UNIVERSITY OF CAPE TOWN

GSB DEFIC DEVELOPMENT FINANCE CENTRE

Telecommunications Development and Economic Growth in Namibia

A Dissