques is that, it allows one to analyze the influence of predictor variables on numerous dependent variables simultaneously, it allows one to account for measurement error and even addresses error in predicting relationships and it is capable of testing an entire model instead of just focusing on individual relationships [214]. CB-SEM Analysis was used in this study. A number of SEM packages are available, namely SPSS-AMOS, Smart PLS, MPLUS and EQS. SPSS - AMOS was found most appropriate for this study; it was readily available as a component of IBM SPSS, relatively easy to use and modify and needed no calculation of covariance matrices [209]. AMOS also performs identification checks as part of the model fitting process [204]. SEM can be used to invoke a measurement model that defines latent variables using one or more observed variables, and a structural model that relates relationships between latent variables [210], SEM modeling technique by Wong that uses two sub models was adopted in this study [202]; the inner model, which specifies the relationships between the independent and dependent latent variables and the outer model that specifies the relationships between the latent variables and their observed indicators. SEM also uses two variable types, exogenous and endogenous. An exogenous variable has path arrows pointing outwards and none leading to it, while an endogenous variable has at least one path leading to it and represents the effects of other variable(s). The MVNO study factors conceptual model in (fig 6) was modelled using SEM into 3-assessment models; one inner measurement structural model and 2-outer measurement models. The inner structural model comprised of 4-exogenous variables and one 1- endogenous variable while the outer measurement models comprised of exogenous measurement model and Endogenous measurement model with 19 observed indicators and 6 observed indicators respectively [202]. Mediator variables were not included in the SEM measurement models but

analyzed separately. An extended view of the proposed SEM measurement models as adopted from Wong are given in fig 10 [202].

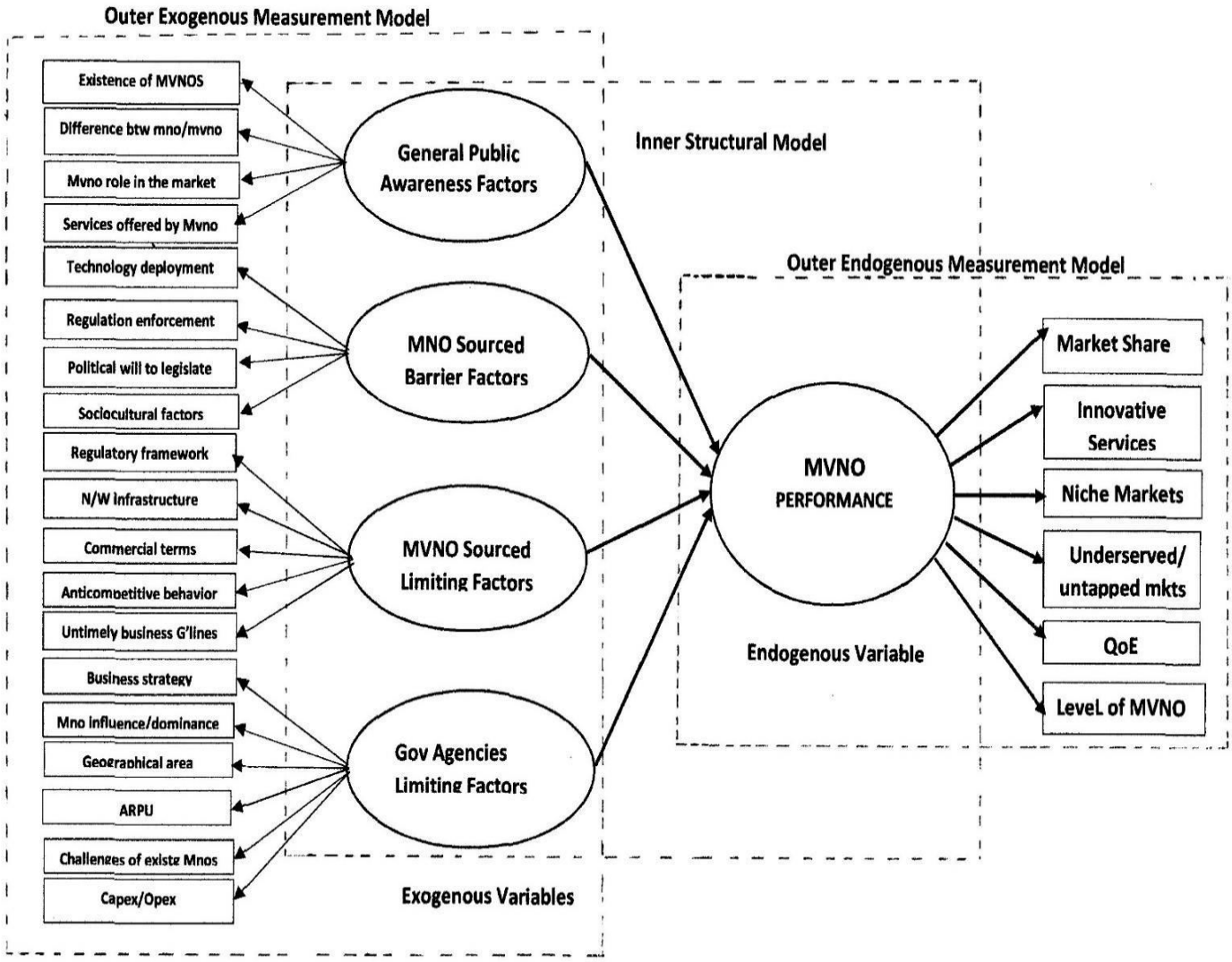


Fig 10: Proposed SEM Assessment Models (Adopted from Wong K. [202])

3.8.3 Model modification

SEM equation modeling is a complex process. Model fit threshold values are hard to come by. It is unlikely that the proposed model will fit the model specification necessitating for model modification and reevaluation. The role of modification is to improve the model fit by changing the model, to fit data. However the changes must be theoretically consistent to be

replicated with new data. The following methods have been suggested to achieve modification: Releasing constraints (adding free parameters), Imposing constraints (deleting free parameters) and use of Modification indices (MI), by covarying error terms with high modification indices. The rule of the thumb for modification is to covary terms within the same construct whose MI >10 [212] to achieve some appreciable change. Modification index values of >20 are typical. Modification indices and deletion of terms are the two modification methods used in this study.

3.8.4 Model evaluation

The goodness of fit of a statistical model describes how well it fits a set of observations. A measurement of the following indices is recommended to establish a model fit: the Chi-Square (X^2 = 1-3), (Adjusted) Goodness of Fit Index (A)GFI >0.90), Goodness of Fit Index (GFI >0.90), Comparative Fit Index (CFI >0.90), Normed Fit Index (NFI >0.90), Tucker Lewis Fit Index (TFI >0.90), Root Mean Square Error of Approximation (RMSEA <0.08) and Standardized Root Mean Residual (SRMR <0.08) [211]. CFI is a revised form of NFI where sample size do not matter and TFI is interchangeable with NFI for small samples sizes [204]. Overall; CFI, (S)RMR, and GFI are goodness of fit indices while RMSEA is a badness of fit index.

3.9 Software and Hardware Tools

Modern and future MVNO networks will be pegged on 5G MNO network configurations and beyond (6G/7G). 3GPP specifications and releases will prove useful in understanding the backward and forward compatibility of future MVNO technologies [123]. Win version 10/Excel, SPSS 21 with SEM-AMOS package incorporated were hardy software and statistical analysis tools. Workstation Pentium duo core 3.0 GHz, 12 GB RAM and 1 TB SSD was a useful hardware tool.

3.10 Ethical Issues

This research study involved collecting data from people, about people and organizations. Ethical issues arose in the course of the study that touched on all the phases of the inquiry,

namely, prior to conducting the study, beginning the study, during data collection and data analysis and in reporting, sharing and storing the data. To this end, some anticipated ethical issues were identified that were central to the study and need to be noted and addressed.

a. Agreements and Terms and Use and End User License Agreement (EULA) were observed, specifically for software, tools and any other information that might have required such agreement.
b. Research permits were sought from National Commission for Science, Technology and Innovation (NACOSTI), Masinde Muliro University of Science and Technology and Government Agencies to ease the process of data collection from study environments. A request for the permits was initiated by the researcher to the respective institutions.
c. Consent was sought from MNOs, MVNOs and Government Agencies to allow collection of data from their organizations. A request for assistance of research data was initiated by the researcher.
d. Principle of beneficence was observed by ensuring the participants freedom from harm, freedom from exploitation and risk as stipulated in the bill of rights in Kenya
e. Principle of human dignity was observed by informing participants of the purpose of the study, how the data was to be used and their right to self-determination (informed consent).
f. Principle of justice was upheld for both participants and study environments by exercising right to fair treatment, anonymity, right to privacy and confidentiality as stipulated in the privacy laws of Kenya.
g. Plagiarism was avoided by giving credit for ownership where it was due
h. Any other agreements pertaining to other third parties and regulator policies on MVNOs were observed and honored.

3.11 Summary

This chapter discussed the research philosophy and research design related to this study. Research paradigms of ontology, epistemology and axiology on beliefs and assumptions about the development of knowledge underpinning the study were outlined. The research design on data collection procedures and analysis were discussed in the context of target population,

interview groups and observation areas besides their sample sizes. Test instruments of questionnaire, interview protocol and observation protocol and data analysis methods applied in the study were given. Reliability, Validity and model fit evaluation parameters were stated. SEM-CFA modeling and validation methods were outlined. Hardware and software tools related to the study were given and finally anticipated ethical issues were stated.

CHAPTER 4: RESULTS AND FINDINGS

4.1 Overview

At the beginning of this study, three MVNO value chain environments shown in Fig 1 (section 1.1.4) and five general categories of stakeholder enablers in the MVNO sector were identified together with their value chain functions [119]. The categories formed a general basis from which test instruments and constructs were classified for this study. Prior to data collection, a pilot visit was made in the study industry to gain more insight into factors that affected our MNO/MVNO industry for the purpose of improving the test instrument. Equitel, Mobile Pay Ltd and Communications Authority were visited and cleared glaring gaps in the test instruments. The pilot visit was followed by a pilot survey that sealed more gaps into the instrument. The SEM-CFA questionnaire was a questionnaire within a questionnaire. It provided the SEM-CFA dataset from which the study assessment models and analysis was based. Preliminary results for descriptive statistics of analyzed data are presented in the following sections.

4.2 Test instrument Response Rates

Out of a target population of 400 respondents, 350 questionnaires were returned; corresponding to response rate of 87.50%. After data screening and cleaning, 155 responses were found suitable for compilation into a data set and subsequent analysis. This translated into an overall response rate of 44.29%. The response rate is above 40% threshold and acceptable for data analysis [198]. 155- Respondents meet the threshold for SEM – CFA analysis that recommends a sample size of 100-200. Seven (7) constructs that guided data collection were identified. It is recommended, at least 3-indicators should be used to measure the constructs [203], [204]. The actual indicators for the individual constructs ranged from 3-6. Test instrument response rates are captured in table 8.

4.3 Derivation and Mapping of Study Quality Factors

4.3.1 LR Quality factors

LR quality factors were factors that were retrieved from related previous studies. They are important because they serve as a guide to similar studies and to some extent, would be replicated in the study. 17-factors from LR were noted among others. 8-factors were key,

Table 8: Test Instrument Response Rates

TEST INSTRUMENTS							
QUESTIONNAIRE					Protocols		
RESPODENTS		Target	Received	Response rate (%)	Interview	Observation	Comments
ALL RESPONDENTS	CBD (Urban)	70	67	85.71%	-	-	N/A
	Kasarani (Semi-Urban)	220	183	83.18%	-	-	N/A
	Ruiru (Rural)	110	100	90.91%	-	-	N/A
Total Respondents		400	350	87.50%			
General Public	GP	100	43	43.00%	-	-	N/A
MNOs/ Outlets	Safaricom	85	42	49.41%	-	-	Partly declined*
	Airtel				Yes	Yes	Conducted
	Telkom				Yes	Yes	Conducted
	Faiba				-	-	Declined*
MVNOs/Outlets	Equitel	115	50	43.48%	Yes	Yes	Conducted
	Tangaza				Yes	Yes	Conducted
	Eferio				Yes	Yes	Conducted
GOV AGENCIES/ Personnel	CA	50	20	40.00%	Yes	Yes	Conducted
	ICT (A)				Yes	Yes	Conducted
	NCS				Yes	Yes	Conducted
Overall Respondents		350	155	44.29%	-	-	N/A

because of their higher frequency of occurrence, while eight (9) others appeared at a lesser extent as follows: Service differentiation, market segmentation, formulation of regulations/policies, niche/underserved/untapped markets and ARPU, came out strongly in that order, while Cost leadership, CAPEX/OPEX, MVNO resistance to change, Technology deployment, unfavorable commercial terms/SLA, Government Subsidy in disadvantaged areas, environmental and geographical issues, market dominance, QoE, level of MVNO, and awareness between MNO and MVNO followed in that order to a lesser extent. The 17-LR quality factors are shown in table 9.

Table 9: LR Quality Factors

	Quality factor	LR Reference Source and Year															
		4 2005	5 2001	40 2009	41 2011	68 2016	69 2013	116 2006	130 2012	131 2014	146 2017	165 2012	168 2018	171 2019	188 2016	194 2018	Freq
1	Service Differentiation	✓		✓	✓		✓						✓				5
2	Market segmentation	✓					✓			✓			✓		✓		5
3	Formulation of Regulations and policies					✓	✓					✓		✓	✓		5
4	Niche markets									✓			✓		✓		3
5	Underserved/ untapped markets									✓			✓		✓		3
6	ARPU					✓			✓					✓			3
7	Cost Leadership			✓	✓												2
8	CAPEX/OPEX						✓					✓					2
9	MNO Resistance to change						✓						✓				2
10	Technology Deployment		✓														1
11	Unfavorable commercial terms - SLA	✓															1
12	Gov Subsidy in disadvantaged areas													✓			1
13	Environmental and Geographical issues													✓			1
14	Market Dominance															✓	1
15	QoS/QoE							✓									1
16	Level of MVNO										✓						1
17	Awareness btw Mno/Mvno													✓			1

4.3.2 Interview thematic framework

The interview protocol contributed 10-factors, 6 factors were LR related and 4–factors were unique to the interview protocol, they included:

Anti-competitive behavior from MNOs and Technology deployment scored highly, while Unfavorable commercial terms from MNOs, Lack of clear business strategy and Lack of separate regulatory framework for MVNOs from MNOs followed in that order. Differentiation of MVNO services from the MNO, Lack of investment capital (CAPEX/OPEX), Network coverage

limitations and Lack of government political will to legislate were other barriers captured from the interview protocol. For each of the factors, a mitigating factor is suggested. Creating a level playing ground in the MNO/MVNO sector, establishing separate regulatory framework for MVNOs, subsidy of resources in rural, remote/marginalized areas, monopoly and public awareness were factors suggested for improvement. The five (5) unique factors from the interview protocol included:

i) Lack of clear business strategy

ii) Network infrastructure coverage limitations

iii) Lack of government Political will to legislate

iv) Social -cultural factors

Summary of Interview thematic framework factors and suggestions for improvement are given in table 10

Table 10: Summary of Interview thematic framework Factors and suggestions for improvement

	IP Key Factors	Freq	Comment	Comments/ Suggestions for Improvement	Freq
1	Anti-competitive behavior from MNOs	(5)	Replicated	Create a level playing ground in the MNO/MVNO sector	(4)
2	Technology deployment	(5)	Replicated	Establish separate regulatory framework for MVNOs.	(2)
3	Unfavorable commercial terms from MNOs	(4)	Replicated	Government subsidy in remote/marginalized and rural areas	(2)
4	Lack of separate regulatory framework for MVNOs	(2)	Replicated	Create public awareness for MVNO	(1)
5	Lack of clear business strategy	(2)	Unique factor		
6	Differentiation of MVNO services	(1)	Replicated		
7	Lack of investment capital (CAPEX/OPEX)	(1)	Replicated		
8	Network coverage limitations	(1)	Unique factor		
9	Lack of government Political will to legislate	(1)	Unique factor		
10	Social and Cultural factors	(1)	Unique factor		

4.3.3 Observation Thematic Framework

Observation thematic framework generated 10 factor. Out of the 10 factors 6- factors were unique to the Kenyan environment. They included: Geographical region of operation, network infrastructure coverage, Government political will to legislate, Level of the MVNO, Adoption of new technologies, ARPU, Regulation enforcement, Lack of timely police guidelines, Challenges of existing MVNOs and market share. Associated with each factor is a suggested mitigating factor.

Table 11: Summary of Observation thematic framework factors and suggestions for improvement

	IP Key Factors	**Suggestions for Improvement**	**Action**	**Comment**
1	Geographical Region of operation (urban , Rural, Remote marginalized)	Government subsidy for network infrastructure in remote/marginalized and rural areas	Government subsidy in remote areas	Replicated
2	Network infrastructure and coverage	Expand Network coverage to all the 47 counties	14 counties not covered –CA to take action or Government Subsidy	
		Share available infrastructure Resources among MNO service providers	Safaricom reluctant to share infrastructure resources with other MNOs and non-compliance with some MNOs –Regulator to take action or Government subsidy	Unique
3	Government political will to legislate	Legal framework or amend existing regulatory framework	Regulator to take action – Formulate policy	Unique
4	Level of MVNO licence	Separate licensing structure depending on MVNO level	MVNOs currently an application within MNOs - Regulator to take action	Unique
5	Adoption of new technologies	MNOs/MVNOs to embrace technology	**MNOs/MVNOs**	**Replicated**
6	ARPU	Government subsidy	Regulator to take action	Replicated
7	Regulation Enforcement	Compliance enforcement	Regulator to take action	Unique
8	Lack of timely policy guidelines	Formulate policy on time	Regulator to take action	Replicated
9	Challenges of existing MNOs		Regulator to take action	Unique
10	Market share	Introduction of more differentiated services and penetration into more market segments	MVNO problem	unique

Government and the regulator are the main culprits but MNO/MVNO have their share of the blame. Below are observation thematic framework unique factors

i) Network infrastructure and coverage
ii) Government political will to legislate
iii) Level of MVNO
iv) Regulation enforcement
v) Challenges of existing MVNOs
vi) Market share

A summary of observation thematic framework factors is shown in table 11.

4.3.4 Questionnaire barrier factors

The questionnaire generated 19-factors. Out of the 19, 12 factors were unique to the questionnaire while 7-factors were replicated from LR quality factors. Replicated factors included the following;

i. Low CAPEX/OPEX
ii. Technology deployment to differentiate services and billing service integration
iii. Inadequate regulatory framework and Policies for MVNOs
iv. Unfavorable commercial Terms from MNOs
v. QoE
vi. Level of MVNO
vii. Lack of awareness of difference between MNO and MVNO

Unique factors to the questionnaire test instrument were as follows:

i. Inadequate MNO Infrastructure n/w coverage
ii. Lack of Government political will to legislate
iii. Lack of awareness of existence of MVNOs
iv. Lack of awareness MVNOs role in the market
v. Lack of awareness of services offered by MVNOs
vi. Good working relations
vii. Level playing ground
viii. Adoption of new technology
ix. Managerial skills
x. Technical skills

xi. Content/Service development skills

xii. Marketing skills

Fig 12a is a summary of the questionnaire test instrument barrier factors

Table 12a: Summary of Questionnaire test instrument barrier factors

	Barrier Factor	Questionnaire Test Instruments					Comment
		Public	MNOs	MVNOs	Gov Agency	Freq dataset	
1	Low CAPEX/OPEX	-	✓	✓	✓	(3)	Replicated
2	Technology deployment to differentiate services and billing service integration	-	✓	✓	✓	(3)	Replicated
3	Inadequate regulatory framework and Policies for MVNOs	-	✓	✓	✓	(3)	Replicated
4	Inadequate MNO Infrastructure (n/w coverage) for MVNOs	-	✓	✓	-	(2)	Unique
5	Unfavorable commercial Terms from MNOs	-	✓	✓	-	(2)	Replicated
6	Lack of Government political will to legislate	-	✓	✓	-	(2)	Unique
7	QoE		✓			(1)	Replicated
8	N/W Gen/MVNO Level		✓			(1)	Replicated
9	Lack of awareness of difference btwn Mno/Mvno	✓	-	-	-	(1)	Replicated
10	Lack of awareness of existence of MVNOs	✓				(1)	Unique
11	Lack of awareness MVNOs role in the market	✓				(1)	Unique
12	Lack of awareness of services offered by MVNOs	✓				(1)	Unique
13	Good working relations	✓				(1)	Unique
14	Level playing ground	✓				(1)	Unique
15	Adoption of new technology	✓				(1)	Unique
16	Managerial skills			✓		(1)	Unique
17	Technical skills			✓		(1)	Unique
18	Content/Service Dev skills			✓		(1)	Unique
19	Marketing skills			✓		(1)	Unique

4.3.5 Test instruments barrier factors

The test instrument barrier factors were a collection of all factors from the test instruments, namely: interview protocol, observation protocol, and questionnaire. Repeated factors under the three categories were merged into one. 32-factors formed the basis of this study.

The 10–key factors that were unveiled include: Technology deployment, Inadequate n/w infrastructure coverage, Inadequate regulatory framework, Unfavorable commercial terms, and Geographical region of operation (urban, rural and remote/marginalized), Lack of government political will to legislate, MNO anti-competitive behavior and low CAPEX/OPEX. Twenty (21) other factors followed at a lower frequency. A summary of test instruments barrier factors are given in table 12b.

Table 12b: Summary of test instruments barrier factors (Questionnaire, Interview & Observation)

	Barrier Factor	**Questionnaire Test Instruments**					**IP & OBs test instruments**		**Over all Freq**	**Comment**
		Public	**MNO**	**MVNO**	**Gov Agency**	**Freq Q**	**Freq IP**	**Freq Obs**		
1	Low CAPEX/OPEX	-	✓	✓	✓	(3)	(1) ✓	-	4	Replicated
2	Technology deployment to differentiate services and billing service integration	-	✓	✓	✓	(3)	(5) ✓	(2) ✓	10	Replicated
3	Inadequate regulatory framework and Policies for MVNOs	-	✓	✓	✓	(3)	(2) ✓	(2) ✓	7	Replicated
4	Inadequate MNO Infrastructure (n/w coverage) for MVNOs	-	✓	✓	-	(2)	(1) ✓	(5) ✓	8	Unique
5	Unfavorable commercial Terms from MNOs	-	✓	✓	-	(2)	(4) ✓	-	6	Replicated
6	Lack of Government political will to legislate	-	✓	✓	-	(2)	-	(3) ✓	5	Unique
7	Lack of clear business strategy	-	-	-	-	-	(3) ✓	-	3	Unique
8	MNO Resistance to change (anti-competitive behavior)	-	-	-	-	-	(5) ✓	-	5	Replicated
9	Service Differentiation	-		-	-	-	(1) ✓	(1) ✓	2	Replicated
10	Geographical Region of operation (urban, rural, marginalized)	-		-	-	-	-	(6) ✓	6	Replicated
11	ARPU	-		-	-	-	-	(2) ✓	2	Replicated
12	Niche markets	-		-	-	-	-	(1) ✓	1	Replicated
13	Penetration into underserved/ untapped) segments							(1) ✓	1	Replicated
14	Regulation enforcement	-		-	-	-	-	(1) ✓	1	Unique
15	Lack of timely	-		-	-	-	-	(2)	2	Replicated

	policy/guidelines formulation							✓		
16	Challenges of existing MNO sector	-		-	-	-	-	(1) ✓	1	Unique
17	MNO influence and Dominance (Safaricom)	-		-	-	-	-(1) ✓	-	1	Replicated
18	Social and Cultural factors						(1) ✓	-	1	Unique
19	QoE	-		✓	-	(1)	-	(1) ✓	2	Replicated
20	N/W Gen/MVNO Level	-		✓	-	(1)	-	(1) ✓	2	Replicated
21	Lack of awareness of difference btwn Mno/Mvno	✓		-	-	(1)	-	-	1	Replicated
22	Market share							(1) ✓	1	Unique
23	Lack of awareness of existence of MVNOs	✓				(1)			1	Unique
24	Lack of awareness MVNOs role in the market	✓				(1)			1	Unique
25	Lack of awareness of services offered by MVNOs	✓				(1)			1	Unique
26	Good working relations	✓				(1)			1	Unique
27	Level playing ground	✓				(1)			1	Unique
28	Adoption of new technology	✓				(1)			1	Unique
29	Managerial skills			✓		(1)			1	Unique
30	Technical skills			✓		(1)			1	Unique
31	Content/Service Dev skills			✓		(1)			1	Unique
32	Marketing skills			✓		(1)			1	Unique

A total of (32) factors in all were generated from the test instruments. A comparison of LR quality factors (table 9) and test instrument factors (table 12) revealed that:

i) Of the 17- LR quality factors in table 9, 15-LR factors were replicated in the study. Cost leadership and Government Subsidy in disadvantaged areas, were the only two LR quality factors that were not replicated in this study. However, Government subsidy in disadvantaged areas is a factor that has been recommended to mitigate some of network coverage problems in rural, remote and marginalized areas.

ii) It is also evident that, out of the 32- factors generated, 17-factors were unique to the Kenyan environment. This represents (53%) of the total, a sizeable factor contribution indeed.

iii) Barrier factors priority ranking in the table is different from that of the LR quality factors. Fit–Viability framework suggests that M-commerce business models are unique to different environments and cultures [19]. Different environments and

cultures are influenced to use technology in different ways. This is a clear validation of Fit-Viability framework which is a by-product of this study and an additional contribution to the study.

4.3.6 Derivation of Study Quality Factors

The study comprised of seven (7) variables and thirty two (32) quality factors. The factors were mapped into their respective variables to form the SEM-CFA questionnaire on which the dataset for analysis was derived. Nineteen (19) factors were associated with independent variables, Six (6) with dependent variable and seven (7) with mediator variables. A summary of study quality factors is given in table 13

Table 13: Summary of Study quality factors

Variables	**INPUT QUALITY FACTORS**
General Public Sourced Awareness Factors (GPAFS)	Quality factors
	GPAF1 - Lack of awareness of existence of MVNOs, GPAF2 - Lack of awareness of the differences btw MNO &MVNO GPAF3 - Lack of awareness of what MVNOs do in the Kenyan market GPAF4- Lack of awareness of services offered by MVNOs)
MNO Sourced Barrier Factors (MNOBFS)	MNOBF1 – Technology Deployment MNOBF2 - Regulation enforcement MNOBF3 - Government political will to legislate MNOBF4 - Sociocultural factors
MVNO Sourced Limiting Factors (MVNOLFS)	MVNOLF1 - Inadequate Regulatory Framework
	MVNOLF2 - Inadequate MNO network infrastructure
	MVNOLF3 – Commercial Terms
	MVNOLF4 – MNO anticompetitive behavior
	MVNOLF5 – Untimely policy guidelines
Government Agencies Sourced Limiting Factors (GALFS)	GALF1 –Lack of Clear Business Strategy
	GALF2 - MNO influence and dominance
	GALF3 – Geographical area
	GALF4 - ARPU
	GALF5 – Challenges of existing MNO
	GALF6 – CAPEX/OPEX
MVNO Performance Factors (MVNOPFS)	**OUTPUT QUALITY FACTORS**
	MVNOP1 – Market share
	MVNOP2 – Innovative Services
	MVNOP3 – Niche Markets
	MVNOP4 – Underserved/untapped markets
	MVNOP5 – QoE
	MVNOP6 – Level of MVNO
Stakeholders Value Chain Factors	**MEDIATOR QUALITY FACTORS**
	SVCF1 – Good working relations

(SVCFS) & Development Phases Value Chain Factor (DVCFS)	SVCF2 – Level playing ground	**Stakeholders Value Chain Factors**
	SVCF3 – Adoption of new technology	**(SVCFS)**
	DVCF1- Managerial skills	
	DVCF2 - Technical skills	**Development Phases Value Chain**
	DVCF3 - Content /Service Dev skills	**Factors (DVCFS)**
	DVCF4 - Marketing skills	

Independent and dependent variables and their corresponding factors were used in the analysis of proposed CFA and SEM models while the mediator variables were used to mediate the SEM model

4.4 Statistical Assessment of study quality factors

Study quality factors formed the SEM – CFA data set on which evaluation and analysis of the proposed models were based. The data was subjected to mean score, normality, reliability and validity tests to assess the suitability of data prior to further analysis.

The pretest revolved around 6-constructs and their respective factors listed below:

i. General Public Awareness Factors (GPAFS): 4-Factors
ii. MNO Sourced Barrier factors (MNOBFS: 4-Factors
iii. MVNO Sourced Limitation Factors (MVNOLFS): 5-Factors
iv. Government Agency Sourced Limitation factors (GALFS): 6-Factors
v. MVNO Performance Factors (MVNPFS): 6-Factors
vi. Mediator 1 and 2: Stakeholders value chain factors (SVCFS) and Development Phases value chain factors (DVCFS) respectively: 7-Factors

4.4.1 Study quality factors Mean Pretest Results

The quality study factors were tested for mean scores under their respective categories and the results recorded in tables 14a -14g. Factors marked in red in the tables are unique to the Kenyan environment as derived earlier. A mean score of (50%) and above is acceptable.

Table 14a: Lack of General Public Awareness Factors (GPAFS)

Item	SA	A	N	D	SD	Factor Mean % SA+A	Variable mean (%) (GPAFS)
	(N) %	(N) %	(N) %	(N) %	(N) %		
GPAF1	(47) 32.4	(90) 62.1	(6) 4.1	(1) 0.7	(1) 0.7	(137) 94.5	95%
GPAF2	(75) 51.1	(64) 44.1	(3) 21.1	(3) 21.1	-	(139) 95.9	
GPAF3	(66) 45.5	(70) 48.3	(4) 2.8	(3) 2.1	(2) 1.4	(136) 93.8	
GPAF4	(54) 37.2	(85) 56.6	(4) 2.8	(1) 0.7	(1) 0.7	(139) 95.9	
Number of Respondents: (N=145)							

Lack of General public awareness factors (GPAFS) scored highly in the range of 93.8% to 95.9% far above the mean. This means, a high percentage of the general public know very little about MVNOs. To the general public, MNOs and MVNOs are interchangeable.
Lack of awareness of existence of MVNOs (GPAF1), Lack of awareness of what MVNOs do in the Kenyan market (GPAF3) and Lack of awareness of services offered by MVNOs (GPAF4) are unique to the Kenyan market.

A lobby group for MVNO market stakeholders among others as suggested by [175], [167] could alleviate the problem. There is no such group in Kenya currently. Rigorous marketing and civic education on MVNOs as alternative service providers would improve their portfolio among other strategies

Table 14b: MNO Barrier Sourced factors (MNOLFS)

Item	SA	A	N	D	SD	Factor mean % SA+A	Variable mean (%) (MNOLFS)
	(N) %)	(N) %	(N) %	(N) %	(N) %		
MNOF1	(62) 42.8	(47) 32.4	(31) 21.4	(5) 3.4	-	(109)75.2	70.2%
MNOBF2	(35) 24.1	(57) 39.3	(40) 27.6	(12) 8.3	(1) 0.7	(92) 63.4	
MNOBF3	(30) 20.7	(62) 42.8	(40) 27.6	(13) 9	-	(92) 63.4	
MNOBF4	(33) 22.8	(81) 55.9	(21) 14.5	(6) 4.1	(4) 2.8	(114) 78.7	
Number of Respondents: (N=145)							

MNO barrier sourced factors (MNOBFS) scored in the range of 63.4% to 78.2%. An acceptable score above the mean. MNO1-Technology deployment know how, is the only factor among LR quality factors. Regulation enforcement (MNOBF2, Government political will to legislate (MNOBF3) and Sociocultural factors (MNOBF4) are unique to the Kenyan environment.

Table 14c: MVNO Limiting Factors (MVNOLFS)

Item	SA	A	N	D	SD	Factor Mean % SA+A	Variable Mean (%) MVNOFS
	(N) %	(N) %	(N) %	(N) %	(N) %		
MVNOLF1	(25) 17.2	(44) 30.3	(56) 38.6	(18) 12.4	(2) 1.4	(69) 47.6	53.7
MVNOLF2	(29) 20	(67) 46.2	(25) 17.2	(17) 11.7	(7) 4.8	(96) 66.2	
MVNOLF3	(30) 20.7	(47) 32.4	(39) 26.9	(22) 15.2	(7) 4.8	(77) 53.1	
MVNOLF4	(25) 17.2	(57) 39.3	(33) 22.8	(20) 13.8	(10) 6.9	(82) 56.6	
MVNOLF5	(16) 11	(49) 33.8	(44) 30.3	(24) 16.6	(12) 8.3	(65) 44.8	
Number of Respondents: (N=145)							

MVNO Limiting factors scored in the range of 44.8% to 66.2.2%. The scores are above the mean except for, Inadequate regulatory framework and policies for MVNO (MVNOLF1- 47.6%) and Lack of timely policy and guidelines formulation (MVNLF5- 44.8%) which are slightly below the mean but acceptable on the strength of the total Variable mean of (53.7%) that is above average. Inadequate regulatory framework for MVNOs (MVNOLF1), and Inadequate MVNO infrastructure coverage (MVNOLF2) are unique to the Kenyan environment.

Table 14d: Government Agencies Limiting factors (GALFS)

Item	SA	A	N	D	SD	Factor mean % SA+A	Variable mean % GALFS
	(N) %	(N) %	(N) %	(N) %	(N) %		
GALF1	(38) 26.2	(47) 32.4	(49) 33.8	(9) 6.2	(2) 1.4	(85) 58.6	72.5%
GALF2	(44) 30.3	(65) 44.8	(21) 14.5	(6) 4.1	(9) 6.2	(109) 75.2	
GALF3	(65) 44.8	(70) 48.3	(7) 4.8	(2) 1.4	(1) 0.7	(135) 93.1	
GALF4	(50) 34.5	(56) 38.6	(29) 20	(9) 6.2	(1) 0.7	(106) 73.1	
GALF5	(30) 20.7	(56) 38.6	(39) 26.9	(17) 11.7	(3) 2.1	(86) 59.3	
GALF6	(63) 43.4	(47) 32.4	(23) 15.9	(6) 4.1	(6) 4.1	(110) 75.9	
Number of Respondents: (N=145)							

Government agencies Limiting factors score in the range of 58.6% to 93.1%. These are acceptable scores above the mean. GA3–Geographical area of operation, GA4 -ARPU and GA6 - CAPEX/OPEX are among LR quality factors. GA1-Lack of clear business strategy, GALF2 - MNO influence and dominance, and GALF5 - Challenges of existing MNO are unique to the Kenyan environment.

Table 14e: MVNO Performance Factors (MVNOPFS)

Item	SA	A	N	D	SD	Factor mean % SA+A	Total mean % MVNOPFS
	(N) %	**(N) %**	**(N) %**	**(N) %**	**(N) %**		
MVNOP1	(35) 24.1	(84) 57.9	(22) 15.2	(3) 2.1	(10) 0.7	82.1	59.1
MVNOP2	(26) 17.9	(55) 37.9	(51) 35.2	(12) 8.3	(1) 0.7	55.9	
MVNOP3	(37) 25.5	(69) 47.6	(26) 17.9	(11) 7.6	(2) 1.4	73.1	
MVNOP4	(37) 25.5	(64) 44.1	(30) 20.7	(11) 7.6	(3) 2.1	69.7	
MVNOP5	(15) 10.3	(46) 31.7	(54) 37.2	(27) 18.6	(3) 2.1	42.1	
MVNOP6	(15) 10.3	(31) 21.4	(57) 39.3	(27) 18.6	(15) 10.3	31.7	
Number of Respondents: (N=145							

MVNO performance factors score in the range of 31.7% to 82.1%. Four scores are above the mean and two below the mean (QoE - MVNOPF5=42.1%) and Level of MVNO -MVNOPFP6 =

31.7%) but acceptable on the strength of the total Variable mean of (59.1) that is above the average. The low response of the two factors could have arisen from the use of technical terms that were not familiar to the respondents. All the factors are among LR quality factors, Market share (MVNOPF1), Number of innovative services (MVNOPF2), Number of Niche markets (MVNOPF3), Penetration of underserved and/untapped markets (MVNOPF4), QoE (MVNOPF5 and Level of MVNO (MVNOPF6).

MVNO development environment comprised of two mediators: Stakeholders value chain factors (SVCFS) and Development phases Value chain factors (DVCFS). Each mediator was tested separately and the values recorded in table 14f and table 14g respectively.

Table 14f: Mediator 1: Stakeholders value chain factors (SVCFS)

Item	**SA**	**A**	**N**	**D**	**SD**	**SA+A**
	N (%)	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**(%)**
SVCF1	(41) 26.5	(81) 52.3	(32) 20.6	(1) 0.6	0	78.7
SVCF2	(58) 37.4	(53) 34.2	(39) 25.2	(4) 2.6	(1) 0.6	71.6
SVCF3	(73) 47.1	(77) 49.7	(4) 2.6	(1) 0.6	0	96.8
Number of Respondents: (N=155)						

Table14g: Mediator 2: Development phases Value chain factors (DVCFS)

Item	**SA**	**A**	**N**	**D**	**SD**	**SA+A**
	N (%)	**N (%)**	**N (%)**	**N (%)**	**N (%)**	
D1VCF1	(39) 25.2	(57) 36.8	(46) 29.7	(13) 8.4	0	61.9
DVCF2	(77) 49.7	(78) 50.3	0	0	0	100
DVCF3	(44) 28.4	(77) 49.7	(29) 18.7	(2) 1.3	(3) 1.9	78.1
DVCF4	(31) 20.0	(58) 37.4	(47) 30.3	(15) 9.7	(4) 2.6	57.4
Number of Respondents: (N=155)						

Stakeholders value chain factors (SVCFS) scored an above average score of 71.6% -100% while Development phases Value chain factors (DVCFS) scored above average values of 57.4%. – 100%. The mean values were above average and acceptable. The 2- Mediator variables and their corresponding 7-factors were analyzed separately from the rest of the study factors. From the foregoing, it is observed that:

i. The 7-study constructs and their corresponding 32-factors scored above average mean values. The study quality factors passed the mean score pretest and are acceptable for the

proposed SEM-CFA assessment models and upheld for further analysis and processing.

ii. It is further observed that, out of the 25 quality study factors for (Independent /dependent variables), 11-factors (44%) are unique to the Kenyan environment, while 14 factors (56%) were replicated from LR quality factors. A 44% of unique factors from the Kenyan environment is a good contribution while a 56% replication of LR factors is commendable.

A summary of unique quality factors in the Kenyan environment and their mean scores are given in table 15.

Table 15: Summary of quality factors unique to the Kenyan environment and their scores

	Quality factors	mean%
GPAFS	GPAF1- Lack of awareness of existence of MVNOs, GPAF3- Lack of awareness of MVNOs role in the Kenyan market GPAF4- Lack of awareness of services offered by MVNOs)	94.5 93.8 95.9
MNOBFS		
	MNOBF2 - Regulation enforcement, MNOBF3 - Government political will to legislate MNOBF4 - Sociocultural factors,	63.4 63.4 78.6
MVNOLFS		
	MVNOLF1- Inadequate regulatory framework for MVNOs	47.6
	MVNOLF2 – Inadequate MNO infrastructure coverage	66.2
GALFS		
	GALF1 – Lack of clear business strategy GALF2 – MNO influence and dominance GALF5 – Challenges of existing MNO	58.6 75.2 59.3

4.4.2 Research Data Normality Test Results

The SEM-CFA dataset was subjected to Normality test (normal curve) using Skewness and Kurtosis. Recommended values for Skewness and Kurtosis are given as (-3 to +3) and (-10 to +10) respectively. Critical value (cr) defines the lower and upper bounds of a confidence interval or threshold of statistical significance).

Normality test results show that; MVNO Performance Factors (MVNOPF), General Public Awareness Factors (GPAF), Government agency Limiting Factors (GALF), MVNO Limiting Factors (MVNOLF) and MNO Barrier Factors (MNOBF), meet the Skewness and Kurtosis

thresholds of (-3 to +3) and (-10 to +10) respectively as depicted in Table 16. It is established that the study research data is normally distributed and suitable for further analysis.

Table 16: Data Normality Test Results

Variable	min	max	skew	c.r.	kurtosis	c.r.	Normality status
MVNOPF1	1.000	5.000	.779	3.828	1.554	3.820	Established
MVNOPF2	1.000	5.000	.167	.822	-.451	-1.109	Established
MVNOPF3	1.000	5.000	.772	3.797	.352	.866	Established
MVNOPF4	1.000	5.000	.736	3.616	.238	.584	Established
MVNOPF5	1.000	5.000	.051	.251	-.532	-1.307	Established
MVNOPF6	1.000	5.000	.054	.268	-.533	-1.310	Established
GPAF1	1.000	5.000	1.082	5.318	4.428	10.884	Established
GPAF2	1.000	5.000	1.636	8.044	4.888	12.015	Established
GPAF3	1.000	5.000	1.720	8.457	4.775	11.738	Established
GPAF4	1.000	5.000	1.186	5.832	4.728	11.622	Established
GALF1	1.000	5.000	.308	1.512	-.454	-1.115	Established
GALF2	1.000	5.000	1.171	5.754	1.017	2.500	Established
GALF3	1.000	5.000	1.333	6.551	3.412	8.386	Established
GALF4	1.000	5.000	.680	3.344	-.133	-.327	Established
GALF5	1.000	5.000	.432	2.126	-.398	-.978	Established
GALF6	1.000	5.000	1.176	5.782	.912	2.242	Established
MVNOLF1	1.000	5.000	.060	.294	-.571	-1.403	Established
MVNOLF2	1.000	5.000	.772	3.794	-.028	-.069	Established
MVNOLF3	1.000	5.000	.371	1.822	-.647	-1.591	Established
MVNOLF4	1.000	5.000	.547	2.687	-.466	-1.144	Established
MVNOLF5	1.000	5.000	.336	1.650	-.582	-1.429	Established
MNOBF1	1.000	5.000	.740	3.640	-.087	-.215	Established
MNOBF2	1.000	5.000	.377	1.853	-.468	-1.151	Established
MNOBF3	1.000	5.000	.384	1.885	-.324	-.797	Established
MNOBF4	1.000	5.000	1.161	5.709	1.894	4.654	Established
Multivariate					39.553	6.481	

4.4.3 Reliability test Results for Outer Exogenous measurement model

Two approaches were used to assess the parameters:

i) SPSS Cronbach Alpha – Measure of Construct reliability and Composite reliability

A Cronbach Alpha value of >0.6 was acceptable for both Construct and Composite reliability

ii) CB-SEM Estimation measurement models using CFA AMos – Measures AVE, Construct Validity, Convergent Validity and Discriminant Validity and many more model parameters.

CB-SEM method measures Construct Validity through composite reliability that measures the internal consistency of indicator variables loading on the latent variable and Average Variance Extracted (AVE) using AMOS on SEM-CFA model. Construct validity is acceptable if the composite reliability (CoR) is (≥ 0.6) and AVE is (≥ 0.5). In case where the AVE values are less than the threshold (0.5 - which is true in this particular case) but the composite reliability meets the threshold of (≥ 0.6) and the SEM model is fit with no deleted terms, construct validity is acceptable and established based on the measures used to correct the data.

Table 17: Reliability test results for Outer exogenous measurement model

No.	Construct	Indicators	Cronbach Alpha	AVE	Construct Reliability	Composite Reliability (CoR)
1	GPAFs	GPAF1, GPAF2, GPAF3, GPAF4	0.727	0.4027	passed	
2	MNOBFs	MNOBF1,MNOBF2,MNOBF3, MNOBF4	0.616	0.2984	Passed	(0.821)
3	MVNOLFs	MVNOLF1,MVNOLF2, MVNOLF3, MVNOLF4, MVNOLF5	0.677	0.3141	passed	
4	GALFs	GALF1, GALF2, GALFF3, GALF4,GALF5, GALF6	0.690	0.2818	Passed	passed

Cronbach Alpha Reliability values were generated in table 17 as: General Public Awareness Factors (GPAFS) 0.727, MNO Barrier Factors (MNOBFS) 0.616, MVNO Limiting Factors (MVNOLFS) 0.677 and Government Agency Limiting factors (GALFS) 0.690. All the exogenous variables of the outer measurement model passed the test for construct reliability with (α) values of >0.6. Composite reliability was even better at 0.821. It can be concluded that the outer exogenous measurement model latent construct indicators are internally consistent, error free and measure true value and the set of latent construct indicators of the outer exogenous model share in their measurement of a construct.

The Average Variance Extract (AVE) for all the constructs were below the 0.5 threshold mark, however the model from which the results were derived was fit with no deleted factors. Construct validity was acceptable and established based on the measures of composite reliability

(0.821) and the unmodified SEM model fit indices with no deleted factors in table 23a. Construct Reliability results for outer exogenous model are captured in table 17

4.4.4 Reliability test results for Outer Endogenous measurement model

Table 18: Reliability Test results for Outer endogenous measurement model

No.	Construct	Indicator	Cronbach's Alpha	AVE	Construct Reliability (CR)
1	MVNOPFS	MVNOPF1, MVNOPF2, MVNOPF3,MVNOPF4,MVNOPF5, MVNOPF6	0.737	0.578	Passed

The outer endogenous measurement model registered a construct reliability (MVNOPFS) of 0.737. It can be concluded that the model (MVNOPFS) met Cronbach's Alpha threshold of > 0.6. Therefore Construct reliability is established. Indicators for MVNO Performance factors are internally consistent, error free and measure true value. The results are shown in table 18. A complete summary for Reliability and Validity parameter results for the unmodified CFA and SEM measurement models is given in table 27 (section 4.5.6)

4.4.5 Reliability test results for Mediator variables

Stakeholders value chain factors (SVCFS) registered a Cronbach's Alpha value of 0.378 that is considered low for a threshold of >0.6. Development Value Chain factor (DVCFS) had an acceptable value of 0.650. The composite construct reliability however was (0.763) and >0.6 Cronbach's Alpha threshold.

Table: 19 Reliability test results for mediator variables

No.	Construct	Indicator	Cronbach's Alpha	Construct Reliability (CR)	Composite Reliability (CoR)
1	SVCFS	SVCF1, SVCF2, SVCF3	0.378	Low	(0.763) Passed
2	DVCFS	DVCF1, DVCF2, DVCF3, DVCF4	0.650	passed	

It can be concluded that the construct reliability of mediators is acceptable and established on the strength of composite reliability (CoR) of 0.763. The mediator construct reliability values are captured in table 19. It is also true that since no factors were deleted in the Mediator SEM assessment model (Sections 4.7.1 and 4.7.2) and the SEM-CFA model fit indices were acceptable without modification (table 23a), construct validity of the mediator variables is acceptable and established. SVCFS and DVCFS variables have indicators that are internally consistent, error free and measure true value that supports the model. The mediator construct reliability values are captured in table 19.

4.5 SEM-CFA Assessment model Results

4.5.1 Overview

The SEM asssessment models comprise of 3-sets of models as given in fig 10 section 3.8.2: The outer Exogenous measurmenent model, the outer Endogenous measurement model and the inner structural model. The outer Exogeneous and Endogenous measurment models comprised of:

i. CFA proposed measurement model
ii. CFA Estimates measurement model
iii. CFA Modified Estimates measurement model

The models evaluated model parameters and fitness features of the proposed MVNO study factors conceptual model in fig 6.

The inner structural model comprised of:

i. Standardized Proposed SEM Structural model
ii. Unmodified SEM Structural Estimates model

The models validated the CFA models the hypotheses and the MVNO Implemementation conceptual framework in fig 7

Mediation Analysis models comprised of:

i. Mediator 1: 4-Analysis measurement models
ii. Mediator 2: 4-Analysis measurement models

The models validated the mediator hypotheses and identified the prime movers of MVNO performance.

4.5.2 Proposed CFA Measurement Models

The CFA proposed measurement model was derived from the two outer measurement models of exogenous and endogenous variables in table 10 using IBM SPSS AMOS. The model comprised of error terms, outer exogenous variables and outer endogenous variable. The endogenous

variable and exogenous variables were covaried to create the CFA measurement estimates model. The Proposed CFA Measurement Model is shown in fig11

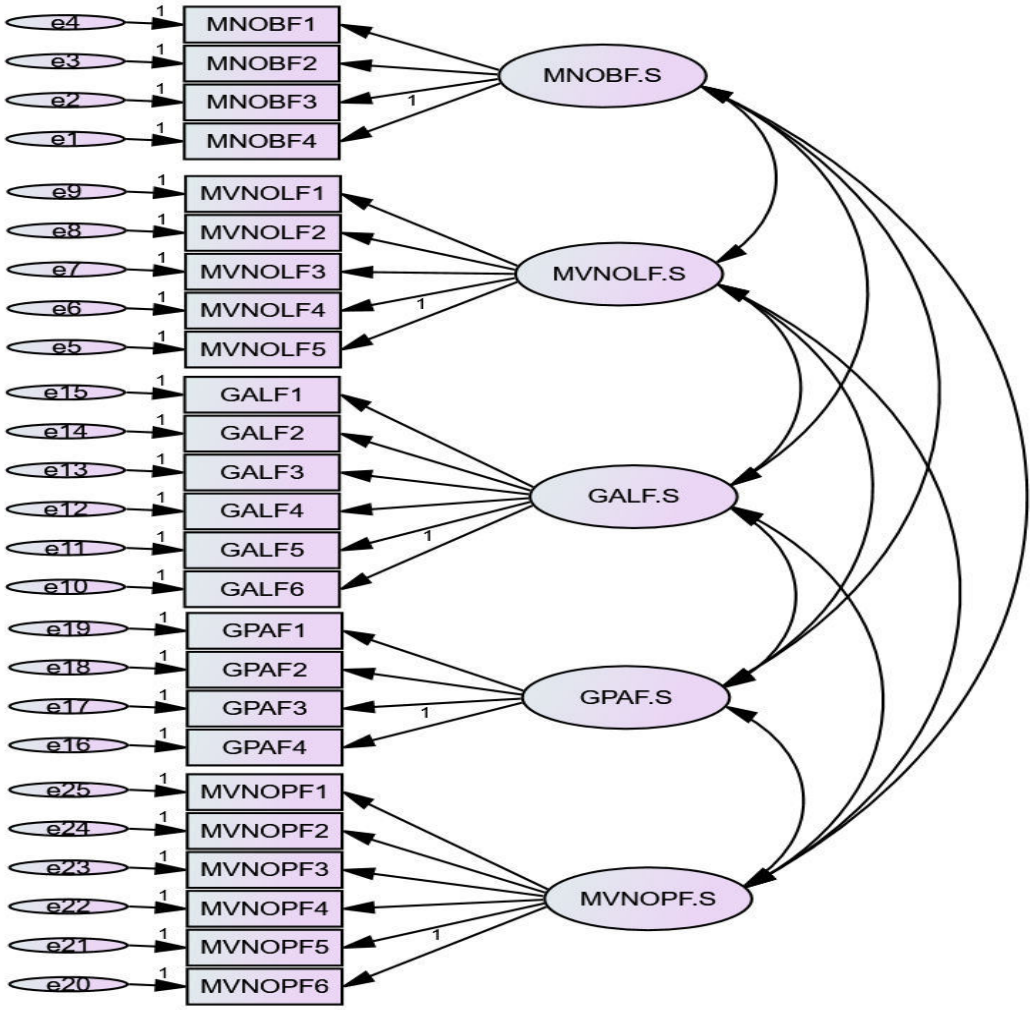


Fig: 11 Proposed CFA Measurement Model (without Estimates)

The measurement model was loaded with estimates (Regression weights) to create a CFA Measurement Estimates Model that was tested for model fit. The CFA Measurement Estimates Model is shown in fig 12, while the Standardized Regression weights for the measurement model and CFA Measurement Modification index Per Change of the model are given in table 20 and table 21 respectively.

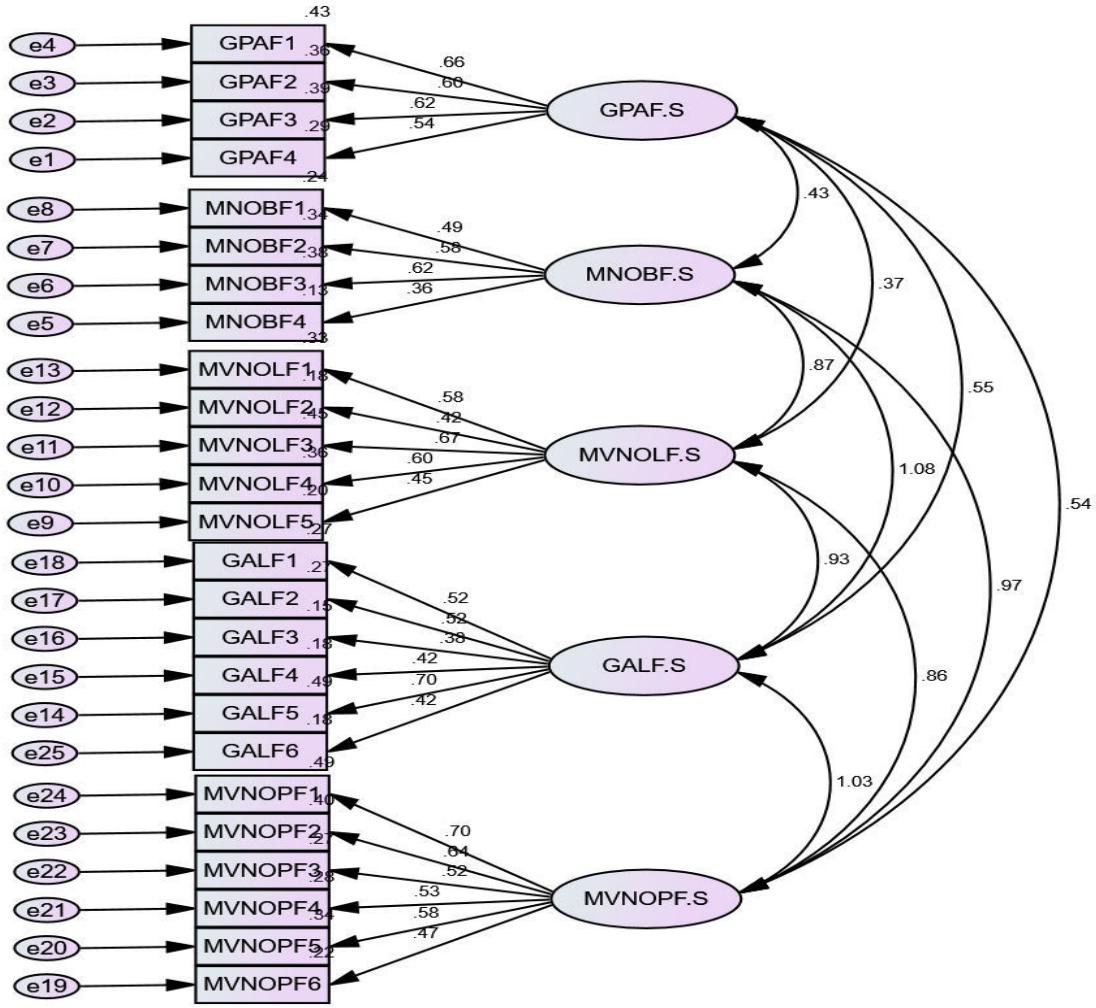


Fig 12: Unmodified CFA Measurement Estimates Model

The CFA measurement estimates model was tested for model fit at three different levels:

i) Unmodified CFA Measurement Estimates Model
ii) Modified CFA Measurement Estimates Model by modification index (MI)
iii) Modified CFA Measurement Estimates Model by deletion of terms

An acceptable model allowed the researcher to establish whether specific paths are significant while acceptable fit indices implied strong relationships among variables. The study used a sample size of (145) that was regarded as between low and high. Eight basic fit indices were recommended for testing at the following thresholds: Chi Square(1-3), AGFI (≥0.90), GFI (≥0.90), CFI (≥0.90), NFI(≥0.90), TLI (≥0.90), RMSEA (≤0.08), (S)RMR (≤0.08), and, [211],

[212]. It should be noted that CFI is a revised form of NFI and TLI and NFI are interchangeable [204]. The CFA measurement model was tested at all the three levels and the results summarized and compared for the best significant diagram and model fit indices from fig.12, fig.13 and fig.14 and tables 23a, 23b, and 23c respectively.

Table 20: Standardized Regression Weights for Unmodified CFA Measurement Model

			Estimate	Sq²multiple Correlation
GPAF4	<---	GPAF.S	.542	.293
GPAF3	<---	GPAF.S	.624	.389
GPAF2	<---	GPAF.S	.597	.357
GPAF1	<---	GPAF.S	.658	.434
MNOBF4	<---	MNOBF.S	.359	.129
MNOBF3	<---	MNOBF.S	.620	.384
MNOBF2	<---	MNOBF.S	.582	.339
MNOBF1	<---	MNOBF.S	.493	.243
MVNOLF5	<---	MVNOLF.S	.452	.204
MVNOLF4	<---	MVNOLF.S	.597	.357
MVNOLF3	<---	MVNOLF.S	.670	.450
MVNOLF2	<---	MVNOLF.S	.423	.179
MVNOLF1	<---	MVNOLF.S	.578	.334
GALF6	<---	GALF.S	.421	.177
GALF5	<---	GALF.S	.697	.486
GALF4	<---	GALF.S	.421	.177
GALF3	<---	GALF.S	.383	.147
GALF2	<---	GALF.S	.519	.269
GALF1	<---	GALF.S	.519	.270
MVNOPF6	<---	MVNOPF.S	.468	.219
MVNOPF5	<---	MVNOPF.S	.581	.338
MVNOPF4	<---	MVNOPF.S	.533	.284
MVNOPF3	<---	MVNOPF.S	.516	.266
MVNOPF2	<---	MVNOPF.S	.636	.404
MVNOPF1	<---	MVNOPF.S	.700	.491

Table 21: Modification Index and Par Change for Unmodified CFA measurement model

	M.I.	Par Change
e24 <--> e25	7.685	.123
e21 <--> e23	5.762	.119
e18 <--> MVNOLF.S	4.261	-.061
e18 <--> e25	6.632	.170
e17 <--> MVNOPF.S	6.748	-.072
e16 <--> e24	7.853	.084
e15 <--> MVNOLF.S	5.889	-.073
e14 <--> e25	6.353	-.148
e14 <--> e17	5.685	.134
e13 <--> GPAF.S	4.209	-.052
e12 <--> MVNOPF.S	4.293	-.062
e12 <--> e25	6.390	-.202
e12 <--> e17	10.567	.249
e11 <--> e18	5.043	-.138
e9 <--> MVNOPF.S	17.901	.129
e9 <--> MVNOLF.S	6.316	-.088
e9 <--> e23	9.237	.183
e9 <--> e21	6.113	.173
e9 <--> e19	6.018	.206
e9 <--> e17	8.617	-.229
e9 <--> e12	4.393	-.175
e9 <--> e11	7.518	-.207
e8 <--> e25	5.535	.149
e8 <--> e15	9.253	.168
e6 <--> e20	5.002	.108
e5 <--> e16	4.396	.094
e3 <--> e13	6.897	-.106

**MI – Modification Index, Par- Parameter Change*

Table 22: Summary of MI and parameter change for Unmodified CFA measurement model

Modified factors	**Factor**	**Error terms**	**MI**	**Par change**
N/W Infrastructure	MVNOLF2	E12 <-- > e17	10.567	0.249
MNO Influence/dominance	GALF2			
Technology Deployment	MNOBF1	E8 <-- > e15	9.253	0.168
ARPU	GALF4			
Untimely Policy Guidelines	MVNOLF5	E9 <-- > e23	9.237	0.183
Innovative Services	MVNOPF2			

4.5.3 CFA Measurement Model Test Results

I. Unmodified CFA Measurement Estimates Model Test results

The unmodified CFA Measurement Estimates Model in fig 12 was tested and the model fit indices summarized as follows: Chi-Square=1.232, SRMR=0.062, GFI=0.836, AGFI =0.799, NFI=0.719, TLI=0.919, CFI= 0.929, RMSEA=0.040. NFI and (A)GFI were slightly low but acceptable. CFI is a modified version of NFI while AGFI is an adjusted version of GFI and could serve as a good replacements resspectively [204]. All the model fit indices therefore passed the test as given in table 23a. It can be concluded that the Unmodified CFA Estimates Measurement Model registered significant paths and acceptable model fit indices without any modification, an indication of strong relationships among the model variables.

II. Modified CFA Measurement Estimates Model by modification index (MI) test results

A set of 3-error terms (e12-e17, e9-e23, and e8-e15) were found wanting because of their high modification indices of 10.567, 9.237 and 9.253 respectively as given in table 21. They were modified by covarying the error terms as shown in fig 13 to improve the model fit as per modification indices and factors given in table 22 as follows:

i) Network infrastructure (MVNOLF2–e12) covaried with MNO influence/dominance (GALF2 –e17) at a modification index of 10.567
ii) Technology Deployment (MNOBF1 – e8) covaried with ARPU (GALF4 - e15) at a modification index of 9.253
iii) Untimely Policy Guidelines (MVNOLF5–e9) covaried with Innovative Services (MVNOPF2 – e23) at a modification index of 9.237

Modified measurement model using Modification indices (MI) gave slightly better model fit results listed in table 23b as follows: Chi square=1.129, SRMR=0.058 ,GFI=0.853, AGFI=817, NFI=0.746, TLI=0.955, CFI=0.961 and RMSEA=0.03. NFI and (A)GFI were slightly low but acceptable [204]. All the model fit indices passed the test.

It is however noted that the modified MI values are low (MI≤10) for any significant paramenter change. The rule of the thumb for modification is to covary error terms whose MI values are (>10) to achieve appreciable parameter change [204] and Covaried error terms should be within the same construct [212]. Typical values of MI for appreciable parameter change are in the range of 10-20. Modified measurement model by MI therefore didn't warrant modification in the first place because of low values of MI paramenter change. Secondly the modified error terms in fig. 13 are across different constructs which is against convariance modification rules. Covariance paths created are redundant and invalid. The Modified CFA measurement model using MI is therefore rejected despite registering slightly better model fit indices. The unmodified measurement model is therefore a better option than the modified model by (MI).

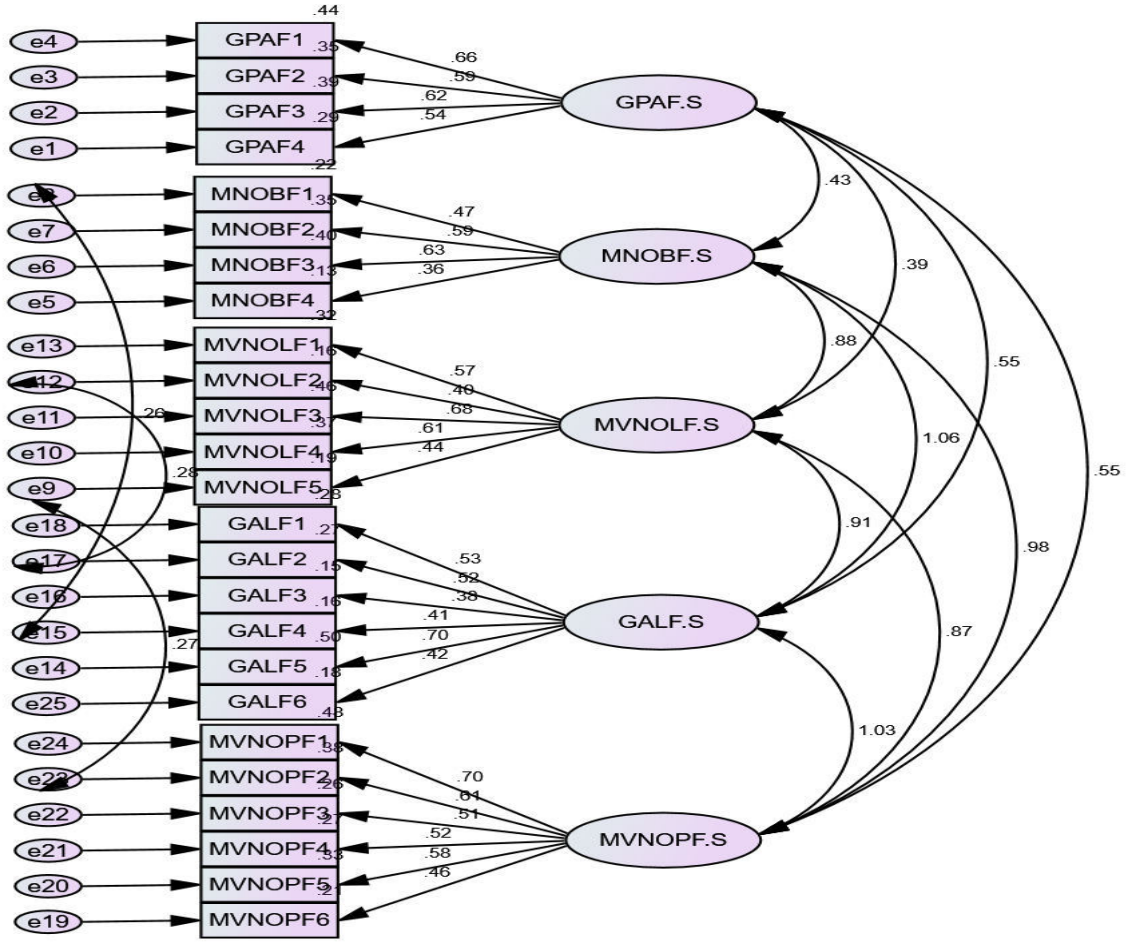


Fig 13: Modified CFA Measurement Estimates model by Modification index (MI)

III. Modified CFA Measurement Estimates Model by deletion of terms test results

The modified measurement model (deletion of terms) method, targeted factors that had low Regression weights (standard estimates/ factor loadings) <0.5 in table 20 that included:

i.	MNOBF4	Social Cultural factors	0.359 (unique factor)
ii.	MVNOLF2	Network infrastructure	0.423 (unique factor)
iii.	GALF3	Geographical area	0.383 (LR factor)
iv.	GALF4	ARPU	0.421 (LR factor)

The 4-terms were deleted to pave way for a modified measurement model with deleted terms that generated the following model fit results: Chi square=1.240, SRMR=0.059, GFI= 0.855, AGFI=0.819, NFI= 0.772, TLI=0.934, CFI=0.944, RMSEA=0.041. NFI and (A)GFI were slightly low but acceptable [204]. All the model fit indices therefore passed the test. The modified CFA diagram is given in fig.14 and the modified Measurement estimates model fit indices results are given in table 23c.

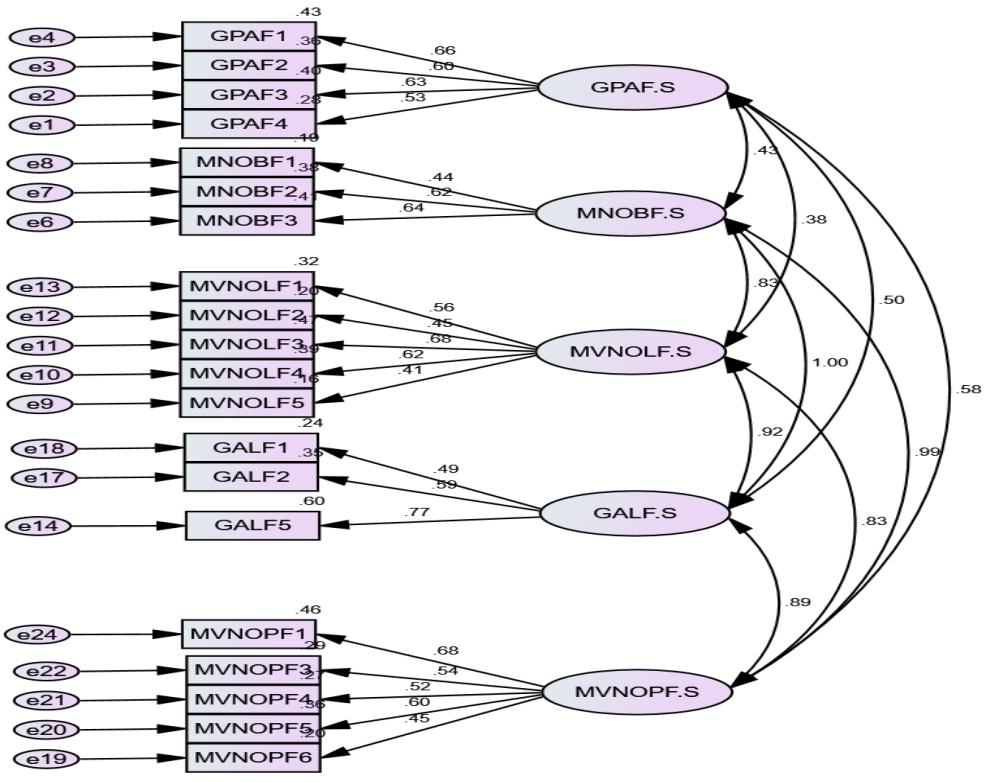


Fig 14 Modified CFA Measurement estimates model Deletion of terms

Table23a: Model fit Indices (Unmodified CFA model)			
Fit Index	**Expected N=145**	**Measured Value**	**Remarks**
Chi-Square	X^2=.05 confidence 1 - 3	326.514/145 1.232	Passed
SRMR	<0.08	0.062	Passed
GFI	>0.90	0.836	Acceptable
AGFI	>0.90	0.799	Acceptable
NFI	<0.90	0.719	Passed
TLI	>0.90	0.919	Passed
CFI	>0.90	0.929	Passed
RSMEA	>0.08	0.040	Passed
CFI is a revised form of NFI and TLI & NFI are interchangeable [204]			

Table23b: Model fit Indices (Modified CFA model MI)			
Fit Index	**Expected N=145**	**Measured Value**	**Remarks**
Chi-Square	X^2=.05 confidence 1 - 3	295.88/145 1.129	Passed
SRMR	<0.08	0.058	Passed
GFI	>0.95	0.853	Acceptable
AGFI	>0.90	0.817	Acceptable
NFI	<0.90	0.746	Passed
TLI	>0.90	0.955	Passed
CFI	>0.90	0.961	Passed
RSMEA	>0.08	0.03	Passed
CFI is a revised form of NFI and TLI & NFI are interchangeable [204]			

Table23c: Model fit Indices (Modified CFA model factor deletion)			
Fit Index	**Expected N=145**	**Measured Value**	**Remarks**
Chi-Square	X^2=.05 confidence 1 - 3	245.56/145 1.240	Passed
SRMR	<0.08	0.059	Passed
GFI	>0.95	0.855	Acceptable
AGFI	>0.90	0.819	Acceptable
NFI	<0.90	0.772	Passed
TLI	>0.90	0.934	Passed
CFI	>0.90	0.944	Passed
RSMEA	>0.08	0.041	Passed
CFI is a revised form of NFI and TLI & NFI are interchangeable [204]			

It was observed that deletion of the 4-terms did not create any significant improvement in the model fit indices, however 2-unique quality factors and 2–LR quality factors were withdrawn from the model. Secondly, deletion of 2-unique and 2-LR quality factors from the model denied the study part of the replication and contribution of unique and LR factors respectively. Thirdly, some of the factor loadings of the factors in question were not very critical to deserve deletion.

Fourthly, the deleted quality factors were validated through a thorough triangulation process of test instruments; (questionaire, interview and observation) prior to their acceptance as quality factors.

It can therefore be concluded that, Unmodified CFA Measurement Estimates Model is the best estimates model in terms of significant paths in fig 12 and model fit indices in table 23a. It produced the best diagram devoid of redundant paths and equally comparable model fit indices with the other two models (Modification by MI and modification by deletion of terms). The overall goodness of fit indices (CFI, GFI and SRMR) and badness of fit index (RMSEA) were acceptable.

4.5.4 Standardized Proposed SEM Structural model

The Standardized proposed SEM structural model referred to as the inner structural model in fig 10 related the exogenous variables and the endogenous variable as shown in fig 15. The model comprises of error terms, endogenous variables and their factors on one end and exogenous variable and its factors on the other. All the endogenous and exogenous variables were covaried and the model loaded with estimate values and tested for fitness.

It has already been established that unmodified CFA estimates model registered the best results in terms of the model significant paths and model fit indices compared to the modified model by MI and modified model by deletion of terms respectively. The unmodified CFA measurement estimates model is therefore the best candidate for the proposed SEM estimation model where no modification of any form was required. As such, a standardized proposed SEM measurement model is given in fig 15. The model was constrained with estimates and transformed into a standardized SEM measurement estimation model given in fig 16. Standardized SEM structural estimation model was then validated by comparing its result parameters (Estimates, model fit indices, covariance, Chi sq,, etc) for conformity with those of the unmodified CFA measurement Estimates model. These parameters are expected to be the same for both models.

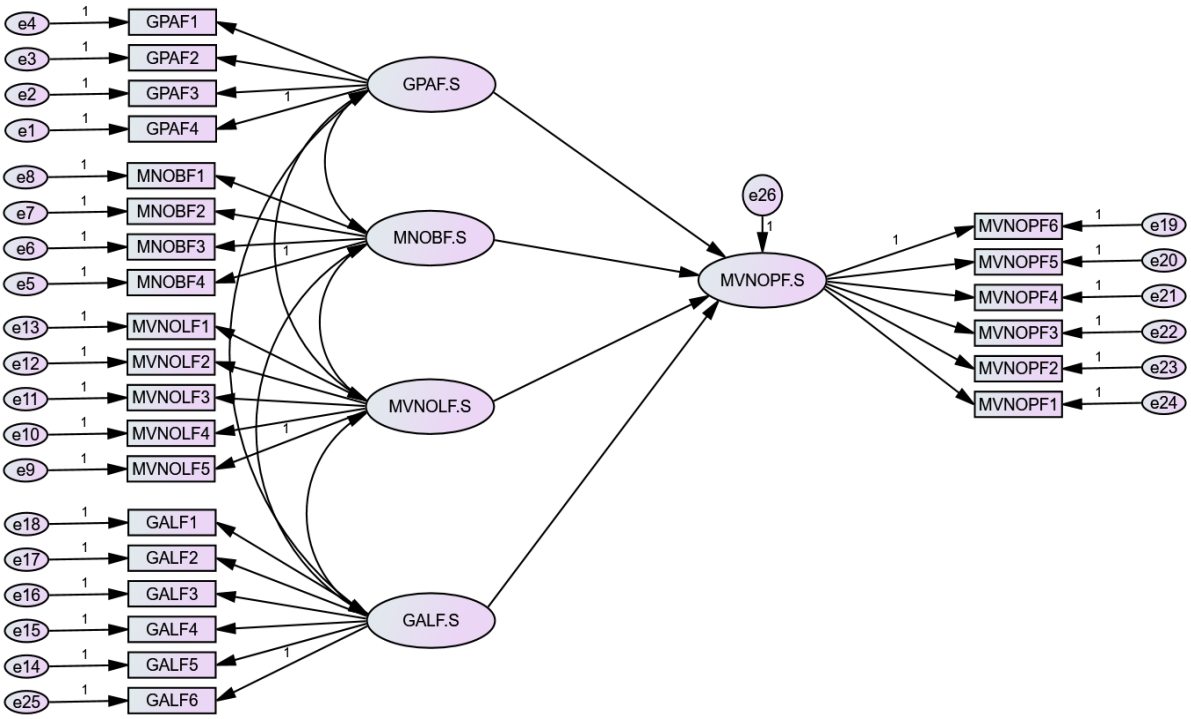


Fig.15: Proposed Standardized SEM Structural model

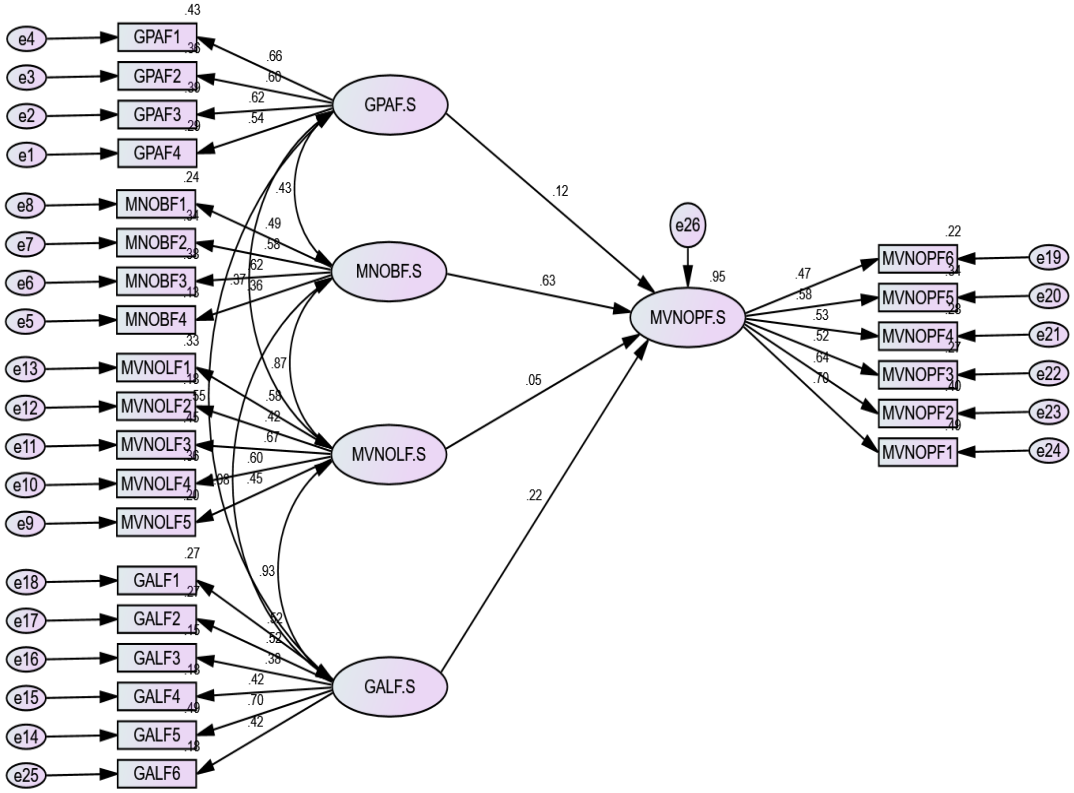


Fig 16: Standardized Unmodified SEM Structural Estimates model

4.5.5 SEM Structural Estimates model Test Results

The SEM Structural Estimates model results were used to validate itself, the CFA measurement model, the hypotheses and the MVNO implementation conceptual model

It was observed that:

i. The CFA estimates model and SEM estimates model were not modified in any way, either by modification index (MI) or by deletion of terms according to fig 12 and fig 16 respectively.

ii. The SEM and CFA estimate model results are a replica of each other as evidenced by table 24, table 25 and table 26. Model fit indices, estimates, standard error, Critical value and Chi sq values are the same, a sign of validation of the two models in terms of model parameters and model fit indices.

iii. SEM structural estimates model meets the critical value (Cr) and statistical significance threshold (p) values of (>2) and (<0.05) respectively. The model fit indices meet the threshold criteria and a replica of the CFA measurement model a further validation of direct and indirect hypotheses and by extension MVNO implementation conceptual framework.

Table 24: CFA/SEM model fit indices comparison results

Fit Index	Expected N=145	CFA model Measured Value	SEM model Measured Values	Remarks
Chi-Square	X^2=.05 confidence 1 - 3	326.514/145 1.232	326.514/145 1.232	Passed
SRMR	<0.08	0.062	0.062	Passed
GFI	>0.90	0.836	0.836	Acceptable
AGFI	>0.90	0.799	0.799	Acceptable
NFI	<0.90	0.719	0.719	Passed
TLI	>0.90	0.919	0.919	Passed
CFI	>0.90	0.929	0.929	Passed
RSMEA	>0.08	0.040	0.040	Passed
	CFI is a revised form of NFI and TLI & NFI are interchangeable [204]			

Table 25: CFA/SEM Estimates comparison results

			CFA Estimate	SEM Estimate
GPAF4	<---	GPAF.S	.542	.542
GPAF3	<---	GPAF.S	.624	.624
GPAF2	<---	GPAF.S	.597	.597
GPAF1	<---	GPAF.S	.658	.658
MNOBF4	<---	MNOBF.S	.359	.359
MNOBF3	<---	MNOBF.S	.620	.620
MNOBF2	<---	MNOBF.S	.582	.582
MNOBF1	<---	MNOBF.S	.493	.493
MVNOLF5	<---	MVNOLF.S	.452	.452
MVNOLF4	<---	MVNOLF.S	.597	.597
MVNOLF3	<---	MVNOLF.S	.670	.670
MVNOLF2	<---	MVNOLF.S	.423	.423
MVNOLF1	<---	MVNOLF.S	.578	.578
GALF6	<---	GALF.S	.421	.421
GALF5	<---	GALF.S	.697	.697
GALF4	<---	GALF.S	.421	.421
GALF3	<---	GALF.S	.383	.383
GALF2	<---	GALF.S	.519	.519
GALF1	<---	GALF.S	.519	.519
MVNOPF6	<---	MVNOPF.S	.468	.468
MVNOPF5	<---	MVNOPF.S	.581	.581
MVNOPF4	<---	MVNOPF.S	.533	.533
MVNOPF3	<---	MVNOPF.S	.516	.516
MVNOPF2	<---	MVNOPF.S	.636	.636
MVNOPF1	<---	MVNOPF.S	.700	.700

Table26: CFA vs SEM measurement models comparison test results

			CFA Model					SEM Structural Model				
			Estimate	S.E.	Cr	P	Label	Estimate	S.E.	Cr	P	Label
GPAF4	<---	GPAF.S	1.000					1.000				
GPAF3	<---	GPAF.S	1.388	.291	4.761	***	par_1	1.388	.291	4.761	***	par_1
GPAF2	<---	GPAF.S	1.185	.254	4.661	***	par_2	1.185	.254	4.661	***	par_2
GPAF1	<---	GPAF.S	1.216	.250	4.867	***	par_3	1.216	.250	4.867	***	par_3
MNOBF4	<---	MNOBF.S	1.000					1.000				
MNOBF3	<---	MNOBF.S	1.759	.444	3.965	***	par_4	1.759	.444	3.965	***	par_4
MNOBF2	<---	MNOBF.S	1.703	.438	3.885	***	par_5	1.703	.438	3.885	***	par_5
MNOBF1	<---	MNOBF.S	1.384	.379	3.648	***	par_6	1.384	.379	3.648	***	par_6
MVNOLF5	<---	MVNOLF.S	1.000					1.000				
MVNOLF4	<---	MVNOLF.S	1.354	.303	4.467	***	par_7	1.354	.303	4.467	***	par_7
MVNOLF3	<---	MVNOLF.S	1.504	.320	4.695	***	par_8	1.504	.320	4.695	***	par_8
MVNOLF2	<---	MVNOLF.S	.909	.247	3.686	***	par_9	.909	.247	3.686	***	par_9
MVNOLF1	<---	MVNOLF.S	1.113	.253	4.397	***	par_10	1.113	.253	4.397	***	par_10
GALF5	<---	GALF.S	1.563	.316	4.946	***	par_11	1.563	.316	4.946	***	par_11
GALF4	<---	GALF.S	.872	.225	3.876	***	par_12	.872	.225	3.876	***	par_12
GALF3	<---	GALF.S	.600	.164	3.652	***	par_13	.600	.164	3.652	***	par_13
GALF2	<---	GALF.S	1.252	.287	4.354	***	par_14	1.252	.287	4.354	***	par_14
GALF1	<---	GALF.S	1.111	.255	4.355	***	par_15	1.111	.255	4.355	***	par_15
MVNOPF6	<---	MVNOPF.S	1.000					1.000				
MVNOPF5	<---	MVNOPF.S	1.072	.224	4.781	***	par_16	1.072	.224	4.781	***	par_16
MVNOPF4	<---	MVNOPF.S	.989	.217	4.557	***	par_17	.989	.217	4.557	***	par_17
MVNOPF3	<---	MVNOPF.S	.917	.205	4.472	***	par_18	.917	.205	4.472	***	par_18
MVNOPF2	<---	MVNOPF.S	1.094	.219	5.002	***	par_19	1.094	.219	5.002	***	par_19
MVNOPF1	<---	MVNOPF.S	.991	.190	5.228	***	par_20	.991	190	5.228	***	par_20
GALF6	<---	GALF.S	1.000					1.000				

S.E. – Standard error
Cr –Critical value (>2)
P –Statistical significance –Chi Square (<0.05)

4.5.6 Summary of Reliability and Validity parameter results

Reliability and Validity of the test data has a great bearing on the quality of the CFA and SEM measurement estimate models. A summary of reliability and validity parameter results is given in table 27. Construct reliability (CR) is a measure of reliability and internal consistency of factors representing a construct. A threshold value of (≥0.6) is acceptable [202]. Construct reliability of exogenous variables measurement model were met as follows: General public awareness factors (GPAF.S) = 0.727, MNO barrier factors (MNOBF.S) = 0.616, MVNO limiting factors (MVNOLF.S) = 0.677 and Government Agencies limiting factors (GALF.S) = 0.690. On the other hand the endogenous variable registered the following CR value: MVNO performance

factors (MVNOPF.S) = 0.737. It is noted that Exogenous and Endogenous outer measurement models achieved the Construct reliability thresholds of (≥0.6). Therefore the constructs representing the model are acceptable.

Table 27: Summary of Reliability and Validity Results

	Estimates	Sq^2multiple Correl	Chi Sq p	$\sum Sq^2m/n$ (AVE)	√AVE	C R	CoR	CV Cond	CoV Cond	DV Cond
GPAF4 <--- GPAF.S	.542	.293	***	.368	.607	.727	.821	Model Fit Indices (Table 23a)	Chi sq <0.05	-No redundant items in Model Master Validity Table (Table 28)
GPAF3 <--- GPAF.S	.624	.389	***							
GPAF2 <--- GPAF.S	.597	.357	***							
GPAF1 <--- GPAF.S	.658	.434	***			pass				
MNOBF4 <--- MNOBF.S	.359	.129	***	.229	.479	.616				
MNOBF3 <--- MNOBF.S	.620	.384	***							
MNOBF2 <--- MNOBF.S	.582	.339	***							
MNOBF1 <--- MNOBF.S	.493	.243	***			pass				
MVNOLF5 <--- MVNOLF.S	.452	.204	***	.238	.488	.677				
MVNOLF4 <--- MVNOLF.S	.597	.357	***							
MVNOLF3 <--- MVNOLF.S	.670	.450	***							
MVNOLF2 <--- MVNOLF.S	.423	.179	***							
MVNOLF1 <--- MVNOLF.S	.578	.334	***			pass				
GALF6 <--- GALF.S	.421	.177	***	.254	.504	.690				
GALF5 <--- GALF.S	.697	.486	***							
GALF4 <--- GALF.S	.421	.177	***							
GALF3 <--- GALF.S	383	.147	***							
GALF2 <--- GALF.S	.519	.269	***							
GALF1 <--- GALF.S	.519	.270	***			pass	pass			
MVNOPF6 <--- MVNOPF.S	.468	.219	***	.334	.578	.737	.737			
MVNOPF5 <--- MVNOPF.S	.581	.338	***							
MVNOPF4 <--- MVNOPF.S	.533	.284	***							
MVNOPF3 <--- MVNOPF.S	.516	.266	***							
MVNOPF2 <--- MVNOPF.S	.636	.404	***			pass	pass	pass	pass	Pass
MVNOPF1 <--- MVNOPF.S	700	.491	***							

CR-Construct Reliability (>0.6)
CoR- Composite Reliability (>0.6)
AVE –Average Variance Extracted (>0.5)
CV – Construct Validity (Fitness indices for a construct achieved)
CoV- Convergent Validity (All terms in the measurement model statistically significant (Chi Sq <0.05)
DV – Discriminant Validity (Model free from redundant terms
Model validation – Fitness indices for the constructs achieved or Items in the measurement model statistically significant)

Exogenous outer measurement model and endogenous outer measurement model registered impressive Composite reliability values of (0.821) and (0.737) respectively, a further confirmation of the suitability of the measurement model constructs.

Construct validity (CV) is achieved when the model fit indices achieve the level of acceptance [203] as given in the unmodified CFA model of table 23a. It is noted that all the model fit indices achieved threshold values. Construct validity of the variables of the unmodified CFA measurement model were therefore established and the constructs acceptable to represent the model.

Convergent Validity (CoV) is achieved when all items in the Unmodified CFA measurement model are statistically significant [203]. The value of Chi sq (≤ 0.05) is statistically significant for all the factors representing the model as given in table 27. Convergent validity for all the factors in the unmodified CFA measurement model is established and therefore suitable to represent the model. Alternatively, Convergent Validity could also be established through Average Variance Extracted (AVE) at a threshold value of (≥ 0.5). All AVE values were below the threshold value. Convergent Validity (CoV) therefore cannot be established through AVE values in table 27.

Discriminant validity (DV) was established on the fact that Unmodified CFA and SEM measurement models in fig11 and fig 15 had significant paths free from redundant items and acceptable model fit indices. Secondly, DV was partly and not wholly established from the Master validity table 28 because the correlation between each pair of latent exogenous construct was less than 0.85 as follows: GPAF.S = 607, MNOBF.S=0.479, MVNOLF.S = 0.488, GALF.S = 0.504 and MVNOPFS = 0.578. Unfortunately, (DV) like (CoV) cannot be established from AVE low values as mentioned earlier. However the Composite reliability (CoR) of the constructs in question is impressive (0.812), the construct validity (CV) and convergent validity (CoV) are established through the model fit indices in table 23a and Chi Sq (<0.05) table 27 respectively, with no modification or deletion of terms in the measurement models. It can therefore be concluded that the discriminant validity of the latent variables is acceptable. A summary of the measurement model validity results is given in table 27.

Table 28: Master validity table – Discriminant Validity

Construct	GPAFS	MNOBFS	MVNOLFS	GALFS	MVNOPFS
GPAFS	**0.607**				
MNOBFS	0.43	**0.479**			
MVNOLFS	0.37	0.87	**0.488**		
GALFS	0.55	1.08	0.93	**0.504**	
MVNOPFS	0.54	0.97	0.86	1.03	**0.578**

Model validation is established when the model fit indices are achieved or when all the items in the measurement model are statistically significant [213]. From table27 and table 23a it is established that, all the items in the measurement model are statistically significant and the model fit indices are achieved without modification or deletion of terms respectively. It can be concluded that the unmodified CFA measurement model and the standardized SEM structural measurement model are validated and acceptable.

4.6 Hypotheses Test Results

Both Direct and Indirect hypotheses were tested separately for statistical significance (p-value <0.05) and critical value t-value >2 at 95% confidence interval) using Multivariate Linear Regression and the SEM-CFA Amos Variance Estimation methods respectively. The results were compared against thresholds levels for support or rejection of the hypotheses

4.6.1 Direct Hypotheses Test Results

The test was performed on the inner structural model of fig 10 (4-Exogenous variables and 1-Endogenous variable) using Multivariate Linear Regression method and the results recorded in table 29. The test was repeated using unmodified covariance CFA Estimates measurement model and the results generated as given in table 30. Both Multivariate Linear Regression and Covariance estimation method, supported all the 4-direct hypotheses (H_1, H_2, H_3 and H_4). All the direct hypotheses are statistically significant and supported by alternative hypothesis as follows:

Table 29: Regression method Direct Hypothesis Results

H	Regression Weights	B coef	R^2	F	t-value	p-value	Hypothesis Support
1	MNOBF.S <-> MVNOPF.S	0.626	0.391	98.337	9.917	0.000	Supported
2	MVNOLF.S <-> MVNOPF.S	1.000	1.000	-	-	-	Supported
3	GALF.S <-> MVNOPF.S	0.682	0.458	129.239	11.368	0.000	Supported
4	GPAF.S <-> MVNOPF.S	0.354	0.126	21.978	4.488	0.000	Supported
	95% confidence interval						

Table 30: Covariance Estimation Method Direct Hypotheses Results

Constructs	Estimate	S.E.	C.R.	P	Label	Hypothesis Support
MNOBF.S <--> MVNOPF.S	.176	.050	3.520	***	par_24	Supported
MVNOLF.S <--> MVNOPF.S	.228	.062	3.688	***	par_27	Supported
GALF.S <--> MVNOPF.S	.228	.061	3.710	***	par_29	Supported
GPAF.S <--> MVNOPF.S	.094	.029	3.292	***	par_30	Supported

S.E: Standard Error
C.R: Critical Value (>2)
P: P value (Statistical significance < 0.05)

H_1: MNO sourced barrier factors (MNOBF.S) have a significant effect on MVNO performance (MVNOPF.S).

H2: MVNO sourced limiting factors (MVNOLF.S) have a significant effect on MVNO performance (MVNOPF.S).

H_3: Government Agencies sourced limiting factors (GALF.S) have a significant effect on MVNO performance (MVNOPF.S).

H_4: General public sourced barrier factors (GPAF.S) have a significant effect on MVNO performance (MVNOPF.S).

It can be concluded that MNO Sourced Barriers factors (MNOBF.S), MVNO Sourced Limiting Factors (MVNOLF.S), Government Agencies Limiting Factors (GALF.S) and General Public awareness factors (GPAF.S), have a significant effect on MVNO performance (MVNOPF.S).
Use of the Regression and CFA methods is a further validation of the direct hypotheses results.

4.6.2 Indirect Hypotheses Test Results

This test was performed on both the Unmodified CFA measurement model and Unmodified SEM measurement model (fig 12 and fig 16) respectively. The test results were a replica of each other. 25-hypotheses were stated in all, out of which, 19-indirect hypotheses were derived from the exogenous variables while 6-indirect hypothesis were derived from the endogenous variable.

It can be concluded that the 25-hypotheses generated from the unmodified CFA Estimates measurement model were supported without modification or deletion of any factors as per table 31. Fourteen (14) LR quality factors were replicated in the study while Eleven (11) factors were unique to the Kenyan environment. The indirect hypotheses are therefore statistically significant and supported by their alternative hypotheses as follows:

H_1: MNO sourced barrier factors (MNOBF.S) have a significant effect on MVNO performance (MVNOPF.S)

H_{11}: *Technology integration and deployment (MNOBF1) has a significant effect on MVNO barrier factors (MNOBFS) (LR quality factor - Replicated)*

H_{12}: *Regulation enforcement (MNOBF2) has a significant effect on the MNO sourced barrier factors (MNOBFS) (Kenyan unique quality factor)**

H_{13}: *Political will to legislate (MNOBF3) has a significant effect on the MNO sourced barrier factors (MNOBFS) (Kenyan unique quality factor)**

H_{14}: *Socio-cultural factors (MNOBF4) has a significant effect on the MNO sourced barrier factors (MNOBFS) (Kenyan unique quality factor)**

H2: MVNO sourced limiting factors (MVNOLF.S) has a significant effect on MVNO performance (MVNOPF.S

H_{21}: *Regulatory framework (MVNOLF1) has a significant effect on the MVNO sourced limiting factors (MVNOLFS) (LR quality factor –Replicated*

H_{22}: *Network infrastructure (MVNOLF2) has a significant effect on the MVNO sourced limiting factors (MVNOLFS) (Kenyan unique quality factor)**

H_{23}: *MNO commercial terms (MVNOLF3) has a significant effect on the MVNO sourced limiting factors (MVNOLFS) (LR quality factor -Replicated)*

Table 31: Unmodified CFA Estimation measurement model indirect hypotheses results

		CONSTRUCTS	Estimate	S.E.	C.R.	P	Hypothesis
MNOBF4	<---	MNOBF.S	1.000				
MNOBF3	<---	MNOBF.S	1.764	.443	3.980	***	Passed
MNOBF2	<---	MNOBF.S	1.705	.437	3.899	***	Passed
MNOBF1	<---	MNOBF.S	1.325	.369	3.588	***	Passed
MVNOLF5	<---	MVNOLF.S	1.000				
MVNOLF4	<---	MVNOLF.S	1.321	.290	4.555	***	Passed
MVNOLF3	<---	MVNOLF.S	1.464	.305	4.792	***	Passed
MVNOLF2	<---	MVNOLF.S	.824	.231	3.568	***	Passed
MVNOLF1	<---	MVNOLF.S	1.082	.242	4.473	***	Passed
GALF6	<---	GALF.S	1.000				
GALF5	<---	GALF.S	1.557	.315	4.948	***	Passed
GALF4	<---	GALF.S	.835	.222	3.768	***	Passed
GALF3	<---	GALF.S	.594	.164	3.627	***	Passed
GALF2	<---	GALF.S	1.237	.285	4.336	***	Passed
GALF1	<---	GALF.S	1.121	.256	4.379	***	Passed
GPAF4	<---	GPAF.S	1.000				
GPAF3	<---	GPAF.S	1.390	.292	4.760	***	Passed
GPAF2	<---	GPAF.S	1.184	.254	4.654	***	Passed
GPAF1	<---	GPAF.S	1.218	.250	4.864	***	Passed
MVNOPF6	<---	MVNOPF.S	1.000				
MVNOPF5	<---	MVNOPF.S	1.054	.218	4.823	***	Passed
MVNOPF4	<---	MVNOPF.S	.980	.212	4.614	***	Passed
MVNOPF3	<---	MVNOPF.S	.903	.200	4.510	***	Passed
MVNOPF2	<---	MVNOPF.S	1.083	.214	5.069	***	Passed
MVNOPF1	<---	MVNOPF.S	.975	.184	5.290	***	Passed

S.E: Standard Error
C.R: Critical Value (>2)
P: P value (Statistical significance < 0.05)

H_{24} *Anti-competitive behavior by MNOs (MVNOLF4) has a significant effect on the MVNO sourced limiting factors (LR quality factor - Replicated)*

$H_{25:}$ *Untimely policy guidelines (MVNOLF5) has a significant effect on the MVNO sourced limiting factors (MVNOB*FS) *(Kenyan unique quality factor)**

H_3: Government Agencies sourced limiting factors (GALF.S) have a significant effect on MVNO performance (MVNOPFS)

H_{31}: *Business strategy (GALF1) has a significant effect on the government agencies sourced limiting factors (GALFS) (Kenyan unique quality factor)**

H_{32}: *MNO influence and dominance (GPAF2) has a significant effect on the government agencies sourced limiting factors (GALFS) (Kenyan unique quality factor)**

H_{33}: *Geographical area of operation (GPAF3) has a significant effect on the government agencies sourced limiting factors (GALFS) (LR quality factor -Replicated)*

H_{34}: *ARPU (GALF4) has a significant effect on the government agencies sourced limiting factors (GALFS) (LR quality factor -Replicated)*

H_{35}: *Existing challenges of MNO sector (GALF5) have a significant effect on the government agencies sourced factors) (Kenya unique quality factor)**

H_{36}: *CAPEX/OPEX (GALF6) has a significant effect on the government agencies sourced limiting factors (GALFS) (LR quality factor –Replicated)*

H_4: General public Awareness (GPAF.S) have significant effect on MVNO performance (MVNOPFS)

H_{41}: *Awareness of existence of MVNOs (GPAF1) has a significant effect on General Public Awareness (GPAFS) (Kenyan unique quality factor)**

H_{42}: *Awareness of the difference between MNOs and MVNOs (GPAF2) has a significant effect on the General Public Awareness (GPAFS) (LR quality factor - Replicated)*

H_{43}: *Awareness of the MVNO's role in the market (GPAF3) has a significant effect on the General Public Awareness (GPAFS) (Kenyan unique quality factor)**

H_{44}: *Awareness of the services offered by MVNOs (GPAF4) has a significant effect on the General Public Awareness (GPAFS) (Kenyan unique quality factor)**

H5: MVNO performance factors (MVNOPF.S) has a significant effect on MVNO Performance

H_{51}: *Size of the market share (MVNOPF1) has a significant effect on MVNO performance (MVNOPF.S) (LR quality factor - Replicated)*

H_{52}: *Differentiated services (MVNOPF2) has a significant effect on MVNO performance (MVNOPF.S) (LR quality factor - Replicated)*

H_{53}: *Number of niche markets (MVNOPF3) has a significance effect on MVNO performance (MVNOPF.S) (LR quality factor - Replicated)*

H_{54}: *Penetration of underserved/untapped markets (MVNOPF4) has a significant effect on MVNO performance (MVNOPF.S) (LR quality factor - Replicated)*

H_{55}: *QoE (MVNOPF5) has a significant effect on MVNO performance (MVNOPF.S) (LR quality factor - Replicated)*

H_{56}: *Level of the MVNO (MVNOPF6) has a significant effect on MVNO performance (MVNOPF.S) (LR quality factor - Replicated)*

4.7 Mediation Analysis and Test Results

Mediation analysis was conducted on 2-sets of mediators; the Stakeholders Value Chain Factors (SVCFS) and Development Phases Value Chain factors (DVCFS) as per MVNO conceptual model in fig.5. The stakeholders value chain comprised of 3-factors, namely: Good working relations (SVCF1), Level playing ground (SVCF2) and Adoption of new technologies (SVCF3) while the Development phases value chain comprised of 4-factors, namely: Managerial skills (DVCF1), Technical skills (DVCF2), content/service development skills (DVCF3) and marketing skills (DVCF4). Each of the mediators was tested against the 4-exogenous variables/endogenous variable in turn resulting in 8-CFA test diagrams, (fig 17a-17h) whose output data was generated and subjected to mediation test interpretation.

4.7.1 Mediator 1 Test Assessment (Stakeholders Value Chain Factors (SVCF.S) Assessment Diagrams

The study assessed the mediation effect of Stakeholders value Chain Factors (SVCF) with respect to:

- General Public Awareness Factors (GPAFS), and MVNO Performance Factors (MVNOPFS)
- MNO Barrier Factors (MNOBFS), and MVNO Performance Factors(MVNOPFS)
- MVNO Limiting Factors (MVNOLFS), and MVNO Performance Factors (MVNOPFS),
- Government Agency Limiting Factors (GALFS) and MVNO Performance Factors (MVNOPFS),

The mediation test diagrams are shown in figs 17a-17d

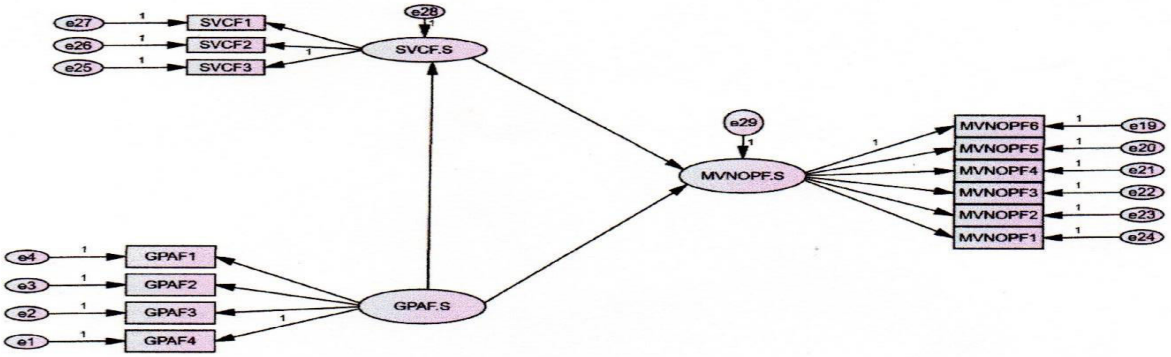


Fig 17a: GPAFS -> SVCFS -> MVNOPFS

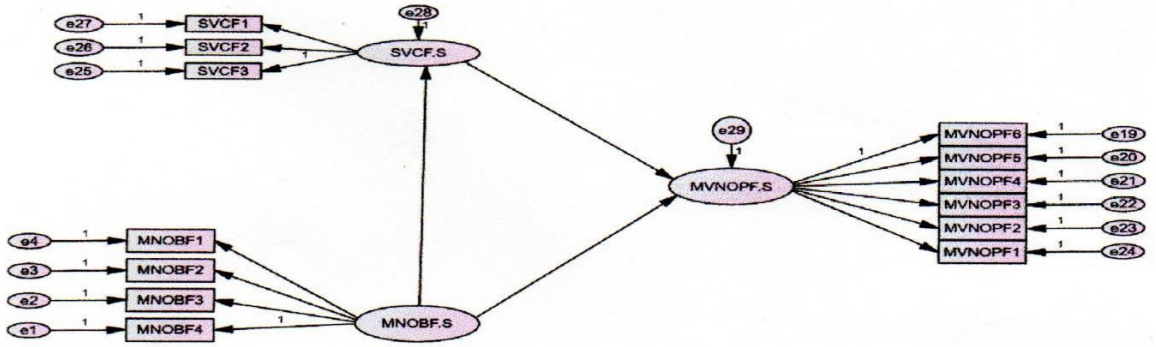


Fig 17b: MNOBFS - > SVCFS -> MVNOPFS

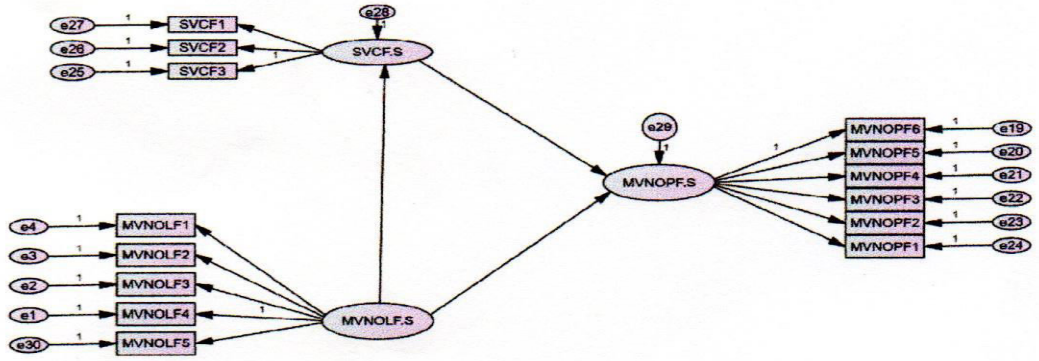


Fig 17c: MVNO ->SVCFS - > MVNOLFS

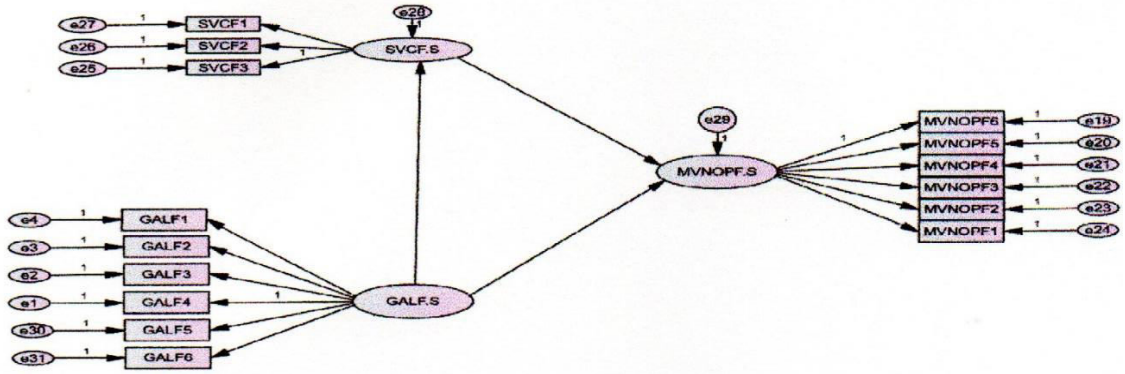


Fig 17d: GALFS ->SVCFS - > MVNOPFS

4.7.2 Mediator 2 Test assessment (Development Value Chain Factors (DVCFS) Assessment diagrams)

Likewise, the study assessed the mediation effect of Development phases value chain factors (DVCFS) with respect to:

- General Public Awareness Factors (GPAFS), and MVNO Performance Factors (MVNOPFS)
- MNO Barrier Factors (MNOBFS), and MVNO Performance Factors (MVNOPFS),
- MVNO Limiting Factors (MVNOLFS), and MVNO Performance Factors (MVNOPFS),
- Government Agency Limiting Factors (GALFS) and MVNO Performance Factors (MVNOPFS),

The mediation test diagrams are shown in figs 17e-17h

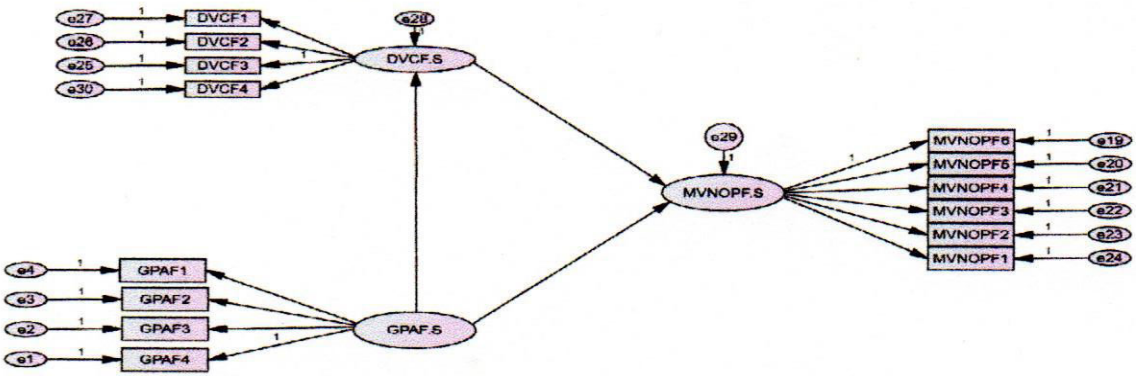


Fig 17e: GPAFS ->DVCFS -> MVNOPS

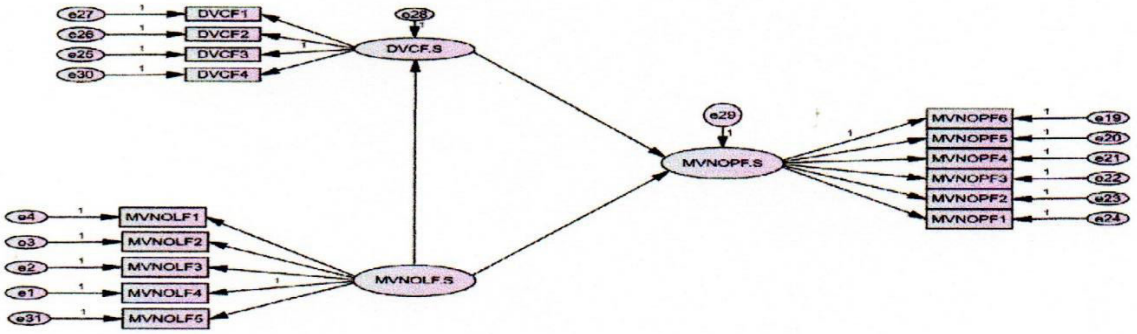


Fig 17f: MVNOBFS ->DVCFS ->MVNOPF

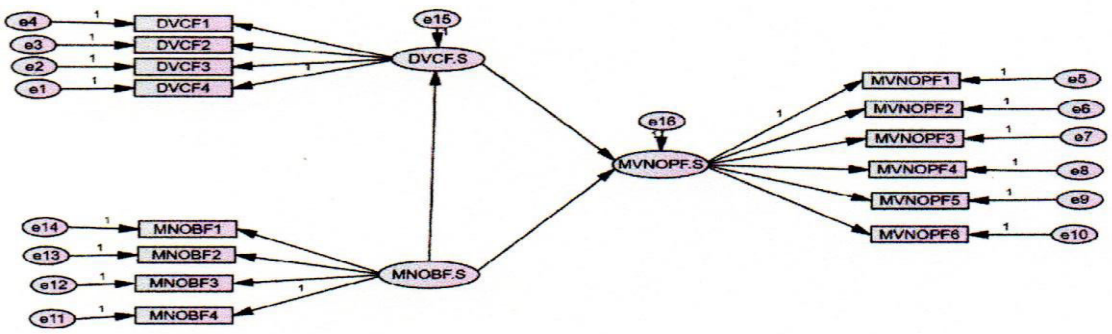


Fig 17g: MNO ->DVCFS ->MVNOPFS

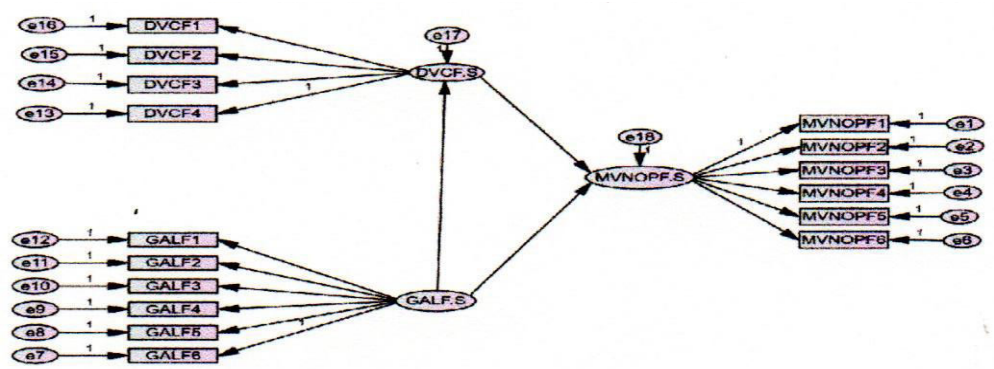


Fig 17h: GALFS -> DVCFS - >MVNOPFS

4.7.3 Mediation Test Results Interpretation

Mediation results may take 4-forms: No mediation, partial mediation, high partial mediation and full mediation. Mediation may also be complementary or Competitive mediation [206]. With no mediation, the mediator has insignificant effect on both direct and indirect paths. With partial mediation there is a significant effect on both direct and indirect paths. With high partial mediation, the mediation is more pronounce in the direct path than the indirect path with full mediation the mediator has a significant effect only on the indirect path but none on the direct path. In complementary mediation the direct and indirect paths supplement each other while in competitive mediation they oppose each other.

Mediation is established if there is no zero transition between the lower bound and the upper bound confidence intervals of the normal curve, otherwise there is mediation. Alternatively, if the p-value (t-test) is <0.05, mediation is established. Interpreted test

results are captured in table 32 for stakeholders value chain factors (SVCFS) and in table 33 for development phases value chain factors (DVCFS) respectively.

I. Mediator 1: Stakeholders Value Chain Factors (SVCFS)

Table 32: Mediation Analysis Summary-Stakeholder's value chain factors (SVCFS)

H_6	Construct Relationship	Total Effect	Direct effect	Indirect effect	Bootstrap confidence	Interval *PC	p-value	Conclusion
					Lower bound	Upper bound		
H61	GPAFS -> SVCFS ->MVNOPFS	0.744	0.333	0.410	0.121	1.075	0.037	Partial mediation
H62	MNOBFS->SVCFS->MVNOPFS	1.477	1.575	-0.099	-1.775	0.366	0.706	No mediation
H63	MVNOLFS->SVCFS>MVNOPFS	0.729	0.601	0.127	0.041	0.223	0.011	High partial mediation
H64	GALFS -> SVCFS ->MVNOPFS	1.185	1.223	-0.038	-0.905	0.221	0.787	No mediation

**PC – Percentile confidence level (95%)*

i) GPAFS -> SVCFS ->MVNOPFS fig 17a registered the following test result: Teff = 0.744, Deff = 0.333, Indeff = 0.410, ci_L = 0.121, ci_U =1,075, and p = 0.037. The p- value is 0.037 and there is no zero transition between the lower bound and the upper bound confidence intervals. Therefore Stakeholders Value chain Factors (SVCFS) has a partial mediation effect on General Public Awareness Factors (GPAFS) in the direct path (0.333) and indirect (0.410) paths respectively with respect to MVNO Performance Factors (MVNOPFS). The total mediation effect (0.744) is complementary

ii) Similarly MVNOLFS->SVCFS->MVNOPFS fig 17c registered the following test results: Teff = 0.729, Deff = 0.601, Indeff = 0.127, ci_L = 0.041, ci_U = 0.223, and p = 0.011. It is observed that p- value is 0.011and there is no zero transition between the lower bound and the upper bound confidence intervals. Therefore the Stakeholders Value chain Factors (SVCFS) have high partial mediation effect on MVNO limiting Factors (MVNOLFS) in the direct (0.601) and indirect paths (0.127) respectively with respect to MVNO

Performance Factors. The total mediation effect (0.729) is complementary.

iii) However MNOBFS->SVCFS->MVNOPFS fig.17b and GALFS-> SVCFS ->MVNOPFS fig. 17d don't meet the criteria for mediation. The p- values are (0.706) and (0.787) respectively and there is a zero transition between the lower bound and the upper bound confidence intervals. Therefore Stakeholders Value chain Factors (SVCFS) don't have a mediation effect on MNO Barrier Factors (MNOBFS) and Government Agency Limiting Factors (GALFS) with respect to MVNO Performance Factors (MVNOPFS). Therefore SVCFS effect is insignificant in the direct (1.575/1.223) and indirect (-0.099/-0.038) paths of table 32 respectively.

II. Mediator 2: Development Phase Value Chain Factors

The study assessed the mediation effect of Development Phases Value Chain Factors (DVCFS) on MNO Barrier Factors (MNOBFS), MVNO Limiting Factors (MVNOLFS), Government Agency Limiting Factors (GALFS) and General Public Awareness Factors (GPAFS) against MVNO Performance Factors (MVNOPFS). The mediation results are given in table 33:

iv) MVNOLFS->DVCFS->MVNOPF, fig 17f registered the following test results: Teff = 0.742, Deff = 0.636, Indeff = 0.106, ci_L = 0.030, ci_U = 0.179, and p = 0.038. The p-value is 0.038 and there is no zero transition between the lower bound and the upper bound confidence intervals. Therefore Development Phases value chain factors (DVCFS) have high partial mediation effect on MVNO limiting factors (MVNOLFS), in the direct (0.636) and indirect paths (0.106) respectively with respect to MVNO Performance Factors (MVNOPFS). The mediation total effect (0.742) is complementary.

v) Similarly, GALFS->DVCFS->MVNOPF, fig 17h registered the following test results: Teff = 0.737, Deff = 0.458, Indeff = 0.279, ci_L = 0.108, ci_U = 0.682, and p = 0.020. The p-value is (0.020) and there is no zero transition between the lower bound and the upper bound confidence intervals. Therefore Development Phases value chain factors (DVCFS) has partial mediation

effect on Government Agencies limiting factors (GALFS), in the direct (0.458) and indirect (0.279) paths respectively with respect to MVNO Performance Factors (MVNOPFS). The mediation total effect (0.737) is complementary.

vi) However MNOBFS->DVCFS->MVNOPFS fig.17e and GALFS->DVCFS ->MVNOPFS fig. 17g don't establish the criteria for mediation. The p- values are (0.860) and (0.722) respectively and there is a zero transition between the lower bound and the upper bound confidence intervals. Therefore Development Phases value chain factors (DVCFS) does not have a mediation effect on MNO Barrier Factors (MNOBFS) and Government Agency Limiting Factors (GALFS) with respect to MVNO Performance Factors (MVNOPFS). DVCFS effect is insignificant on MNOBFS and GALFS in the direct (1.393/1.211) and indirect (0.039/-0.027) paths in table 33 respectively.

Table 33: Mediation Analysis Summary - Development Phases Value Chain Factors

H_6	Construct Relationship	Total Effect	Direct effect	Indirect effect	Bootstrap Confidence	Interval PC/BC	p-value	Conclusion
					Lower bound	Upper bound		
H_{65}	MNOBFS->DVCFS->MVNOPFS	1.432	1.393	0.039	-0.415	0.248	0.860	No mediation
H_{66}	MVNOLFS-> DVCFS >MVNOPFS	0.742	0.636	0.106	0.030	0.179	0.038	High partial mediation
H_{67}	GALFS -> DVCFS ->MVNOPFS	1.184	1.211	-0.027	-0.274	0.099	0.722	No mediation
H_{68}	GPAFS -> VCFS ->MVNOPFS	0.737	0.458	0.279	0.108	0.682	0.020	Partial mediation

**PC – Percentile confidence level (95%)*

In summary, Stakeholders Value Chain Factors (SVCFS) and Development Phases value chain factors (DVCFS) have significant mediation effect on General public awareness factors (GPAFS) and MVNO limiting factors (MVNOLFS) with respect to MVNO performance factors (MVNOPFS) but insignificant effect on MNO barrier factors (MNOBFS) and Government Agency limiting factors (GALFS) with respect to MVNO performance factors (MVNOPFS). SVCFS and DVCFS influence General

Public Awareness Factors (GPAFS) and MVNO limiting factors (MVNOLFS) but not otherwise (MNOs and Government agencies).

Comparatively, the Stakeholders Value Chain factors (SVCFS) mediator contributes more to the indirect effect than the Development Phases Value Chain factors (DVCFS). This can be explained by the fact that SVCFS is a continuous process while DVCFS is a one-time process.

4.7.4 MEDIATION HYPOTHESES TEST RESULTS

H6: Mediation Hypothesis as stated earlier in section 2.9 has the following results as established in table 32 and table 33:

Ha61: The effect of general public awareness on MVNO performance is significant when mediated by stakeholders V-chain factors of good working relationship, level playing ground and adoption of new technologies (Accepted – partial mediation)

Ha62: The effect of MNO barriers factors on MVNO performance is significant when mediated by stakeholders V-chain factors of good working relationship, level playing ground and adoption of new technologies. (Rejected)

Ha63: The effect of MVNO limiting factors on MVNO performance is significant when mediated by stakeholders V-chain factors of good working relationship, level playing ground and adoption of new technologies. (Accepted)

Ha64: The effect of Government Agency sourced limiting factors on MVNO performance is significant when mediated by stakeholders V-chain factors of good working relationship, level playing ground and adoption of new technologies. (Rejected)

Ha65: The effect of MNO barriers factors on MVNO performance is significant when mediated by development phases value chain factors of managerial skills, technical skills, Content/service development skills and marketing skills (Rejected)

Ha66: The effect of MVNO limiting factors on MVNO performance is significant when mediated by development phase value chain factors of managerial skills,

technical skills, Content/service development skills and marketing skills (Accepted –partial mediation)

Ha67: The effect of Government agency limiting factors on MVNO performance is significant when mediated by development phases value chain factors of managerial skills, technical skills, Content/service development skills and marketing skills. (Rejected)

Ha68: The effect of general public awareness on MVNO performance is significant when mediated by development phase value chain factors of managerial skills, technical skills, Content/service development skills and marketing skills. (Accepted – High partial mediation)

It can be concluded that, out of the stated 8-mediation hypotheses in section 2.9, four were accepted and 4 rejected. The mediation of Stakeholders Value Chain Factors (SVCFS) and Development Phases Value Chain Factors (DVCFS) have a significant effect on General public awareness factors (GPAFS) and MVNO limiting factors (MVNOLFS) with respect to MVNO performance factors (MVNOPFS). On the contrary, (SVCFS) and (DVCFS) have an insignificant effect on MNO barrier factors (MNOBFS) and Government Agencies limiting factors (GALFS) with respect to MVNO performance factors (MVNOPFS).

It is further noted that, mediation by Stakeholders value chain factors (SVCFS) on General public awareness factors (GPAFS) are indirect prime movers of MVNO performance as evidenced by their significant effect (0.410) on the indirect path.

CHAPTER 5: ACHIEVEMENTS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

This chapter presents the achievements of the study by reviewing the study goal and research objectives stated earlier. The chapter evaluates how the study process addressed each of the research objectives and presented the approaches on how the objectives were achieved. The chapter underscored the achievements of the study and confirmed whether the study objectives were addressed or not. The chapter further gave the contributions of the research to theory and practice and suggested recommendations for future work and limitations of the study. The research process was guided by a research problem that formed the goal of the study and four research objectives that were stated at the beginning of the study.

The goal of the study was to assess the status of the MVNO sector in Kenya and its utilization. The four research objectives of the study are stated below as follows:

a) Assess the available MVNO differentiated services, market segments and their level of utilization.

b) Establish key determinants, facilitators and barriers to the growth of MVNOs

c) Determine key strategies for the implementation of MVNOs

d) Develop an implementation framework for MVNO startups, development and Deployment.

5.1.1 Main Research Objective

Status of the MVNO Sector in Kenya and its utilization

The mobile phone penetration in Kenya as of October – December 2023 was 129.4% with a total of 65,454.426M mobile phones of which 66.4% (33,613.828M) were smart phones and 62.9% (38,840.598 M) feature phones. Safaricom, Airtel, Telkom and Jamii Telecom are the four MNO operators in Kenya with market shares of 65.9%, 29.0%, 2.0 % and 2.3 % respectively [205]. This is a clear indication that the MNO industry in Kenya is mature, ripe and vibrant to support the MVNO sector [161], [165]. Nine MVNOs have been incubated cumulatively since 2014 that

contribute a market share of about 2.3% of the total. Ideally all the share contribution is due to Equitel MVNO, an indication that the contribution by the other MVNOs is insignificant.

Out of the nine, registered MVNOs in Kenya since 2014, six are hosted by Airtel - 67% (Equitel, Tangaza, Zioncell, Sema, Homeland Media and Lycamobile), two by Telkom - 22% (Eferio and Jambo Telecom) and one by Safaricom - 1.1% (JamboPay). Two MVNOs have since closed shop (Zioncell Kenya and Sema). Three MVNOs and one MVNE are active but not in the public domain (Homeland Media, Jambo Telecom, Lycamobile and Eferio Kenya respectively) - their share contribution in the market and broadband services are insignificant. Two MVNOs are active and in the public domain (Equitel, and JamboPay). Equitel has a market share of 2.3% and broadband services of 1.3%. Jambopay market shares are insignificant. Faiba is in a class of its own. It started as an MVNO but later upgraded to a MNO to provide VoLTE Data and SMS on Fiber Optic on a special assignment n/w band of 700 MHz. Three companies (Kenya Airways, Nakumatt and Cooperative Bank) were denied registration as MVNO by the regulator for some unknown reasons. Like Equity Bank, Cooperative Bank had high chances of success because of its banking customer base and the SACCO movement in Kenya had it been granted a licence. Two companies (Infura Limited and Hidiga Investment have their registration applications pending. A summary of registered MVNOs in Kenya is given in Table 3 together with the pending registrations and some of the unsuccessful applications.

From the study, Finserve Africa (Equitel) is the only MVNO that can be said to be alive and well with a market share of 2.3% and a broadband data share of 1.3% [205]. The rest of the MVNOs have insignificant market shares as well as broadband data shares. It can be concluded that 8 out of the 9 MVNOs (89 %) registered in Kenya are either dead, struggling to start or not performing in the market 10 years since the first MVNO launch in 2014. A total MVNO market share of 2.3% is too small for nine MVNOs in a span of ten years. Is this a case of market failure? Not really because key mother MNOs are upbeat and well save for Telkom Kenya that is struggling with compliance issues.

From the regulatory perspective, the first 3-frameworks in fig 1 are legal frameworks enacted through parliament that are general in nature. It is from the legal frameworks that regulatory frameworks are formulated. The ICT Board and Communications Authority (CA) of Kenya are

two Government Agencies responsible for formulating regulatory policy (regulations and guidelines) to regulate respective sectors in the information and communication industries as the need arises. The Kenya Information and Communications (Interconnection and Provision of Fixed Links, Access and Facilities) Regulations, 2010 [191] is a policy document spelling out general interconnectivity regulation and guidelines in the sector while the National Payment Systems Regulation, 2014 [193], heralded a formal legal framework for electronic money in Kenya. It is observed that, it takes a while before workable regulatory frameworks are formulated from legal frameworks. Interconnection and Provision of Fixed Links, Access and Facilities as a regulatory framework has not addressed issues like number portability, local loop unbundling, call termination charges and network connectivity rates. If it has, then there is a lapse in the implementation and compliance departments of the regulator. The buck stops with the regulator.

The Unified Licensing Structure Framework [158], [190] under MNOs is outdated and cannot serve the MVNO sector at this time and age. It is more of a MNO licensing framework. The framework considers MVNOs as applications within host mother MNOs and yet they are supposed to compete on the same products and services in the same networks. Mobile money interoperability is partial and skewed towards MPesa and Safaricom. More often than not, transactions have to pass through the two unnecessarily because Mobile Money Interoperability framework 2018 and its amendments are partially implemented. The National ICT policy Guidelines 2020 [192] maps the future of ICTs in Kenya with emphasis on mobile and the knowledge economy, broadband and high speed networks, universal access and infrastructure sharing, interoperability and data sharing with the onus left on CA to develop national policies to regulate the entities in the sectors. Most of the regulatory policies by the regulator have not seen the light of day. Like Pham Hai Son MVNO Framework [178] and SATRC MVNO Regulatory Framework [176], this study considers formulation and implementation of policies rules and regulations a big challenge for MVNOs in Kenya.

The current MVNO business models in the Kenyan market are not flexible enough to explore innovative services, niche, underserved/tapped market segments because of the level of the MVNOs and network limitations. Majority of the MVNOs provide reseller services save for

Equitel that is at an enhanced level to provide better services. The 4G/5G MVNO network services are available in urban areas while rural areas have to make do with 2G, 2.5G and 3G legacy networks that are limited for the services. Remote and marginalized areas are completely in the network shadow areas.

Utilization of the current MVNO space is characterized by low competition, low business returns and low market share. Penetration into niche markets, differentiated services, underserved and untapped markets is insignificant. Last mile distribution channels are not fully utilized due to content, service and network infrastructure limitations. However, despite the challenges, there is a handful of MVNO's business services that are skewed towards the financial market segment. Mobile money services, Mobile-banking services, Merchants Pay Bill, services, Business Till services, Business Pochi La Biashara services and customized services to organizations. MVNOs have also embraced un-banked population in rural areas through Sacccos and Chamas. Other suggested segments like Religious/Faith, Ethnic, and Diaspora market segments are still insignificant. Literally MVNOs and MNOs are currently competing on the same services and in the same market segments [157], [175].

All is not well in the MVNO industry in Kenya. The regulator and MVNOs must put their houses in order and mother MNOs should embrace competition and provide the necessary network support for MVNOs.

Despite the challenges, the future of MVNOs in Kenya is promising if the regulatory issue is streamlined. The latest 5G networks adopted by Safaricom, Airtel and Equitel will afford MVNOs opportunities for target and location based broadband data services such as VoLTE, M2M, IoT and IoE that are ideal for niche, underserved and untapped market segments. JamboPay under Safaricom is experimenting on M2M and IoT services.

Among the list of key observations and recommended features are:

- MVNO should be introduced as a distinct service provider with its own licensing and regulatory framework and issued a license under its own tariffs but not under a unified license with MNOs. According to Communication Authority of Kenya (CA), the MVNO

market is too small to deserve a regulatory framework on its own. This study differs, MVNOs are here to stay; they are the scalable service providers of the future for differentiated, innovative services and niche markets. They serve as market tools to preserve and stimulate competition for the markets where consolidation has resulted in reduction of number of operating MNOs.

- The MNOs are often reluctant to share spectrum with other service providers. Safaricom is a case in point that is hosting only one MVNO while the rest are hosted by Airtel and Telkom. Safaricom is the leading MNO in Kenya with the most effective network in 47 counties and the first to be 5G compliant but hosts only one MVNO (JamboPay – Feb 2022). Safaricom has the capacity to host many more MVNOs. However, they feel better off without MVNOs. Airtel is the mother of MVNOs with six MVNOs under its wings, unfortunately it is not as endowed with a good network infrastructure like Safaricom's. Telkom Kenya hosts two MVNOs and one MVNE whose services are yet to be felt in the public domain. It has a share of network and compliance issues to address before it can effectively support MVNOs. Besides, Airtel and Telkom network is absent in 14 counties that represent 50% of the total County Area in Kenya. This is a big catchment area to skip.

- Regulators need to be timely and look at the issue of whether (and to what extent) intervention is necessary. If regulators intervene, they may have to formulate policies and guidelines for access, while taking into account the effect on spectrum availability, entry into licensing framework, and license fees [176]. There is a big lapse of policy formulation for MVNOs by the regulator despite the presence of legal framework and policy guidelines

- MVNOs in Kenya have been left at the mercy of MNOs. SLAs are unfavorable. They are competing on the same products and services with MNOs. Differentiated services are minimal due to the level of MVNOs (Reseller and Hybrid). Underserved and untapped markets are unreachable due to network and infrastructure limitations and anticompetitive behaviour by some MNOs. Niche markets in the data driven services

(e.g. IOT, M2M, mobile banking and rural markets) are promising alternatives that require the intervention of the regulator.

- Entry of MVNAs/MVNEs in the Kenyan market will make the work of MVNO easier by offloading them of SLAs, licensing, billing and administrative chores such that they concentrate on their core business issues of building their portfolios. There are no operational MVNAs/MVNEs currently in the Kenyan market. One is registered (Eferio Kenya under Telkom) but it has yet to see the light of day. This again requires the intervention of the regulator.

- The regulator should engage with MNOs and other stakeholders in the fast growing digital economy of e-commerce, Fintechs, IT players AI etc. on issues related to operations of MVNOs by providing incentives to prospective MVNOs and further sensitize the general public on the role of MVNOs as a service provider.

- Finally a private body to lobby and champion the interests of MVNOs would alleviate its current situation.

5.1.2 Research objective one

Assess the available MVNO differentiated services, market segments and their level of utilization

MVNOs are about competition, service differentiation and market segmentation that is pegged on customers, community and market segments. Service differentiation hinges on value addition and innovative products while market segments thrive on untapped/underpenetrated and niche markets and depends on the breadth of the core network platform an MVNO operates and the service level agreements (SLAs) contracted with the host MNO [4].

Equitel is the most active and effective MVNO on the ground, 5G compliant with a significant market share of 2.3% and a broadband service share of 1.3%. Very little is known about the services offered by other active MVNOs save for insignificant market share of (< 0.01%) in the services they offer. With reference to table 3, it is noted that all the MVNOs are competing on similar services of voice, data, mobile money and financial services with their host MNOs. They

are also competing in the same market segments among themselves and their host mother MNOs. The level of differentiation of services and market segments is quite low. Most popular services with MVNOs were given as: mobile money services, Mobile voice services mobile data services in that order while the differentiated services were given as : M-**Banking** services, Electronic Airtime vending (all MNOs) services and Merchant Pay Bill Services. The market segments embraced or proposed for utilization by current MVNOS include:

- Financial – Provision of financial services ((money transfer, Paybill, Business tills etc)
- Business - customized services provided to business organizations
- Retail – Reseller who buys in bulk and sells in retail
- M2M – Use of technology that enables networked machines to exchange information and provide services
- MVNO/MVN E – Proposed services by Eferio Kenya (not operational)
- I o T – Internet of things proposed service by JamboPay (not operational)
- Roaming/Diaspora- Services external to the network that targets external markets

Financial, Retail and Roaming/Diaspora are the most popular market segments, while M2M, IoT and MVNO/MVNE are in the proposal stage.

Equitel and JamboPay are the only two active MVNOs that are afloat and trying. The two have cut a niche in M-Banking services, Electronic Airtime vending and Merchant Pay Bills. They have penetrated the Financial, Retail and Diaspora (Regional) market segments albeit to a small extent. Jambo Pay is a relatively new MVNO in the market and putting its house in order. It looks promising with proposals to venture into M2M and IoT market segments. It enjoys the support of Safaricom the most successful Mobile network provider in Kenya.

Tangaza offered financial services to Saccos and Chamas but its trading license was revoked back in 2021; its current status is unknown. Lycamobile Kenya, Momeland Media, Eferio Kenya and Jambo Telecoms are active but their current statuses are unknown and the services they offer are not in the public domain. Lycamobile Kenya and Homeland Media provided services in Voice and Data but they have not been in the public domain of late. Eferio Kenya had proposed a MVNE infrastructure and IoT rollout that has not seen the light of day to date. Jambo Telecoms was branded for broadband services but not traceable on the ground. It should be noted that the

five MVNOs are hosted by Airtel (Tangaza, Lycamobile Kenya, & Homeland Media) and Telkom (Eferio Kenya, Jambo Telecoms) MNOs respectively that are disadvantaged in network infrastructure in 14 Counties in Kenya. Besides, Telkom has compliance issues to sort with the Regulator. Save for Equitel, no performance statistical data is available for the other MVNOs, a sign of nonperformance of the sector. Table 34, is a summary of popular MVNO services, differentiated services and market segments in Kenya.

Table 34: MVNO Popular Services, Differentiated services and market segments in Kenya

MVNO Services	**Active MVNOs**						
Popular MVNO Services	**Equitel**	**Tangaza**	**Lycamobile Kenya**	**Homeland Media**	**Eferio Kenya**	**Jambo Telecom**	**JamboPay**
Money transfer services	✓	✓			Not public	Not public	✓
Mobile Voice services	✓	✓	✓	✓	Not public	Not public	✓
Mobile Data Services	✓	✓	✓	✓	Not public	Not Public	✓
Differentiated Services							
M-Banking Services	✓	-	-	-	-	-	✓
Electronic Airtime vending	✓	-	-	-	-	-	✓
Merchant Pay bill	✓	-	-	-	-	-	✓
Business Till	-	-	-	-	-	-	-
Business Wallets	✓	-	-	-	-	-	✓
Mobile Money Transfer	✓	-	-	-	-	-	✓
Market Segments							
Financial	✓	-	-	-	-	-	✓
Business	-	-	-	-	-	-	✓
Retail	✓	-	-	-	-	-	✓
M2M	-	-	-	-	-	-	Proposed
IoT	-	-	-	-	-	-	Proposed
Roaming/Diaspora	✓	-	-	-	-	-	✓
MVNE/MVNO		-	-	-	Proposed	-	-
Indeterminate Segments		✓	✓	✓	✓	✓	-

The differentiated services offered and market segments operated by MNOs and MVNOs were literally the same [157], [175]. Value addition and innovation are minimal or completely absent. There are many un-served/underserved market segments that are yet to be explored. Bulk of the

differentiated services are in the financial market segment. There are many more innovative services and Niche markets open to MVNOs in the areas of location based services (M2M, IoT, IoE), Knowledge economy and AI based services, High speed networks, Universal access and infrastructure sharing. Underserved and untapped market segments are still virgin and unpenetrated in rural, remote and marginalized areas, potential fertile grounds for innovative services.

In conclusion, there are no defined unique innovative services in the MVNO sector in Kenya. What there is, is a duplication of services across all the available market segments that are skewed towards financial services [193]. Underserved and untapped market segments in the rural areas are still virgin and not exploited. Niche markets are yet to be created. The biggest undoing for MVNOs is the National Payment System (NPS 2014) [193] that legalized electronic money and the Kenya Telecommunications market structure under Unified Licensing Framework (ULF), January 2016 that lumped MVNOs as applications under MNOs [158], [190]. The two legislations were enacted when MVNOs were still in the drawing boards and policies of the same unclear. Financial institutions took advantage of the legislations and started offering services that MVNOs are struggling to offer today. Mpesa, Airtel Money, T-Kash, Mobikash and all other mobile money services offered by commercial banks are part of differentiated services that should be in the list of MVNO differentiated services offer but not under financial institutions if MVNOs were to grow their portfolios. That's why Zioncell Kenya Ltd, Sema Mobile Services Ltd and Tangaza are dead and their counterparts struggling in the market today without success. How about Mpesa converting into an MVNO after breaking from Safaricom?

The silver bullet is to enhance regulatory policy for MVNOs, improve MNO network infrastructure in rural areas and enforce interoperability between MNOs and MVNOs. The National ICT policy 2020 [192] maps the future of ICTs in Kenya with emphasis on mobile and the knowledge economy, broadband and high speed networks, universal access and infrastructure sharing, interoperability and data sharing with the onus left to CA to enforce the policies and guidelines to regulate the entities in the sectors. Compliance and policy enforcement by the regulator could be an immediate panacea for MVNOs.

5.1.3 Research Objective Two

Establish key determinants, facilitators and barriers to the growth of MVNOs

Fourteen (14) LR factors were replicated in the study and eleven (11) factors were found to be unique to the Kenyan environment. Facilitators and barriers of MVNOs go hand in hand. The 25 factors therefore play a key role in facilitating or hindering the growth of MVNOs. From LR viewpoint, MVNO challenges are technical in nature among other things. Understanding and managing technology, device management, billing and cash management rank the highest challenges for MVNOs [5]. Formulation and implementation of policies, rules, and regulations is a major issue for developing nations [171]. Regulatory issues and low ARPU have been cited as the key barriers to launching of MVNOs, more so in Africa and Middle East countries [68], [69], [130]. Resistance to change by MNOs, lack of MVNE/MVNA services Lack of well formulated SLAs with core network providers, lack of innovative business services and differentiated market segments are other factors that facilitate the growth of MVNOs [7]. [69], [165], [168],

The current tragedy is that there is not a single operational MVNE/MVNA in the Kenyan market to provide technical/business consultancy services to offload MVNOs of SLA, licensing and administrative chores such that they can concentrate on the core business issues of growing their portfolios. Formulation and implementation of policies for MVNOs in Kenya is still a pipe dream. The regulatory issue for MVNOs is still outstanding. Innovative services and differentiated market segments are still far-fetched.

Secondly, MVNOs are about competition service differentiation and market segmentation. LR informs us that investing in innovative/differentiated services, venturing into niche markets and underserved/untapped market segments, increase of mobile adoption and penetration are factors that facilitate the growth of MVNOs [7]. It has been established in this study that, MNOs and MVNOs are competing on the same services and products and operating in the same market segments. The level of service differentiation is very low. Niche markets have yet to be created and the underserved/untapped market segments are yet to be ventured into in the rural, remote and marginalized areas.

Thirdly, key determinant of MVNO performance are the MVNO Business stakeholders and the MVNO personnel. It was established in this study that MVNO business stakeholders should uphold good working relations, exhibit level playing ground in their operations and embrace new

technologies as a competitive advantage. MVNO development stages of planning, development and deployment require skilled managers for planning, technical skills for development and content/service and marketing skills for deployment that has been established by this study through mediation value chain factors.

Finally, the study further established that there were eleven (11) barrier factors that were unique to the Kenyan environment, namely:

a) General public sourced barrier factors
   i. Lack of awareness of existence of MVNOs
   ii. Lack of awareness of role of MVNOs in the Kenyan market
   iii. Lack of awareness of services offered by MVNOs

The general public is the main consumer of MVNO services. Lack of awareness of MVNO existence, role and services signifies a blackout of MVNO products in the market. To the public, a MVNO is another MNO. Civic education, marketing, differentiated services and tapping into niche and new market segment would alleviate the problem.

b) MNO sourced barrier factors
   i. Regulation enforcement
   ii. Government political will to legislate
   iii. Socio-cultural factors

Regulation enforcement and Government political will to legislate are regulatory based barriers that are supposed to be solved by the Regulator. Socio-cultural factors are prevalent in remote, marginalized and some rural communities in Kenya as a result of cultural, traditional practices and nomadic lifestyles. These are barriers that can be solved by National and Regional Governments through civic education, equitable and essential services distribution, land settlement and alternative methods of livelihood.

c) MVNO sourced barrier factors
   i. Inadequate regulatory framework for MVNOs,
   ii. MNO network infrastructure

These two barrier factors are regulatory and compliance problems that can be resolved by the Regulator by giving MVNOs a separate regulatory framework from that of MNO and improving the network infrastructure in signal shadow areas for MVNO utilization.

d) Government Agencies sourced barrier factors

i. Lack of clear business strategy
ii. MNO influence and dominance
iii. Challenges of existing MNO

Lack of clear business strategy is a MVNO in-house problem, MVNO influence and dominance and Challenges of existing MNOs are compliance issues that again should be resolved by the Regulator. A summary of unique barrier factors in the Kenyan environment are given in table 15. From the foregoing, the regulator (CA), seems to carry the biggest burden and blame of non-performance of MVNOs.

5.1.4 Research Objective Three

Determine key strategies for the implementation of MVNOs

From a global perspective, the structure of the telecom industry has shifted to an open system of collaboration, communication, and co-ordination; use of standards is therefore a big strategic factor not only in the Mobile industry but also in the MNO and MVNO sectors [3], [9], [10], [77], [110], [143]. Properly negotiated service level agreements (SLAs) are a strategic business issue [7]. Cost leadership, market segmentation and service differentiation are further identified as three generic types of business strategies [12]. Proper distribution channels and a royal customer base are important strategies for MVNO survival.

The Finish industry looks at MVNO strategies as low price, narrow focus (niche), service differentiation, service reselling and international clustering [4]. MVNO deployment in Asia started with two types of strategies: the growth strategy that targeted consumers and industry and the generic strategy that targeted developed markets for economic growth [178]. The mobile telecom industry is attractive for MVNOs in terms of offering new revenue sources accepting MVNOs as business models that should claim their share of Porter's five forces framework of Suppliers, consumer demand, new entrants, substitute products and competitive rivalry [12]. Porter's five forces framework are formidable strategies for MVNOs from the business point of view. PEST Analysis [181], (Political, Economic, Social, Technological) further suggests that most of the external environment factors favour MVNO business model as fertile grounds for

consideration for suitable strategies for the MVNO sector in Kenya besides other unique strategies unveiled by this study.

Lack of clear business strategy is one unique factor that came out strongly in this study concerning MVNO in Kenya. The factor summarizes the status of MVNOs as far as implementation of strategies is concerned. Cost leadership is not a competitive feature at all. It is one of the two LR quality factors that was not replicated in this study. Cost leadership is not an entity because the MNO industry in Kenya currently is a monopoly with negligible competition from both MVNOs and other MNOs. SLA agreements as a strategy is unfavorable because of the absence of MVNAs/MVNEs and lack of guiding policies. Service differentiation, market segmentation, proper distribution channels and royal customer base are present albeit at a very low level. Standards are in force for collaboration, data sharing and interoperability but the level of compliance is questionable. Porter's five forces framework and PEST Analysis are fertile grounds for consideration for suitable strategies for MVNOs, however the extent to which they were applicable was not part of this study.

The critical success factors suggested for MVNO include: supportive regulatory policy to stimulate competition, well formulated SLA with core network providers [7], investment on innovative/differentiated services, target on niche markets, underserved/untapped market segments, and adoption of technology [165], [69]. These strategies have been found to be missing in the current crop of MVNOs; if present, they are at a very low level. The current regulatory policy is not supportive to MVNOs to stimulate competition. There are no well formulated SLA guidelines on core network providers for reference, neither are there MVNAs/MVNEs in the Kenyan market to offload MVNOs of technical and RAN agreements. MVNO differentiated services and niche markets are duplicated across the board in MNOs and financial sectors. There are still many market segments in the rural, remote and marginalized areas that are underserved and untapped.

Besides, below are five (5) quality factors that are unique to the Kenyan environment sourced from Government Agencies, the General Public and MVNOs from this study that summarize the strategic failure of MVNOs:

i) Lack of clear business strategy (GALF1) – This is a true account and observation from the regulator that MVNOs don't have a clear business strategy for their undertaking.

ii) Lack of awareness of existence of MVNOs (GPAF1) – General Public to date don't know anything about MVNOs as a service provider in Kenya. MVNOs to the public is another MNO. General public is the main customer; without them, there is no business. The marketing strategy by MVNOs as a group or individually is a complete failure.

iii) Lack of awareness of the role of MVNOs in the Kenyan market (GPAF3) – The fact that the General Public are not aware of the existence of MVNOs in the Kenyan market automatically implies that they don't know what MVNOs do. This again is a failure of marketing strategy.

iv) Lack of awareness of the services offered by MVNOs (GPAF4) – Services are branded by the supplier. If the supplier is unknown the service cannot create an impact in the market, another failure of market strategy.

v) Inadequate regulatory framework for MVNOs (MVNOLF1) – MVNOs came out strongly and expressed their views on a separate framework from that of MNOs. The Unified Licensing Framework is the biggest undoing for MVNOs that considers them an application under MNOs. A separate framework for MVNOs will do them a lot of good.

The regulator (CA) condemns MVNOs for lack of total business strategy; the general public as main customers don't know there is a service provider known as MVNO in Kenya, their role and the services they offer; conversely MVNOs want their autonomy of a separate framework. Only a third party is in a better position to arbitrate and advice on this!!

5.1.5 Research Objective Four

Develop an implementation framework for MVNOs

Open standards and frameworks have been noted as important elements that facilitate collaboration, sharing and interoperability in systems [10], [26], [42], [59], [60]. Open standards and frameworks further prevent design and development of proprietary products and services and

allow interoperability and sharing of applications/services from different providers and vendors [14], [62], [63], [137], [138]. Federal and National governments intervention is necessary where the market is least likely to provide a timely and useful answer in regard to standards, security, open access and protection of the vulnerable [154], [158], [167]. MVNOs are expected to deliver services according to national policies defined by each country's telecom regulatory body as well as international standards and practices [171]. MVNO implementation framework should therefore be a guiding standard document meant to mitigate internal and external challenges that inhibit the smooth running of the industry from the point of view of Porter's competitive strategies [12], PEST's external environment analysis [181] and other anticipated and unique challenges that may arise to the detriment of the industry.

To this end, the MVNO framework should consider but not limited to Political factors, Economic factors, Social factors, Technological factors, Environmental factors and Legal factors. Besides, it should include quality factors that have been found to work from earlier studies (LR quality factors), Study quality factors from test instruments (Questionnaire, Interview protocol/Observation protocols) and existing MVNO regulatory frameworks factors and policies relevant to the industry. Porter's competitive strategies [12], and PEST's external environment analysis [181] have been articulated extensively in other studies and are not part of this study, however they are a component of the framework because MVNOs are business models that directly subscribe to Porter's competitive strategies and PEST's external environment in their functionality.

With reference to table 19, Fifteen (15) LR quality factors were replicated in this study out of seventeen factors (17) except two, namely Cost Leadership and Government subsidy in disadvantaged areas recording a replication of 88.23%. Referring to table 12 and table 15, it is further observed that out of twenty five (25) test instrument quality factors, eleven factors (11) were unique to the Kenyan environment translating to 44% contribution (Note mediation factors are not included). These factors and their respective variables provided the backbone of the framework in this study.

As a starting reference point, Table 2 is a summary of existing Legal and Regulatory frameworks related to MNO/MVNO industry in Kenya and their relevance to MVNOs. Regulatory frameworks are formulated from legal frameworks..

i. Legal Frameworks –The legal frameworks in the table are the basis on which the Regulatory frameworks and policies were formulated. They are very general in nature and targeted the Information and Communications and the Financial and Banking institution industries. ICT Board and Communications Authority are the two key Government Agencies charged with the formulation of policy from the legal frameworks among others.

ii. The Kenya Information and communications (Interconnection and Provision of Fixed Links, Access and Facilities) Regulations, 2010. A general regulatory framework for Information and communications Industry.

iii. Telecommunications Market Structure - Unified Licensing Framework (ULF-2016). A regulatory framework for Telecommunications, Considers MVNOs as applications within MNOs. Relevant to MVNOs but for licensing purposes only.

iv. The National Payment Systems (NPS) Regulations, 2017. A regulatory interoperability framework for banking industry and financial institutions. It is somehow relevant to MNOs/MVNOs but specifically meant for commercial banks and financial institutions.

v. The National Payment Systems (NPS) Regulations, Mobile Money Interoperability, 2018. A National Mobile money Interoperability Framework for Mobile money Service providers industry. It is .relevant to MVNOs but skewed more to MNOs, commercial banks and financial institutions

vi. The National Information Communications and Technology (ICT) Policy Guidelines, 2020. These are general ICT guidelines for the ICT industry. They are relevant to MVNOs but need to be refined by the regulator to align to MVNO services among others.

vii. The Kenya National Digital Master Plan 2022-2032. This is a master plan for ICT human capital and workforce development, Integrated ICT infrastructure and Integrated information infrastructure. It is relevant to MVNO services but needs to be refined to be of better value to MVNO services.

viii. Mobile money interoperability framework by NPS 2018 Amendment 2022. It is a mobile Money Interoperability Framework 2022 (Amendment of NPS 2018). It is relevant to MNO/MVNO but favors MNOs and financial institutions more

The existing regulatory frameworks in Kenya are general frameworks meant to serve MNOs, commercial banks and other financial institutions. MVNOs are applications within MNOs. The Mobile Money interoperability frameworks have extended limited services to MNOs/MVNOs but much more needs to be done. The National ICT policy 2020 [192] and The Kenya National Digital Master Plan 2022-2032 [216] align well with MVNO services and products but there is no regulatory framework to facilitate MVNO's agenda. MVNOs should be introduced as distinct service providers with their own licensing and regulatory framework as suggested by similar studies for developing countries SATRC [176] and Pham Hai Son [178] that is further supported by findings of this study.

It can be concluded that a replication of 88.23% of LR quality factors in this study is a big contribution from earlier studies. Likewise 44% contribution of unique factors from the Kenyan environment suggests that part of the MVNO problems are internal n special attention should be paid to these unique factors to mitigate the prevailing problems by formulating domestic policies that align to the MVNO sector.

The final MVNO implementation framework should therefore include:

i. MVNO business environment of Porter's competitive strategies and PEST's external environment analysis factors
ii. General public sourced barrier factors
iii. MNO sourced barrier factors
iv. MVNO sourced limiting factors
v. Government Agencies Limiting factors
vi. MVNO performance factors
vii. MVNO value chain environment factors (Mediator)

MVNO is a business model; as such, the business environment contributes significantly in mitigating Porters 5 forces model [12], PEST analysis external environment, and SWOT analysis strategic tools [181]. They are therefore essential components of the MVNO framework, although they are not directly part of this study.

The MVNO implementation framework components (ii) to (vi) contributed the SEM study models as per fig 10. The models were transformed into measurement models through CFA AMOS for analysis as captured in fig 12, fig 13 and fig14 and assessed for model fit. The model fit indices results were impressive without modification of any form as given in table 23a, an indication that the components support the MVNO Implementation Framework.

From mediator value chain environment components; Stakeholders Value Chain Factors (SVCFS) and Development Phases value chain factors (DVCFS) in table 32 and table 33 respectively support the MVNO implementation framework.

It can therefore be concluded that: Porter's competitive strategies and PEST's external environment factors, General public sourced awareness factors (GPAFS), MNO sourced barrier factors (MNOBFS), MVNO sourced limiting factors (MVNOLFS), Government Agencies Limiting factors (GALFS), MVNO performance factors (MVNOPFS) and MVNO value chain environment factors (Mediator) support the MVNO implementation framework. The MVNO implementation conceptual framework is acceptable as given in fig 7. Respective quality factors of the framework are given in fig 6, while the key contribution of the study is given in the comparison of existing MVNO models in table 4-column 3.

5.2 Contribution of the study to knowledge and practice

Study gaps were identified during the initial proposal stages of literature review analysis. It is these research gaps that the study attempted to fill by identifying factors that influenced the performance of MVNOs and developed a model that was used to evaluate these factors to bridge the identified gaps. The new knowledge acquired after bridging the research gaps was the contributions to knowledge. This study contributed to knowledge in three different areas, methodical, theoretical and practical. The contributions are summarized in table 35

Table 35: Summary of contributions of study to knowledge and practice

	Area of Contribution		Contribution
1	**Methodology**	a.	This study was supported by ontological, epistemological and axiological worldviews of Pragmatism, Constructivism, Positivism and Ethical philosophies respectively that form the first layer of Saunders research onion [180]. MVNO in Kenya is a technological, scientific study hinged on ontological worldview that partly embraces pragmatism research philosophy whose data source is likely to change with the times as the social behavior of the people it is meant to impact changes and partly constructivism philosophy that believes social actors create social phenomena that may change the view of the past to accommodate the future. The study is also hinged on epistemological worldview that embraces positivism philosophy due to the fact that it is an emerging technology in the world (Africa/Kenya) included where its existence is not well understood and could therefore be supported by research questions that are tested against accepted knowledge. Besides, ethical issues played a key role in all stages of the study invoking axiology philosophy. The study therefore embraced mixed methods of research and design that align well with philosophical worldviews of Pragmatism paradigm.
		b.	Research strategy used mixed methods of qualitative and quantitative research approaches. Qualitative because it was partly exploratory; MVNOs were emerging business models that needed to be assessed and understood through interviews, observations and content analysis. Quantitative because it was partly descriptive; there was need to get the picture of the situation as it unfolded where questionnaires were used to sample the MVNO market. Both deductive and inductive development theory approaches were used because of the quantitative

			and qualitative nature of the data that was collected. Research Strategy of the study therefore took a multilateral approach of mixed qualitative and quantitative data collection methods using questionnaires and a triangulation of interviews, observations, and content analysis respectively. Because of the qualitative and quantitative nature of the data collected, both deductive and inductive development theories were used for data analysis.
		c.	The test instrument was a blend of research instruments - Qualitative and quantitative (questionnaire, interview, observation and documentary analysis), Multimodal communication methods were used (telephone, email and physical contact). The questionnaire test instrument was a mixer of questions (multiple choice, multilevel dropdown, likert scale, fill in and Yes & No answer questions). The CFA/SEM questionnaire (Likert scale questions) was a questionnaire within the main questionnaire test instrument. The different test methods provided a range of test scenarios and a wider scope of validating the results.
		d.	Covariance based analysis (CB-SEM) was used for data analysis because of its superior ability to analyze numerous dependent variables simultaneously, measure error and test an entire model. SPSS-AMOS SEM was found most appropriate for modeling because it was readily available in IBM SPSS, relatively easy to use and modify and needed no calculation of covariance matrices as well as performing identification checks as part of the model fitting process. Introduction of CB-SEM and SPSS – AMOS as modeling and analysis tools made the modeling, analysis and testing processes simpler despite the large amount of data involved.
		e.	The CFA estimates measudement model was tested for model fit at three different levels of testing: The Unmodified CFA Estimates Measurement Model, Modified CFA Estimates Measurement Model by modification index (MI) and Modified CFA Estimates Measurement

			Model by deletion of terms. The different levels of testing provided a comparison for the best results on model fit indices and validity of significance of the model paths. This was a comparative testing method where the best results were adopted unlike the traditional single ended testing method. Unmodified CFA Estmates Measurement Model registered good model fit indices results, that implied a strong relationships between latent variables and a simple measurement model devoid of modification on original significant paths. The other two models were compromised by invalid significant paths through modification and deleted quality factors respectively that diluted the quality of results.
2	**Theory**	a.	**LR Factor Replication:** Out of 17 LR quality factors in table 9, 15-quality factors were replicated (88%) except for two factors, a good replication contribution indeed. Cost leadership and government subsidy in disadvantaged areas were the only two LR quality factors that were not replicated by the study. The Kenyan MNO/MVNO market is currently a monopoly (Safaricom). Competition is negligible from Airtel and Equitel the only operational MNO and MVNO respectively. Therefore Cost Leadership does not apply as a competitive advantage in the Kenyan MNO/MVNO market. Furthermore MVNOs don't compete on low price, but on content, brands and service differentiation [4]. In the third world economies (Africa and Kenya included) subsidy is hard to come by. Civil society, Self - help groups and private investors play that role in the Kenyan market.
		b.	Out of the 25 quality study factors for (Independent /dependent variables) in table 13, 11-factors (44%) were unique to the Kenyan environment, while 14 factors (56%) were replicated from LR quality factors. The 44% of unique factors from the Kenyan environment is indeed a sizeable factor contribution by the study- The unique factors to the Kenyan environment (table 15) in descending

			order of priority is listed below: i) Lack of General public awareness of existence, role and services offered by MVNOs (94.7%) ii) Sociocultural factors (78.6%) iii) MNO influence and dominance (75.2 %) iv) Inadequate MNO infrastructure coverage (66.2%) v) Regulation enforcement (63.4%) vi) Government political will to legislate (63.4%) vii) Challenges of existing MNO (58.6%) viii) Lack of clear business strategy (58.6%) ix) Inadequate regulatory framework for MVNOs (47.6%) The above 9-factors are unique to the Kenyan environment. They are among the factors that are ailing the MVNO industry and a major theoretical contribution to the study.
		b-i)	**Lack of General public awareness for existence, role and services offered by MVNO**: These were three factors lumped together sourced from the General Public who are key stakeholders in the MVNO industry. The general public are not aware of the presence of MVNOs in the Kenyan market, the role they play as mobile service providers and the services they offer. Lack of awareness of MVNO products and services in the market, is akin to sounding a death knell for the MVNO industry.
		b. ii)	**Sociocultural factors:** This was a MNO sourced factor. The North Rift and North Eastern parts of Kenya are semi-arid and inhabited by pastoralist communities that are on the move the better part of the year. The area covers about 50% of the area of Kenya and occupies about 14 Counties. It is sparsely populated, remote and partly marginalized. Because of the roaming nature of nomadic communities and insecurity, mobile network infrastructure is uneconomical and challenging to provide.

		b. iii)	**MNO influence and dominance:** This was a Government Agency sourced factor. Safaricom hosts the best network in Kenya and is a dominant investor who feels better off without MVNOs. Out of 9-MVNOs, Safaricom hosts only one MVNO (very lately) while the majority are hosted by Airtel which is less endowed in network infrastructure countrywide. Safaricom is a dominant investor and the regulator has not done much to contain the situation. [194], [195].
		b. iv)	**Inadequate MNO infrastructure coverage:** Most of the population in Kenya live in the rural areas where they make do with 2G, 2.5G and 3G networks if they are lucky. 4G and 5G is the preserve of urban areas. Safaricom, Airtel and Equitel are the only service providers that have 4G/5G networks. Safaricom is the only MNO that has a reasonable network infrastructure coverage countrywide but hosts only one MVNO. Airtel the mother of MVNOs is disadvantaged in 14 counties that cover 50% of the total area in Kenya. Telkom is nowhere in the picture but struggling with compliance issues. 4G/5G networks is the way to go, if MVNO services have to become a reality in this country. The buck stops with the regulator
		b. v)	**Regulation enforcement:** This was a MNO sourced factor. The prevailing issues of MNO influence and dominance and inadequate MNO infrastructure coverage are governance issues that should be solved by the regulator. The buck stops with the regulator
		b.vi)	**Government political will to legislate:** This was the third sourced MNO factor. It is a legislative issue that may arise from arms of government due to political, economic and private individual interests (Corruption). This is a government legislative issue

		b. vii)	**Challenges of existing MNO:** This was a Government Agency sourced factor. Airtel and Telkom have had their unique challenges related to network and compliance issues respectively. These are normal in business environments but should not be allowed to persist for long period of time to the detriment of customers, who in this particular case are MVNOs meant to provide services to their customers as well. The buck stops with the regulator.
		b. viii)	**Lack of clear business strategy:** This was the third factor sourced from Government Agencies. It is a MVNO in-house management problem that should be sorted out by the MVNO. However MVNAs/MVNEs should be in a position to help when available. Unfortunately, there are none in the Kenyan market currently. This is basically MNO/MVNO in-house Challenge
		b. ix)	**Inadequate regulatory framework for MVNOs:** This was the second factor sourced from MVNOs and the elephant in the room. Telecommunications Market Structure - Unified Licensing Framework (ULF-2016) for MNOs is the current regulatory framework governing MVNOs. As an application under MNO, MVNO does not have the capacity to play a spurring role of competition and creating differentiated services/niche markets against mother MNO. It can only do that as a separate entity. Therefore, there is need for a separate framework that will give MVNO the autonomy to honour its mandate as suggested by similar studies in developing countries SATRC [176] and Pham Hai Son [178] that are further supported by findings of this study. The wisdom of the regulator (CA) however is to formulate policy after experiencing the failures. Failures are now here, let the regulatory framework follow. This is both a government legislative and a regulatory problem.

		b. x)	**Mediation:** Comparatively, the Stakeholders Value Chain factors (SVCFS) mediator contributes more to the indirect effect than the Development Phases Value Chain factors (DVCFS). Mediation by (SVCFS) on General public awareness factors (GPAFS) are indirect prime movers of MVNO performance as evidenced by their significant effect (0.410) on the indirect path.
		b. xi)	**Research Papers complete for publication:** ➢ Review of Factors Influencing the Growth of MVNOs in Kenya: Barriers and Facilitators ➢ Availability of MVNO innovative/differentiated services, market segments and their level of utilization in the Kenyan Market ➢ A Review of strategies for the implementation of MVNOs in a Developing Country
3	**Practice**	a.	**Mediators: MVNO Value Chain Environments** i) **Stake holders value chain factors (SVCFS):** Good working relations (SVCF1), Level playing ground (SVCFS2), and Adoption of new technologies (SVCF3) ii) **Development Phases value chain factors (DVCFS):** Managerial skills (DVCF1), Technical skills (DVCF2), Content/Service development skills (DVCF3) and Marketing skills (DVCF4) Stakeholders Value Chain Factors (SVCFS) and Development Phases value chain factors (DVCFS) have significant mediation effect on General public awareness factors (GPAFS) and MVNO limiting factors (MVNOLFS) with respect to MVNO performance factors (MVNOPFS) but insignificant effect on MNO barrier factors (MNOBFS) and Government Agencies limiting factors (GALFS) with respect to MVNO performance factors (MVNOPFS) - table 32 & table 33.

			General Public Awareness factors (GPAFS) and MVNO limiting factors (MVNOLFS) of the mediator assessment model are the prime movers of MVNO performance in the indirect path. Improvement of the factors results in a better MVNO performance. MNO barrier factors (MNOBFS) and Government Agencies limiting factors (GALFS) have insignificant effect in the indirect path.
		b.	**General Public Awareness factors (GPAFS) vs. mediators i) & ii) performance:** Awareness of: Existence of MVNO, Difference between MNO/MVNO, MVNO role in the Kenyan market and Services offered by MVNO when, mediated by (SVCFS) and (DVCFS), greatly improves the performance of MVNOs
		c.	**MVNO sourced limiting factors (MVNOLFS) vs mediators i) & ii) performance:** Regulatory Framework, Network infrastructure, MNO commercial terms, MVNO anti-competitive behavior and Untimely policy guidelines when mediated by (SVCFS) and (DVCFS) greatly improves the performance of MVNOs
		d.	**Overall Performance:** A combination of the direct effects of all exogenous variables and the mediator variables effects by (SVCFS) and (DVCFS) respectively on (GPAFS) and (MVNOLFS) gives the overall MVNO performance.
		e.	**SEM Assessment models and mediator test results validated the** MVNO Conceptual framework Study Factors paving way for **An Implementation Framework for MVNOs.** The MVNO study quality factors in fig 6 including mediation factors and the SEM Assessment models by Wong K. [202] given in fig 10 were extended to validate "An Implementation Framework for MVNO" given in fig 7.

		f.	**MVNO Association:** MVNO market stakeholders should be allowed to form an association to lobby and champion for their rights as suggested by [167], [175]. MVNOs in Kenya do not have such a body currently.
		g.	**MVNO Stakeholders Involvement:** MVNO key stakeholders should be involved in startups, development and deployment stages for informed decision and guidance.

5.3 Conclusions

This section summarizes the research findings as reported in the study.

5.3.1 Factors determining the performance of MVNOs

MVNO Performance is represented by 6-quality factors: The market share, Innovative/differentiated services, Niche markets, underserved/untapped market segments, QoE and Level of MVNO. The study found that the factors that determined the performance of MVNOs were associated with key stakeholders under 5-general categories:

i) **The General Public Awareness Factors:** Awareness of MVNOs, Difference between MNOs/MVNOs, The role of the MVNOs in the market and the Services offered by MVNOs.

ii) **MNO Sourced barrier Factors:** Technology deployment, Regulation enforcement, Political will to legislate and Sociocultural factors

iii) **MVNO Sourced Limiting Factors:** Regulatory framework, Network Infrastructure, MNO commercial terms, MNO anti-competitive behavior and Untimely policy Guidelines

iv) **Government Agencies Sourced Limiting Factors**: Business strategy, MVNO influence and dominance, Geographical Area, ARPU and APEX/OPEX

v) **MVNO Value Chain Environments of Stakeholders Value Chain Factors**: Good working Relationship, Level playing ground and Adoption of new technologies and **Development Phases Value Chain Factors:** Managerial Skills, Technical Skills, Content/Service Development Skills and Marketing Skills

The MVNO Performance quality factors and the key Stakeholders Sourced barrier factors is what the study refers to as "MVNO Study Factors Conceptual model" given in fig 6.

5.3.2 MVNO Conceptual Frameworks Review

The proposed SEM/CFA measurement models adopted from Wong [202] given in fig 10 together with mediator test results of figs 17a-15h given in table 32 and table 33 were used to validate MVNO study factors conceptual model and MVNO Implementation conceptual framework given in fig 6 and fig 7 respectively. It should be noted that the business environment included in the diagram was not part of this study, however since MVNOs are business models, the business environment block is automatically relevant to the framework.

5.3.3 MVNO Implementation Framework

SATRC [176] and Pham Hai Son [178] studies on **MVNO** frameworks for developing countries (South East Asia, Latin American and Africa) share a lot in common with the study. The Framework key findings are given in table 4 column 3 and unique findings to the Kenyan market further expounded in table 33. A diagram representation of the MVNO implementation framework is given in fig 7. From the foregoing, it can be concluded that the MVNO implementation framework developed in this study is useful for Kenya and generalizable for Africa and other developing countries.

5.4 Recommendations

Cost leadership [12] and Government subsidy in disadvantaged areas [171] are two LR quality factors rejected by the study. Further investigations are recommended to find out the underlying reasons in the Kenyan environment.

Stakeholders Value Chain Factors (SVCFS) and Development Phases value chain factors (DVCFS) each has insignificant effect on MNO barrier factors (MNOBFS) and Government Agencies limiting factors (GALFS) with respect to MVNO

performance factors (MVNOPFS) respectively. Out of the eight (8) hypotheses, four (4) mediator hypotheses were rejected. Further investigation is recommended on the four especially on the quality factors involved.

This study was conducted in Nairobi, Kenya (Africa) in urban, semi-urban and rural settings. Two (2) similar studies in developing countries were found that resonated well with the study [176], [178]. However no similar studies were traced for comparison purposes from African countries. Researchers are encouraged to carry out similar studies in Africa for better understanding of the MVNO sector in the region.

5.5. Limitations of the Study

Limitations to this study revolved around three areas: sample size, data collection process and access to classified data. The sample size could not be determined with certainty. To address this challenge, an acceptable margin of error of 5% was used and factored in the analysis. The data collection process had its challenges of uncooperative and unknowledgeable respondents and research assistants who were not articulate enough. To this end, consent was sought from targeted institutions prior to conducting the survey/interviews and knowledgeable managers on the subject matter were sought as respondents from targeted organizations. Research assistants were trained on the proper use of communication etiquette, the content of the test instrument and the process of conducting the survey. Managers from targeted organizations were interviewed by the researcher himself. MNOs/MVNOs are business environments that took confidentiality seriously and were suspicious of classified data falling into wrong hands. To mitigate this, secondary sources like Government Agencies, employees and friends were approached to fill in the gaps when the need arose.

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APPENDICES

APPENDIX A: DATA GATHERING INSTRUMENTS

A1: QUESTIONNAIRE

Dear Respondent,

My name is Murori Arimbi, a Doctor of Philosophy (PhD) student in the School of Computing and Informatics, Masinde Muliro University of Science and Technology (MMUST). As part of my PhD requirement, I am required to undertake an academic research study on a relevant topic. I am conducting a research study titled **"An Implementation Framework for Mobile Virtual Network Operators (MVNOs)"**

I humbly request you to participate in this research study by completing the attached questionnaire. The questionnaire will take approximately 5 minutes to complete. You are at liberty to refrain from answering any question you deem inappropriate. The data collected will be treated with utmost confidentiality and used for academic purposes only. If you choose to participate in this research study, answer all questions as honestly as possible and return the completed questionnaire as directed.

Thank you for taking time to assist me in my educational endeavors.

A1-0: LOCATION CATEGORIES

NAIROBI COUNTY								
SUB COUNTIES			MANAGERS – H/Q OFFICE					
URBAN	SEMI - URBAN	RURAL	MNO	MVNO	CA	ICT Authority	NCS	CAK
Starehe (CBD)	Kasarani	Ruiru						

A1-1: GENERAL DEMOGRAPHIC DATA (For all Respondents)

1. Check the appropriate box with a tick (√) to indicate your Gender, Age bracket, Highest education level and Occupation

Gender/Age				Education Level				Occupation		
Male	Age bracket (Years)	Female	Age bracket (Years)	Pry School	High School	College	University	Pupil/ Student	Self Employed	Professional (Employee)
	☐ 18-25		☐ 18-25							
	☐ 26-35		☐ 26-35							
	☐ 36-45		☐ 36-45							
	☐ 46-55		☐ 46-55							
	☐ >56		☐ >56							

A1-2: MVNO NETWORK AWARENESS (For all Respondents)

2. Do you own a mobile phone? YES [ ], NO [ ].
3. If your answer is YES to question 2 continue to question 4 otherwise jump to question 17
4. Is your phone a smart phone or an ordinary phone? Smart phone [ ], Ordinary phone [ ]
5. Check (√) in the appropriate box to indicate the generation of your mobile phone.

Generation of mobile phone					
2 G	3G	4G	5G	Don't know	Others (specify)

6. Who is your mobile network provider (MNO)? Check (√) in the appropriate box. (In case of more than one mobile network operator, check as appropriate).

Mobile Network Operator (MNO)				
Safaricom	Airtel	Telkom (Orange)	Jamii Telecom	Others (specify)

7. Are you aware that in addition to Mobile Network Operators (MNOs) like Safaricom, Airtel and Telkom; there are also Mobile Virtual Network operators (MVNOs) like Equitel, Tangaza etc. in the Kenyan market? YES [ ], NO [ ].
8. If your answer is YES to question 7, continue to question 9, otherwise end your Session
9. Do you know that MNOs are different from MVNOs? YES: [ ], NO: [ ].
10. Have you subscribed to any MVNO services in Kenya? YES: [ ], NO: [ ].
11. If your answer to question 10 is YES, check (√) the appropriate box for the MVNO providers you have subscribed to otherwise jump to question 15

Mobile Virtual Network Operator (MVNO)					
Finserve Africa Ltd (Equitel)	Mobile Pay Ltd (Tangaza)	Homeland Media Ltd	Eferio Kenya Ltd	Jambo Telecoms	Others (Specify)

12. Check (√) in the appropriate box for the services you have subscribed to in the MVNO provider (s)

Services Subscribed to in the (MVNO)		
Service Category	Service	Check (√)
Data Messaging services	SMS	
	Voice SMS	
	EDGE	

	GPRS	
	Seamless Roaming	
Voice Services	Voice	
	Voice mail	
	VoIP	
	VoLTE	
	Seamless Roaming	
Transactional Services	Reservation	
	Buy ticket	
	Book for services	
Financial Services	Money transfer	
	Buy goods and services	
	Pay Bill	
	Loans and savings	
Information Services	News	
	Alerts	
	Check a/c balance	
	GPS	
Entertainment Services	Music	
	Games	
	Ringtones	
Security Services	Car track	
Others (Specify)		

13. What motivated you to subscribe for services in MVNO(s)? Respond in the likert scale of 1-5 (1-Strongly agree, 5- strongly disagree)

Motivation Statement	1-Strongly agree	2-Agree	3-Undecided	4-disagree	5-Strongly disagree
Some of the services I have subscribed for are not offered by MNOs					
The services offered by MVNO(s) are comparatively cheaper					
The quality of services offered by MVNO(s) are better					
MVNO(s) provides better customer care					
It is only the MVNO who has ventured into this market segment					
It is only the MVNO who					

offers this service (product)					

14. 14a. Specify other services of your choice that are currently not offered by your MVNO that you would like to be introduced

i) ……

ii) …….

14b. The MVNO sector in Kenya is not performing. Respond in the Lickert scale of 1-5 to the statements listed below that contribute to the non-performance of the sector. (1-strongly agree, 5- strongly disagree)

Awareness factors	1-Strongly agree	2-Agree	3-Undecided	4-disagree	5-Strongly disagree
Lack of awareness of existence of MVNOs					
Lack of awareness of the difference between MVNOs and MNOs					
Lack of awareness of what MVNOs do in the Kenyan market					
Lack of awareness of services offered by MVNOs					

14c. Stakeholders play a key role in the MVNO development and performance value chain. Rate in the likert scale of 1-5 the level at which the stakeholders' factors listed below influence both the input and overall performance of MVNOs (1-strongly agree, 5- strongly disagree) (and end your Session).

Stakeholder Value Chain Factors	1-Strongly agree	2-Agree	3-Undecided	4-disagree	5-Strongly disagree
Good working relations					
Level Playing ground					
Adoption of New technologies					

15. Check (√) in the appropriate box against reason(s) why you have not subscribed to any services in MVNOs in Kenya

Reasons	Check (√)
Not aware of services offered by MVNOs	

Services offered are similar to those offered by the MNO	
Services offered are not innovative	
Services offered are not competitive in price from those of the MNO	
Services offered are not attractive	
Services offered are poorer in quality	
Services offered do not add value to my business activities	

16. Would you like to be introduced to services that are offered by MVNOs in Kenya? YES [ ], NO [ ]. (You have come to the END of your Session)

17. Check (√) in the appropriate box against the reasons why you don't own a mobile phone (and end your Session).

Reasons	Check (√)
I cannot afford a mobile phone	
Mobile phones are expensive to maintain	
Mobile phones are a source of immorality	
Owning a mobile phone will not add value to my activities	
There is no mobile network in my area	
Mobile networks are poor in my area	
I am not aware of any services offered through mobile phones	
I am illiterate, I don't know how to operate a mobile phone	
Others (Specify)	

A1-3: MNO MANAGERS (Safaricom, Airtel, Telkom and Faiba)

18. Check (√) in the appropriate box by indicating the Mobile Network Operator (MNO) you work for.

Mobile Network Operator (MNO)				
Safaricom	Airtel	Telkom	Faiba	Others (specify)

19. Do you host MVNOs in your network? YES [ ], NO [ ]
20. If your answer is YES to question 19, Check (√) against the MVNOs you host, otherwise jump to question 25

Mobile Virtual Network Operator (MVNO)					
Finserve Africa Ltd (Equitel)	Mobile Pay Ltd (Tangaza)	Homeland Media Ltd	Eferio Kenya Ltd	Jambo Telecoms	Others (Specify)

21. For the statements listed below, to what extent do you agree are reasons why you decided to host MVNOs in your network? Respond in the scale of 1 – 5 (1-Strongly agree, 5-strongly disagree)

Statement	1-Strongly agree	2-Agree	3-Undecided	4-disagree	5-Strongly disagree
MVNOs would use our idle network capacity & spectrum					
MVNOs would reach market segments that we have not been able to reach					
MVNOs would introduce new innovative services & products into our company					
MVNOs would diversify our company's business portfolio					
MVNO business partnership would improve our profit margins					
MVNOs would improve our market share and competition					
MVNO is a global business trend that we decided to try					
MVNOs were imposed on us by the regulator					

22. To what extent do you agree the statements below capture the contribution of hosted MVNOs to the mother MNO? Respond in the scale of 1 – 5 (1-Strongly agree, 5-strongly disagree)

Statement	1-Strongly agree	2-Agree	3-Not decided	4-disagree	5-Strongly disagree
MVNOs have utilized our idle network capacity and spectrum					
MVNOs have ventured into markets that were underserved and untapped by our Company					
MVNOs have introduced new differentiated services & products into the market					
MVNOs have brought more business to our organization					

MVNOs have improved our company profit margins					
MVNOs have improved our customer base and competition					
MVNOs have helped bring down the cost of services					
MVNOs have eaten into the profits of our Company					
MVNOs have become a liability to our company					

23. How do you rate the performance of the MVNO sector in Kenya: i) Good [ ], ii) Fair [ ], iii) Poor [ ].
24. If the performance rating in Q23 is poor, rate the statements listed below in the Likert scale of 1-5 that you think contribute to the poor performance of MVNOs in Kenya. (and end your session).

Reasons for non- performance of MVNOs	1-Strongly agree	2-Agree	3-Not decided	4-disagree	5-Strongly disagree
Lack of Technology integration and deployment knowhow					
Poor Regulation Enforcement					
Government political will to legislate					
Socio cultural factors					

25. To what extent do you agree is the reason why, you decided not to host MVNOs in your network? (Respond to a Likert scale of 1-strongly agree – 5 .strongly disagree.

Reasons for not hosting MVNOs	1-Strongly agree	2-Agree	3-Not decided	4-disagree	5-Strongly disagree
We have utilized our network capacity and spectrum and nothing left to support MVNOs					
No MVNO was interested to be hosted in our network					
No MVNO could meet our Service Level Agreements					
No MVNO could afford our network fees					
We were better off without MVNOs					
MVNOs would destabilize our market monopoly					
We were denied the opportunity to host MVNOs by the regulator					

We are a dominant investor in the sector & found no need to host MVNOs					
Hosting MVNOs was not our priority then but something we would consider in the future					

A1-4: MVNO MANAGERS (Equitel , Tangaza, Homeland Media, Eferio and Jambo Telecoms)

26. What MVNO do you work for? Check (√) in the appropriate box: i) Finserve Africa Ltd [ ], ii) Mobile Pay Ltd [ ], iii) Homeland Media iv) Eferio Kenya v) Jambo Telecoms iv) Other (s) Specify…….. [ ]
27. What MNO provides you with a radio access network? Check (√) in the appropriate box. i) Safaricom [ ], ii) Airtel [ ], ii) Telkom [ ]
28. To what extent do you agree the statements below are reasons why you chose the MNO as your RAN provider? Rate in the scale 1-5 (1-Strongly agree to 5- strongly disagree)

Statement	1-Strongly agree	2-Agree	3 –undecided	4-Disagree	5- Strongly disagree
This was the only MNO willing to share its network infrastructure with us					
The MNO had idle spectrum capacity in its network					
Service Level Agreements (SLA) were favorable compared to other MNOs					
The MNO required a partner to boost its revenue and customer base					
The MNO required a partner to diversify its business portfolio					
The MNO required a partner to explore new market segments and products					

29. What business services are offered by your MVNO? Check (√) the MVNO box against the appropriate service(s)

SERVICES	MVNOs					
	Finserve Africa Ltd (Equitel)	Mobile Pay Ltd (Tangaza)	H'land Media	Eferio Kenya	Jambo Telecoms	Others (Specify)

Voice services:						
• Cellphone voice call • VoIP call • VoLTE call • Voice mail						
• National Roaming						
• International roaming						
Data Messaging services:						
• SMS • EDGE • GPRS						
Financial Transactional Services:						
• Money transfer • Buy goods • Pay bills • Buy air time • Access bank account • Apply for loans						
General transactional services						
• Booking services • Reservation services						
Information Services:						
• Get news • Get alert messages • Check a/c balance • Check bill						
Entertainment Services:						
• Music • Games • Ringtones						
Security Services:						
• Car track						
• Others (specify)						

30. List three most popular services provided by your MVNO? (List in the order of priority from most popular to least popular).

	Most Popular Services
i	

ii	
iii	

31. Does your organization have differentiated (innovative) services that are not offered by your host MNO? Yes [ ], NO [ ]

32. If your answer to question 31 is Yes, Specify 3-differentiated (innovative) services offered.

	Differentiated (Innovative) Services
i	
ii	
iii	

33. What Market segment(s) does your MVNO specialize in? Check (√) box against the appropriate segment(s).

Market Segments	check (√)
Ethnic/migrant (Target ethnic communities and offer specialized services)	
Advertising (Discounted call rates/ free minutes/ text messages for adverts)	
Business (Customized service provided to business organizations)	
Discount (Mobile communication reduced call rates)	
Lifestyle (Focus on niche market demographics and offers customized service)	
Financial (Provide financial services e.g. money transfer, pay bills, etc)	
Retail (Reseller who buys in bulk and sells in retail)	
Media (Provide media related information and services)	
M2M (Use of technology that enables networked machines to exchange information and provide services)	
Gender (Gender related services targeting the youth, Aged, Challenged etc)	
Roaming/diaspora (Services external to the network that targets external markets)	
Cooperative Sacco (Cooperative Organizations, Chamas etc0	
Religion and Faith (Churches, Church Organizations, Church Chamas etc)	
Others (specify)	

34. Has your organization ventured into new market segments that are untapped or underserved by your host MNO? i) Yes [ ], ii) No [ ]

35. If your answer to question 34 is Yes, Specify any 3 such market segments
    i) ……
    ii) …….
    iii) …….

36. What level of MVNO business model does your organization operate? Check (√) the box against the appropriate business model.

	MVNO Value Added Services						
MVNO Model	Radio access	Switching &	Content and	Customer	Marketing	Sales	Check (√)

	N/w & Transmission	N/w core devices	Applications	Relationship Management & Billing	and Branding	Channel (Reseller)	
Full MVNO							
Hybrid MVNO							
Enhanced Service Provider MVNO							
Service Provider MVNO							
Thin MVNO (Reseller)							

37. Check (√) core network devices that your MVNO owns that are not contracted from the host MNO

Owned Core Network Devices					
2G - 3G Networks		(√)	4G - 5G Networks		(√)
i	MSC (Mobile switching Centre)		i	HSS (Home Subscriber Server)	
ii	HLR (Home Location Register)		ii	MME(Mobility Managmnt Entity)	
iii	VLR (Visitor Location Register)		iii	SAE (System Arch Evolution – GPRS core Network)	
iv	EIR (Equipment Identity Register)		iv	PCRF (Policy & Charging Rule Function)	
v	AuC (Authentication Center)		v	EPC (Evolved Packet Core)	
vi	SGSN (Service GPRS Support Node)		vi	VEPC(Virtualized EPC)	
vii	GGSN (Gateway GPRS Support Node)		vii	SEPC (Software defined EPC)	
viii	IMS (IP Multimedia subsystem)				
ix	MNC (Mobile N/W Code)				
x	SIM (Subscriber Identity Module)				
xi	CRM (Customer Relationship Management) and Billing system				

38. What three key areas are emphasized by the Service Level Agreement (SLA) that your MVNO has entered into with the host MNO?

i) ……

ii) ……

iii) ……

39. Rate the factors listed below in the Likert scale of 1-5 that you think are a limitation of MVNOs performance in Kenya? (1- strongly agree, 5- strongly disagree)

Limitations of MVNOs startups, development and deployment	1-Strongly agree	2-Agree	3-Not decided	4-disagree	5-Strongly disagree
Regulatory framework and policies for MVNO					
MNO network infrastructure coverage					
Unfavorable MNO commercial terms					
MNO anti-competitive behavior					
Formulation of timely policy/guidelines by regulator					

39a. MVNO development comprises of a number of phases prior to product launch. Rate in the likert scale of 1-5 the level at which you agree MVNO development value chain skills listed below influence both the input and the overall performance of MVNOs (1-strongly agree, 5 – strongly disagree)

Development Value Chain Factors (DVCFS)	1 strongly agree	2. agree	3 Not decided	4 disagree	5strongly disagree
Managerial Skills					
Technical Skills					
Content/Service Development Skills					
Marketing Skills					

A1-5: Government Agency Managers (Communications Authority (CA), ICT Authority, National Comms Secretariat (NCS) and Competition Authority of Kenya (CAK)

40. How many Mobile Network operators (MNOs) are currently licensed to operate in Kenya? [……..].
41. How many Mobile Virtual Network Operators (MVNOs) both operational and nonoperational have been licensed to operate in Kenya [.....]
42. List the names of licensed MNO and MVNO operators and check (√) the appropriate box of hosting MNOs against their respective MVNOs

LICENSED OPERATORS			Hosting MNO				
	MNOs	MVNOs	i	ii	iii	iv	v
i							
ii							
iii							
iv							
v							

43. Are all the licensed MVNOs in Q 41 operational? i) YES [ ], ii) NO [ ]
44. If the answer to Q 41 is NO, how many MVNOs are operational? […..]
45. Kindly give reasons why the licensed MVNOs are not operational.
    [……...……
    ……]
46. Are there any pending applications for companies that would like to join the MVNO sector in Kenya? YES [ ], NO [ ]

47. If the answer to question 46 is YES, please list the names of any three companies whose applications are pending.

i) …….
ii) …….
iii) …….

48. Is there a Regulatory framework in place for MNOs/MVNOs in Kenya?
YES [ ], NO [ ]

49. If the answer to Q.48 is YES please mention salient document(s) of the existing regulatory framework for MNOs/ MVNOs, otherwise, jump to Q. 50
    i) ……..
    ii) ……

50. What are the reasons for there being no regulatory framework for MNOs/ MVNOs in Kenya?
[……..
…….]

51. Does Kenya have an interoperability framework for MNO/MVNO? i) YES [ ], ii) NO [ ]

52. If the answer to Q. 51 is YES, please mention salient document(s) of the existing Interoperability framework. {……
……
……..... }

53. As a stakeholder in the telecommunication industry in Kenya, how do you rate the quality of MNO operators (SA-Safaricom, AI- Airtel, TE-Telkom, FA-Faiba) under the features given in the table below? Rate in the scale of 1-5 (1-very good…… 5-Very Poor). Check (√) the appropriate box for each MVO

Features	1-Very Good				2-Good				3-Barely Acceptable				4-Poor				5-Very Poor			
	SA	AI	TE	FA	SA	AI	TE	FA	SA	AI	TE	FA	SA	AI	TE	FA	SA	AI	TE	FA
Network Infrastructure																				
Network coverage																				
Adequacy of Services provided																				
Quality of Service (QoS)																				

Quality of Experience (QoE)																			
Preparedness to 5G migration																			

54. To what extent do you agree that lack of statutory policy listed below compromise MVNO startups, development and deployment in Kenya? Rate in the Likert scale of 1-5 (1- strongly agree,….5-strongly disagree)

Statement	**1-strongly agree**	**2-Agree**	**3-Undecided**	**4-Disagree**	**5-Strongly disagree**
MVNO Regulatory framework					
MVNO Interoperability framework					
Government Enterprise framework					
Guidelines for SLA (Service Level Agreement)					
Regulation enforcement					

55. To what extent do you agree that the features listed below influence the performance of MVNOs in Kenya? Rate in the Likert scale of 1-5 (1- strongly agree,….5-strongly disagree)

Statement	**1-strongly agree**	**2-Agree**	**3-Undecided**	**4-Disagree**	**5-Strongly disagree**
Average Revenue per User (ARPU)					
Geographical Region (Urban, Rural, Remote Areas)					
Telecom Infrastructure					
Proper implementation of technology to harness services and markets					
CAPEX (Capital Expenditure)					

56. Comment on the level of compliance of MNO industry in Kenya under the legislative policies below. Rate in the Likert scale of 1-5 (1-Excellent, …5- Extremely poor

Legislative Policy	1-Very high	2-Above Average	3-Average	4-low	5-Does not exist
Number Portability					
Call termination Charges					
Local loop unbundling					
Network connectivity rates					
Market dominance					

57. Interoperability is an important consideration for collaboration, data exchange and sharing of information between communicating systems. To what extent have standards been observed in the listed areas to facilitate Interoperability in MNOs/MVNOs and e-Government services? Respond in the Likert scale of 1-5 (1-Excellent…5- Poor)

Factors	**1-excellent**	**2-Good**	**3-Average**	**4-below Average**	**5-Extremely Poor**
General Standards					
Open standards					
International standards					
Regional standards					
National standards					
Technical Interoperability					
Radio Access Networks devices					
Switching and core network devices					
Application Software					
Semantic Interoperability					
Use of Standard formats					
Use of standard methods					
Use of standard procedures					
Use of standard practices					
Use of standard specifications					
Organizational Interoperability					
Use of standard enterprise architectures (TOGAF etc)					
Use of standard Application program interfaces (API)					
Use of standard Electronic programme Guides (EPGs)					
Use of standard Decoder Interfaces					

58. In your opinion, is the MVNO sector performing in Kenya? i) YES [ ], ii) NO [ ], iii) undecided [ ]

59. If your answer to question 58 is NO; rate the extent to which the reasons in the table below contribute to non-performance of MVNOs in Kenya. Respond in the Likert scale of 1-5 (1-srongly agree, 5-Strongly disagree)

Reason contributing to MVNO non-performance	**1.Strongly agree**	**2.Agree**	**3. undecided**	**4. Disagree**	**5.Strongly disagree**
Lack of clear business					

strategy					
MNO influence and dominance					
Geographical area of operation (Urban, rural, marginalized)					
ARPU (Poverty)					
Challenges of existing MNO sector					
Lack of CAPEX/OPEX					

60a. The factors listed below are a measure of MVNO performance in the Kenyan market. Rate them in the Likert scale of 1-5 (1- strongly agree, 5- strongly disagree)

MVNO Performance Factors (MVNOPF)	**1.Strongly agree**	**2.Agree**	**3. undecided**	**4. Disagree**	**5.Strongly disagree**
Market Share (%)					
Number of Innovative services					
Number of Niche markets					
Penetration of underserved/untapped markets (%)					
QoE (Overall user satisfaction					
Level of MVNO (Reseller – Full MVNO)					

60b. What is the future of 5G MVNOs in Kenya in terms of opportunities and barriers?

i) Opportunities: ……
……..
……..
……..

ii) Barriers: ……
……
……

A2: INTERVIEW PROTOCOL

Dear Sir/Madam

My name is Murori Arimbi, a Doctor of Philosophy (PhD) student in the School of Computing and Informatics, Masinde Muliro University of Science and Technology (MMUST). As part of my PhD requirement, I am required to undertake an academic research study on a relevant topic. I am conducting a research study titled **"An Implementation framework for Mobile Virtual Network Operators (MVNOs)"**

I humbly request you to participate in this research study by familiarizing yourself with the 15 guided interview questions listed in the table below. The interview will take approximately 20 minutes. The data collected will be treated with utmost confidentiality and used for academic purposes only. If you choose to participate in this research study, kindly give me an appointment for an interview at your earliest convenience in the month of July 2020.
Thank you for taking time to assist me in my educational endeavors.

Interview Guiding Questions

Interview Protocol Matrix

	Research Questions	Interview protocol Questions	Guiding Notes
i	What is the state of MVNO differentiated services, market segments and their level of utilization?	How would you describe the status of the MVNO sector in Kenya?	* Past, present and future
		Besides traditional services offered by MNOs, what differentiated services has the MVNO introduced in the mobile market to boost its competition and market share?	* Number of innovative services * Level of market share
		What un-served/underserved and niche markets has MVNO ventured into to boost its competition and market share?	* Number of niche and untapped markets * Level of market share
		How would you rate the level of utilization of the current services and market segments on offer?	* Lucrative services/market segments & vice versa
		Do you regard MVNOs as partners in business to host MNOs or competitors, and Why?	Reasons?
ii	What are the key facilitators, and barriers to the growth of MVNOs?	What basic phases of development did you undertake to realize an operational MVNO and what challenges did you encounter in each stage?	* Startup, * Development * Deployment
		The MVNO industry in Kenya and Africa is not performing compared to the rest of the world; what problems in your opinion is facing startups in Kenya and Africa in general?	* Challenges and barriers
		What suggestions and advice would you give to startups and government agencies tasked with formulating policy on MVNOs	* Facilitation

Iii	What are the key strategies for the implementation of MVNO?	From your experience, what do you consider as key strategies in the implementation of a vibrant MVNO industry?	* Strategies
Iv	What design components would constitute an acceptable implementation framework for MVNO	There are no clear indicators that Kenya has a regulatory framework for MVNOs, what do you consider as the reasons contributing to this?	* Political goodwill *Stakeholders goodwill
		What do you consider as the major components that should be included in the implementation of an MVNO framework?	* Framework components
V	Failed MVNOs in a span of 4-years	• Zioncell • Sema	Why the high rate of failure?
Vi	Muted MVNO Startups	• Kenya Airways • Nakumatt • Cooperative Bank • Etc.	What went wrong?
Vii	Future of MVNOs	• Kenyan Market • African market • Global market	General comments: Challenges? Success stories?
Viii	Comment on the cellular network infrastructure in Kenya	• 47 Counties • Urban Areas • Rural Areas • Remote Regions	*Fibre Optic *Wireless *Satellite *Others

61. Detailed Interview Protocol guiding questions

a. How would you describe the status of the MVNOs in Kenya?

b. What innovative services has your MVNO introduced into the Kenyan market?
c. What underserved, un-served and niche market segments is your MVNO operating in?
d. What reasons can you give for nonperformance of MVNOs in Kenya and Africa?
e. What suggestions and proposals would you give to government agencies tasked with formulation of policy for a better MVNO sector?
f. What basic phases of development did you undertake to realize an operational MVNO and what challenges did you encounter in the process
g. What key strategies do you consider suitable for the implementation of a vibrant MVNO sector in Kenya?
h. MVNOs in Kenya are grouped as Applications under MVNOs, why doesn't Kenya have an MVNO framework just like one for MNOs?
i. What in your opinion should comprise the main components of an MVNO framework?

j. What do you consider as the main cause of the high rate of MVNO turnover in Kenya?
k. Give your opinion of the future of MVNOs in Kenya, Africa, and global market.
l. How would you compare the status of the wireless network infrastructure in urban, rural and remote areas of Kenya?
m. What social and cultural factors do you feel are contributing negatively to the MVNO sector in Kenya?
n. How do you rate the level of utilization of services and market segments currently on offer?
o. Do you regard MVNOs as partners in business to host MNOs or competitors, and why?

A3: Observation Protocol

Dear Sir/Madam

My name is Murori Arimbi, a Doctor of Philosophy (PhD) student in the School of Computing and Informatics, Masinde Muliro University of Science and Technology (MMUST). As part of my PhD requirement, I am required to undertake an academic research study on a relevant topic. I am conducting a research study titled **"An Implementation framework for Mobile Virtual Network Operators (MVNOs)"**

I humbly request to be allowed to visit your organization for the purpose of making an observation on your MVNO infrastructure for the benefit of this research study in the thematic areas listed below. My visit will be brief and may take about 30 minutes. You are at liberty to choose the areas I may visit and the documentation I may collect. The data collected will be treated with utmost confidentiality and used for academic purposes only. If you choose to allow me to pay you a visit for the purpose of this research study, kindly give me an appointment for the visit at your earliest convenience in the month of July 2020.

Thank you for taking time to assist me in my educational endeavors.

Thematic Areas for Observation

a) Network and core device infrastructure
   - Level of MVNO
   - Hosted network infrastructure (Spectrum)
   - In house core infrastructure
   - Use of standards; both hardware and software (In house infrastructure)
   - Network coverage – Urban/Rural/Remote areas (statistical data?)
   - Quality of service/Experience (QoS)/QoE – statistical data?
   - Technological trends and readiness for (4G, 5G and beyond)

b) Regulatory Policy
   - MNO/MVNO framework - Documents?
   - Service Level Agreements (SLA) - Documents?

c) Market penetration and share
   - Innovative services, Niche markets, Penetration of un-served/underserved Market segments

62. Detailed Observation Protocol Guiding factors

1. Level of MVNO (Levels 1- Resellers, 2, 3, 4, 5 - Full MVNO)
   Determining factors:
   a. Geographical region of service (Urban, Rural, Remote)
   b. Hosting MNO Network Infrastructure in service area (Safaricom, Airtel, Telkom)
   c. In house core devices infrastructure
2. Network coverage

Determining factors

a. Geographical region of service (Urban-, Rural, Remote)
b. Hosting MNO Network Infrastructure in service area (Safaricom, Airtel, Telkom):
c. Type of License (License category)

3. QoS and QoE

   Determining factors:

   a. Geographical region of service (Urban, Rural, Remote)
   b. Hosting MNO network infrastructure in the service area (Safaricom, Airtel, Telkom)
   c. Generation of Network (4G, 3G, 2G)

4. Interoperability

   Determining factors

   a. Use of standards (Technical, semantic, organizational)

5. Regulatory Policy

   Determining factors:

   a. Regal framework
   b. Information and Communication Policy framework (MNO and MVNO)
      i. Service Level guidelines
      ii. Licensing guidelines
      iii. Compliance guidelines
      iv. Competition and conflict resolution guidelines

6. Market penetration and share

   Determining factors:

   a. Geographical region of service (urban, rural, remote)
   b. Average revenue per user (ARPU)
   c. Innovative services
   d. Niche, underserved and un-served market segments

A4: SEM-CFA ASSESSMENT QUESTIONNAIRE

(Note: Retrieved from the main questionnaire)

A4-1 GENERAL DEMOGRAPHIC DATA (For all Respondents)

1. Check the appropriate box with a tick (√) to indicate your Gender, Age bracket, Highest education level and Occupation

Gender/Age					Education Level				Occupation		
Male	Age bracket (Years)		Female	Age bracket (Years)	Pry School	High School	College	University	Pupil/ Student	Self Employed	Professional (Employee)
		18-25		18-25							
		26-35		26-35							
		36-45		36-45							
		46-55		46-55							
		>56		>56							

INPUT SIDE – (Independent Variables)

A4-2 MVNO AWARENESS (For all Respondents –General Public)

Q14b. The MVNO sector in Kenya is not performing. Respond in the Likert scale of 1-5 to the statements listed below, that you think contribute to the non- performance of the sector (1- strongly agree, 5- Strongly disagree)

	Factors	1- strongly agree	2. Agree	3 undecided	4 disagree	5 strongly disagree
1	Lack of awareness of existence of MVNOs					
2	Lack of awareness of the difference between MVNOs and MNOs					
3	Lack of awareness of what MVNOs do in the Kenyan market					
4	Lack of awareness of services offered by MVNOs					

A4-3 MNO MANAGERS, STAFF AND OUTLETS (Safaricom, Airtel and Telkom)

Q24. If your performance rating for MVNOs in Q23 is poor, rate the statements listed below in the Likert scale of 1-5 that you think contribute to the poor performance of MVNOs in Kenya. (1- strongly 3agree – 5-strongly disagree

	Factors	1-strongly agree	2. Agree	3 undecided	4 disagree	5 strongly disagree
1	Lack of technology deployment know how					
2	Skewed regulation enforcement					
3	Lack of government political will to legislate					
4	Social and cultural factors					

A4-4: MVNO MANAGERS, STAFF AND OUTLETS (Equitel, Tangaza, Eferio)

Q39. Rate the factors listed below in the Likert scale of 1-5 that you think are a limitation of MVNO startups, development and deployment. (1-strongly agree – 5 –strongly disagree)

	Factors	1-strongly agree	2. Agree	3 undecided	4 disagree	5 strongly disagree
1	Inadequate regulatory framework and policies for MVNOs					
2	Inadequate MNO infrastructure n/w coverage					
3	Unfavorable commercial terms					
4	MNO anti - competitive behavior					
5	Lack of timely policy/guidelines formulation					

A4-5: GOVERNMENT AGENCIES MANAGERS AND STAFF (Communications Authority (CA), ICT Authority, National Communication Secretariat (NCS) and Competition Authority of Kenya (CAK)

Q59. If your answer to question 58 is NO; rate the extent to which the reasons in the table below contribute to non-performance of MVNOs in Kenya. Respond in the Likert scale of 1-5 (1-srongly agree, 5-Strongly disagree)

	Factors	1-strongly agree	2. Agree	3 undecided	4 disagree	5 strongly disagree
1	Lack of clear business strategy					
2	MNO influence and dominance					
3	Geographical Area of operation (urban, Rural, marginalized areas)					
4	ARPU					
5	Challenges of existing MNO sector					
6	Lack of CAPEX/OPEX					

OUTPUT SIDE – (Dependent Variables)

A4-6: MVNO Performance factors

Q60a. The factors listed below give a measure of MVNO performance in the Kenyan market. Rate them in the lickert scale of 1-5 (1-strongly agree, 5 – strongly disagree)

	MVNO Performance Factors (MVNOPFS)	1-strongly agree	2. Agree	3 undecided	4 disagree	5 strongly disagree
1	Market share (%)					
2	Number of Innovative services					
3	Number of Niche Markets					
4	Penetration of underserved/untapped markets (%)					
5	QoE (Overall user satisfaction)					
6	Level of MVNO (Reseller – Full MVNO)					

QA4-7: Mediators – MVNO Value Chain Environments

Q14c. Stakeholders play a key role in the MVNO development and performance value chain. Rate in the likert scale of 1-5 the level at which the stakeholders' factors listed below influence both the input and overall performance of MVNOs (1-strongly agree, 5- strongly disagree)

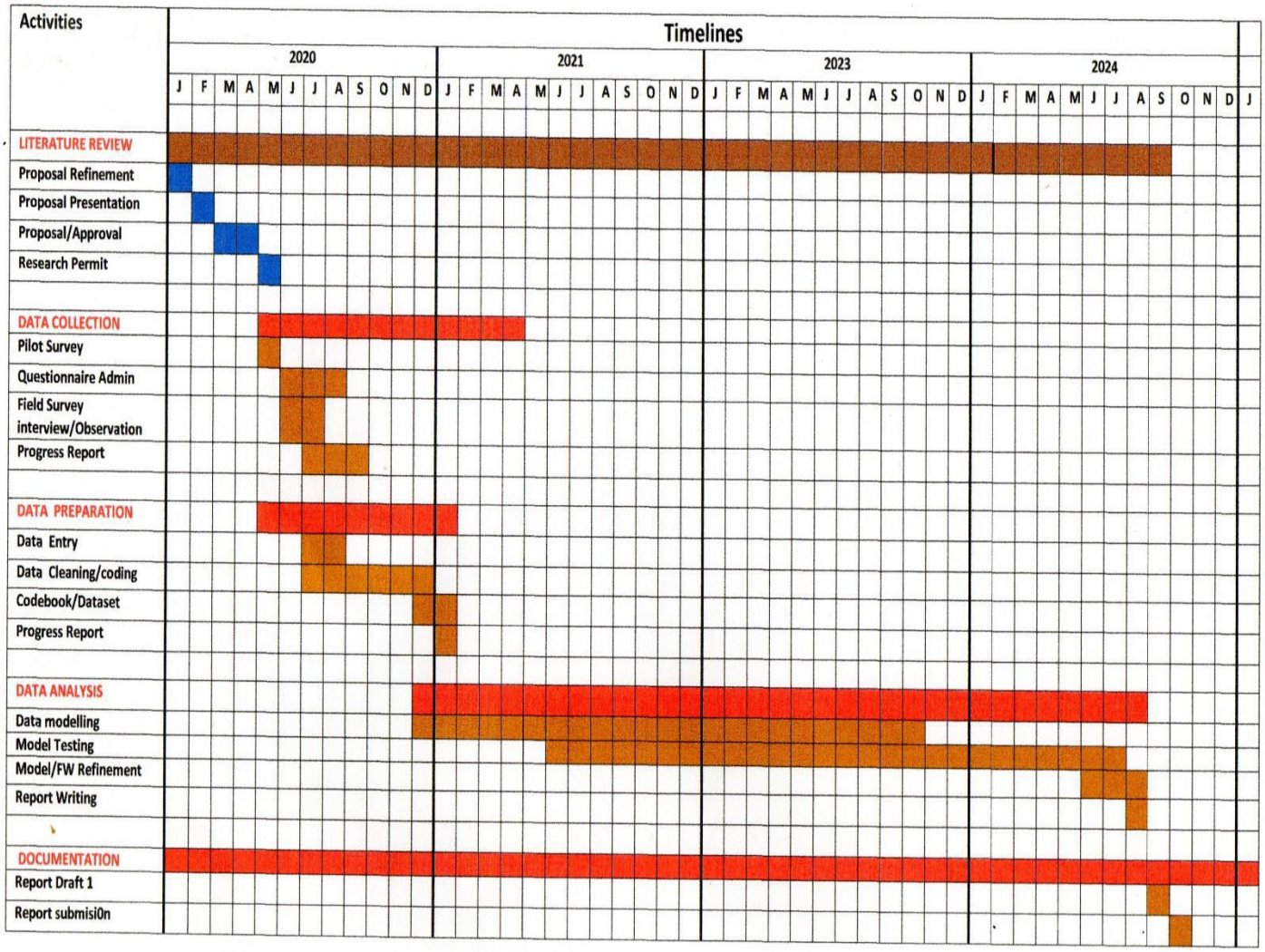
Stakeholder Value Chain Factors (SVCFS)	1-Strongly agree	2- Agree	3-Undecided	4-disagree	5-Strongly disagree
Good working relations					
Level Playing ground					
Adoption of New technologies					

Q39a. MVNO development comprises of a number of phases prior to product launch. Rate in the likert scale of 1-5 the level at which you agree MVNO development value chain skills listed below influence both the input and the overall performance of MVNOs (1-strongly agree, 5 – strongly disagree)

Development Phases Value Chain Factors (DVCFS)	1 strongly agree	2. agree	3 Not decided	4 disagree	5strongly disagree
Managerial Skills					
Technical Skills					
Content/Service Development Skills					
Marketing Skills					

APPENDIX B: WORK PLAN AND BUDGET

B1: WORK PLAN



B2: BUDGET

ACTIVITIES	DESCRIPTION	Cost KSh.
Document exploration		
Journal Papers subscription	@ Ksh. 10,000 per year for three years	30000
Library Services	@ Ksh. 5000 per year for three years	15000
Internet Services	@ Ksh. 1000 per month for 36 months	36000
Cell phone Airtime	@ Ksh. 500 per month for 36 months	18000
	Sub Total	**99,000**
Field Intervention		
Questionnaire administration Interview/Observation Admin	• Subsistence for three people (3 research assistants) for 14-days at Ksh 1500 pay day (3x14x1500) • Transport @ Ksh 2000 per day for 14 days (14x2000) • Main Researcher @ Ksh 3500 Per day for 14-days (2x14x5000)	63000 28000 49000
	Sub Total	**140,000**
Equipment and Tools		
Laptop	Duo core 3Ghz processor, 12 GB RAM, 150 GB HDD	80000
Software Application Licenses & network tools	• OS-MS Win 10 (licence) • Antivirus (Kaspersky latest version) @ Ksh 6000 per yr for 3yrs (license) • Network test tools • SPSS Licence + training • IBM AMOS training	12000 18000 15000 40000 30000
Mobile phon/camera/AudioTape	• Mobile phone , Digital Camera/Audio tape all in one	50,000
	Sub Total	**185,000**
Data Analysis		
Data entry, Data Cleaning, Data test runs	Hire 2-research assistants for data entry and test runs @ Ksh 3500 for 7-days (2x7x3500)	49000
Data Analysis –Research Asst.	Hire2-research assistant for test runs @ Ksh. 3500 for 7-days (2x7x3500)	49000
Data Analysis Researcher	Researcher - Test run result checks @ksh 10,000/- for 7days (1x7x5000)	70,000
	Sub Total	**133,000**
Framework Development		
Graphical development	Hire -1 graphical design assistant @ Ksh 3500 per day for 7 days (1 x7x3500)	24,500
	Sub Total	**24,500**
Final Report		
Stationery/Photocopy	@ Ksh. 3000 quarterly for three years	27,000
Report Typing		10,000
Report editing		6,000
Report proofreading/format		5,000
Report Binding		5,000
	Sub Total	**53,000**
Funding	**NIL**	**00**
	TOTAL	**639,500**
	10 % CONTIGENCIES	**63,950**
	GRAND TOTAL	**703,450**

APPENDIX C: THEMATIC FRAMEWORKS

C1: Interview Thematic Framework

Table CI: Interview Thematic Framework

	Research Questions	Themes	Codes (Sub Themes)
1	What is the state of MVNO differentiated services, market segments and their level of utilization?	MVNO current status	1. Low business and low market share but sector promising 2. Zioncell and Sema MVNOs failed within 3yrs of launch 3. Kenya Airways, Nakumatt and Cooperative Bank were aspiring MVNOs that never saw the light of day 4. Operational, original MVNOs: Equitel and Tangaza 5. Status of Jamii Telecom (Faiba) is unknown, it is neither an MNO nor an MVNObut operational (declined our interview and questionnaire) 6. New entrants in the market in the last 2 yrs:: Homeland Media, Eferio Kenya and Jambo Telecom 7. Eferio Kenya ltd is Kenya's first MVNE 8. Pending licences: Web Tribe, Infura ltd and Hidiga Investment
			9.
		Differentiated (innovative) services offered	1. Mobile financial services (2) 2. Enterprise Market services (New) 3. Boda Boda sector services (New) 4. M- banking services 5. Electronic airtime vending for MVNOs 6. Merchants pay bill/till/pochi 7. Customized services to organizations
		Un-served, /underserved and niche markets	1. Un-banked population in rural areas 2. Saccos and Chamas 3. Religious/Faith 4. Ethnic 5. Diaspora
		Level of utilization of services and market segments	1. Utilization of services is fair although level of differentiation is minimal 2. Utilization of market segments is poor

2	What are the key facilitators, and barriers to the growth of MVNOs?	Challenges and problems encountered in the MVNO sector	1. Lack of separate regulatory framework for MVNOs from MNOs (2) 2. Anti-competitive behavior from MNOs.(5) 3. Technical deployment (5) 4. Differentiation of MVNO services from the MNO (1) 5. Lack of investment capital (CAPEX/OPEX) (1) 6. Unfavorable commercial terms from MNOs (4) 7. Network coverage limitations (1) 8. Lack of clear business strategy(3) 9. Political interest and interference (1)
		Suggestions for improvement	1. Establish separate regulatory framework for MVNOs.(2) 2. Act on monopoly and dominance (1) 3. Create a level playing ground in the MNO/MVNO sector (4) 4. Government should chip in the remote and rural areas where N/W infrastructure is missing (2)
3	What are the key strategies for the implementation of MVNO?	Phases of MVNO development	1. Planning (Startup) 2. Technical integration (Development) 3. Testing 4. Launch in the market (Deployment)
		Key strategies in the implementation of MVNO	1. Identification of the niche market to target. 2. Differentiation of service offering 3. Good customer experience (QoE) 4. Negotiation for favorable commercial terms
4	What design components would constitute an acceptable implementation framework for MVNO?	Reasons for MVNO lack of separate framework	1. MVNO sector is still young and small 2. Problems and challenges of the sector have not yet been understood 3. MNO influence and dominance is too strong
		Design components that MVNO framework should have	1. Network sharing for all MNOs. 2. National Roaming 3. Commercial/pricing models 4. SLA guidelines
	OTHER RELATED THEMES OF THE INTERVIEW		
	Area	Themes	Codes (Sub Themes)

5	Future of MVNOs in Kenya, Africa and globally	Future of MVNOs	• Kenyan Market • African market • Global market • 5G and beyond 1. MVNO business model unpopular in Kenya and Africa but promising 2. Globally, MVNOs are performing in Europe, USA and Asia and command an appreciable market share 3. World MVNO leaders are already riding on 5G 4. 5G still in the drawing boards in Kenya (2024) 5. 5G will herald a new breed of MVNOs for location based services
6	Cellular Network infrastructure	Status of N/W infrastructure in Kenya	• Urban Areas • Rural Areas • Remote Regions • 47 Counties 1. Infrastructure concentrated in urban areas 2. Rural areas served with old 2G//3G technology 3. No N/W infrastructure at all in remote and marginalized areas 4. 47 counties unevenly served with N/W, 14 counties excluded or make do with poor infrastructure
7	Socio- cultural/ geographical/Security factors that affect MVNOs	Socio- cultural/ geographical/Security factors influence	1. Corruption: Endemic social factor (contributes to skewed distributions of N/W resources and denial of services) 2. Migration of pastoralist communities: Socio-Cultural factor (discourages investment of permanent infrastructure) 3. Geographical location – Economic factor (discourages investment in sparsely populated and remote areas) 4. Poverty: Economic factor (does not guarantee return of investment) 5. N/W infrastructure vandalism: Security factors (prone in remote and North Eastern parts of Kenya)

8	Dominance in the telecommunications industry	Dominant Investor in Kenya	1. Safaricom is a dominant investor but not officially acknowledged by the Government and regulator (2) 2. Complaints of misuse of dominance have been raised but no accommodative measures taken (2) *Mpesa separated from Safaricom in 2022 to partly address the issues of dominance in the mobile money sector 3. Safaricom does not host MVNOs and feels better off without them (2). * Jambo Pay hosted in 2023
	Score Card of challenges and Suggestions for improvement of the MVNO Sector		
A	Score card of challenges and problems in the MVNO sector	Frequency of influencing codes	1. Anti-competitive behavior from MNOs.(5) 2. Technology deployment (5) 3. Unfavorable commercial terms from MNOs (4) 4. Lack of clear business strategy(3) 5. Lack of separate regulatory framework for MVNOs from MNOs (2) 6. Differentiation of MVNO services from the MNO (1) 7. Lack of investment capital (CAPEX/OPEX) (1) 8. Network coverage limitations (1) 9. Political interest and interference (1)
B	Score card of suggestions for improvement	Frequency of influencing codes	1. Create a level playing ground in the MNO/MVNO sector (4) 2. Establish separate regulatory framework for MVNOs.(2) 3. Government should chip in, in remote and rural areas where N/W infrastructure is missing (2) 4. Act on monopoly and dominance (1)

Table 6: Summary of Interview Protocol Key Factors and suggestions for improvement

	IP Key Factors	Score		Suggestions for Improvement	Score
1	Anti-competitive behavior from MNOs	(5)	1	Create a level playing ground in the MNO/MVNO sector	(4)

2	Technology deployment	(5)	2	Establish separate regulatory framework for MVNOs.	(2)
3	Unfavorable commercial terms from MNOs	(4)	3	Government subsidy in remote/marginalized and rural areas	(2)
4	Lack of clear business strategy	(3)	4	Act on monopoly and dominance	(1)
5	Lack of separate regulatory framework for MVNOs from MNOs	(2)	5	Create public awareness for MVNO	(1)
6	Differentiation of MVNO services from the MNO	(1)			
7	Lack of investment capital (CAPEX/OPEX)	(1)			
8	Network coverage limitations	(1)			
9	Political interest and interference	(1)			

Table 6 is a summary of interview protocol key factors and suggestions for improvement**.**

Anticompetitive behavior from MNOs: Not all MNOs were willing to host and share their infrastructure resources with MVNOs. They felt they were better off without them. MVNOs depend on the frequency spectrum and RAN of the mother MNOs for their operation.

C2: Observation Thematic Framework

Table C2: Observation Thematic Framework

	Item of Observation	Themes	Codes
1	Cellular Network infrastructure and coverage	Cellular N/W infrastructure categories	1. 3-subcategories of N/W infrastructure (NFP Tier1- Tier3) 2. MNO belong to NFP Tier1 3. MVNOs registered as ASPs under NFP tiers 4. MVNOs currently supported byTier1 (MNO)
		Factors influencing Network Infrastructure	1. Number of deployed TXs (1) 2. Level of licence (2) 3. Bandwidth (1) 4. Coverage Area (1) 5. Geographical region (urban, rural, remote) (6)
		Network Coverage	1. Safaricom's infrastructures covers all the 47 counties 2. Airtel and Telcom covers 14 counties less that represent 50% of the total County Area 3. Safaricom not ready to share its n/w in 14 counties
		Factors influencing N/W coverage	1. Network infrastructure (4) 2. Level of licence (2) 3. Geographical Region (6)
2	Mother MNOs and levels of hosted MVNOs	MNOs and Hosted MVNOs	1. Only 3 MNOs in NFP Tier1 subcategory that qualify to host MVNOs (Safaricom, Airtel and Telkom) 2. Safaricom has not host MVNOs (.*Jambo Pay hosted in 2023) 3. Airtel hosts 3 MVNOs (Equitel, Mobile Pay, homeland media) 4. Telkom hosts one MVNO (Jambo Telecom) and one MVNE (Eferio Kenya Ltd) 5. Jamii Telecom is neither an MNO nor an MVNO
		Level of hosted MVNOs	1. Equitel and Tangaza are enhanced Service providers 2. Eferio Kenya is an MVNE but not yet in the public domain 3. JamboTelecom is a broadband internet provider with MVNO expansion plans in future 4. Homeland Media services are not in the public domain

		Factors influencing Level of MVNOs	1. Core RAN devices (1) 2. Network infrastructure (4) 3. Geographical Region (6)
3	Quality of Services	QoS Network Metrics	1. QoS Network metrics: Throughput, Delay, Packet loss rate, BER, and Reliability 2. Safaricom n/w offers better QoS than Airtel and Telkom 3. Safaricom's QoS is not beneficial to MVNOs because it does not directly support MVNOs in its network. (Jambo Pay supported in 2023)
		Factors influencing QoS	1. Network metrics (1) 2. Network infrastructure (4) 3. Generation of the n/w (2G-4G) (1) 4. Geographical region (6)
		QoE Metrics	1. QoE metrics: Reliability (Availability, Accessibility and Retainability of services) and Satisfaction (Ease of use and Level of support) 2. QoE of Safaricom is far much better that Airtel and Telkom
		Factors influencing QoE	1. By default QoS (1) 2. Service reliability(1) 3. Customer satisfaction (1)
4	Interoperability	Interoperability Frameworks in MNO/MVNO industry	1. Interconnection and Provision of Fixed Links, Access and Facilities) Regulations, 2010 2. The National Payment Systems (NPS) Regulations 2017 3. Mobile money interoperability framework by NPS 2018 4. Amendment …2022
		Factors influencing interoperability	1. Government political will to legislate (4) 2. Legal framework (2) 3. Use of standards (1) 4. Compliance enforcement (1)

5	Legal and Regulatory frameworks	Legal Frameworks	1. The Kenya Information and Communications Act (CAP. 411A–Rev 2011). 2. The Kenya Information and Communications (Interconnection and Provision of Fixed Links, Access and Facilities) Regulations, 2010 3. Payment Systems Act (No 29 of 2011)
		Factors influencing Legal framework	1. Government political will to legislate (4) 2. Challenges that inhibit the smooth running of an existing sector (2) 3. Adoption of new technologies (2)
		Regulatory Frameworks	1. Telecommunications Market Structure - Unified Licencing Framework (ULF-2016) 2. The Kenya Information and Communications - Interconnection and Provision of Fixed Links, Access and Facilities) Regulations, 2010 3. The National Payment Systems (NPS) Regulations -Mobile Money Interoperability, 2018 4. The National Information Communications and Technology (ICT) Policy Guidelines, 2020 5. A wide range of guidelines in Licensing, Compliance, Competition and conflict resolution under Act 411A
		Factors influencing Regulatory framework	1. Government political will to legislate (4) 2. Legal framework (2) 3. Challenges experienced in the smooth running of existing sectors (2) 4. Adoption of new technologies (2)
6	Market Share and Penetration	Mobile phone penetration and Market share	1. Mobile phone penetration stands at 125% in telecom industry 2. Safaricom leads at 64%, Airltel at 27%, Telecom at 6% and Equitel at 3% 3. Equitel is the only MVNO with a significant share of 3% 4. Mobile Pay out of the scene with compliance Challenges 5. Jambo Pay is the new kid on the block (2023) 6. Other mvnos are currently insignificant in the market
		Factors Influencing mobile phone penetration	1. Network infrastructure (4) 2. ARPU (2) 3. Geographical Region(6)

		Factors influencing market share	1. Network infrastructure (4) 2. ARPU(2) 3. Geographical Region (6) 4. Innovative Services (1) 5. Niche/underserved /untapped markets(1) 6. Competition (1)
7	5G Readiness and Migration	Readiness and migration to 5G	1. 5G still in the drawing boards 2. Trials and testing by Safaricom in the drawing boards -2024) 3. Upgrade of the existing network to 4G is one reason for the delay to 5G but all MNOs now on 4G 4. 5G already launched by Safaricom and Airtel (2024) 5. Telkom Kenya performance dismal and struggling with compliance issues (2024)

Table 7: Summary of Observation Protocol Key Factors and suggestions for improvement

	IP Key Factors	Suggestions for Improvement	Comment
1	Geographical Region of operation (urban , Rural, marginalized)	Government subsidy for network infrastructure in remote/marginalized and rural areas	Private sector interested in return on investment –Gov subsidy in disadvantaged areas
2	Network infrastructure and coverage	Expand Network coverage to all the 47 counties	14 counties not covered –CA to take charge or Gov Subsidy
		Share available infrastructure Resources among MNO service providers	Safaricom reluctant to share infrastructure resources – CA to take charge or Gov subsidy
3	Government political will to legislate	Legal framework or amend existing regulatory framework	CA to take charge
4	Level of licence	Provide separate licensing structure for MVNOs depending on the level of MVNOs	MVNOs currently an application within MNOs - CA to take charge)
5	Adoption of new technologies	MNOs/MVNOs to embrace technology	
6	ARPU	Government subsidy	
7	QoE	Improve n/w QoS, Reliability and customer satisfaction	

APPENDIX D: RESEARCH AUTHORIZATION DOCUMENTS

D1: LETTER OF APPROVAL OF PROPOSAL

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

Tel: 056-30870
Fax: 056-30153
E-mail: directordps@mmust.ac.ke
Website: www.mmust.ac.ke

P.O Box 190
Kakamega – 50100
Kenya

Directorate of Postgraduate Studies

Ref: MMU/COR: 509999

Date: 23rd April, 2020

Murori J. Arimbi,
SIT/H/14-57471/2016,
P.O. Box 190-50100,
KAKAMEGA.

Dear Mr. Murori,

RE: APPROVAL OF PROPOSAL

I am pleased to inform you that the Directorate of Postgraduate Studies has considered and approved your Ph.D proposal entitled: ***"An Implementation Framework for Mobile Virtual Network Operations (MVNOs)"*** and appointed the following as supervisors:

1. Dr. Daniel Otanga - School of Computing and Informatics, MMUST
2. Dr. Jasper Ondulo - School of Computing and Informatics, MMUST

You are required to submit through your supervisor(s) progress reports every three months to the Director Postgraduate Studies. Such reports should be copied to the following: Chairman, School of Computing and Informatics Graduate Studies Committee and Chairman, Computer Science Department. Kindly adhere to research ethics consideration in conducting research.

It is the policy and regulations of the University that you observe a deadline of three years from the date of registration to complete your Ph.D thesis. Do not hesitate to consult this office in case of any problem encountered in the course of your work.

We wish you the best in your research and hope the study will make original contribution to knowledge.

Yours Sincerely,

DEAN
SCHOOL OF GRADUATE STUDIES
MASINDE MULIRO UNIVERSITY
OF SCIENCE & TECHNOLOGY

Prof. John Obiri
DIRECTOR, DIRECTORATE OF POSTGRADUATE STUDIES

D2: RESEARCH LICENCE

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 159314

Date of Issue: 29/May/2020

RESEARCH LICENSE



This is to Certify that Mr.. MURORI JEREMY ARIMBI of Machakos Muthyo University of Science and Technology, has been licensed to conduct research in Nairobi on the topic: AN IMPLEMENTATION FRAMEWORK FOR MOBILE VIRTUAL NETWORK OPERATORS (MVNOs) for the period ending : 29/May/2021.

License No: NACOSTI/P/20/5055

159314

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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The Grant of Research Licenses is Guided by the Science, Technology and Innovation (Research Licensing) Regulations, 2014

CONDITIONS

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3. The Licensee shall inform the relevant County Director of Education, County Commissioner and County Governor before commencement of the research
4. Excavation, filming and collection of specimens are subject to further necessary clearance from relevant Government Agencies
5. The License does not give authority to transfer research materials
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8. NACOSTI reserves the right to modify the conditions of the License including cancellation without prior notice

National Commission for Science, Technology and Innovation
off Waiyaki Way, Upper Kabete,
P. O. Box 30623, 00100 Nairobi, KENYA
Land line: 020 4007000, 020 2241349, 020 3310571, 020 8001077
Mobile: 0713 788 787 / 0733 400 245
E-mail: dg@nacosti.go.ke / registry@nacosti.go.ke
Website: www.nacosti.go.ke

D3: JAMII TELECOMS (FAIBA) RESEARCH DATA REQUEST

MURORI JEREMY ARIMBI

P.O. Box 14960-00100

NAIROBI

Cell phone: 0722784773

Email: murorij@gmail.com

July 6, 2020

CEO JTL (FAIBA)

Jamii Towers – Upper Hill

NAIROBI

Email: jcsc@jtl.co.ke

Dear Sir/Madam,

REF: REQUEST FOR ASSISTANCE OF RESEARCH DATA

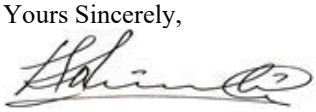
I greet you in the name of Jesus Christ Our Lord and Saviour.

My name is Murori Arimbi, a Doctor of Philosophy (PhD) student in the School of Computing and Informatics, Masinde Muliro University of Science and Technology (MMUST). As part of my PhD requirement, I am required to undertake an academic research study on a relevant topic. I am conducting a research study titled **"An Implementation Framework for Mobile Virtual Network Operators (MVNOs)"**

I humbly request Jamii Telecoms Limited to participate in this research study by completing the attached questionnaire whose data will help me in my research project. The questionnaire will take about 5 minutes to complete. The data collected will be treated with utmost confidentiality and used for academic purposes only. Also attached are NACOSTI Research Permit and a Letter of introduction from Masinde Muliro University of Science and Technology.

Thank you in advance for taking time to assist me in my educational endeavors.

Yours Sincerely,



Murori J. Arimbi

D4: SAFARICOM LIMITED REQUEST FOR RESEARCH DATA

MURORI JEREMY ARIMBI

P.O. Box 14960-00100

NAIROBI

Cell phone: 0722784773

Email: murorij@gmail.com

August 6, 2020

Safaricom CEO

P.O. Box 66827-00800

NAIROBI

Email: ceo@safaricom.co.ke

Cc prcomms@safaricom.co.ke

hr@safaricom.co.ke

Dear Sir/Madam,

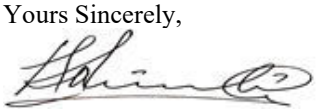
REF: REQUEST FOR ASSISTANCE OF RESEARCH DATA

I greet you in the name of Jesus Christ Our Lord and Saviour.

My name is Murori Arimbi, a Doctor of Philosophy (PhD) student in the School of Computing and Informatics, Masinde Muliro University of Science and Technology (MMUST). As part of my PhD requirement, I am required to undertake an academic research study on a relevant topic. I am conducting a research study titled **"An Implementation Framework for Mobile Virtual Network Operators (MVNOs)"**

I humbly request Safaricom Limited to participate in this research study by completing the attached questionnaire whose data will help me in my research project. The questionnaire will take about 5 minutes to complete. The data collected will be treated with utmost confidentiality and used for academic purposes only. Also attached are NACOSTI Research Permit and a Letter of introduction from Masinde Muliro University of Science and Technology. Thank you in advance for taking time to assist me in my educational endeavors.

Yours Sincerely,



Murori J. Arimbi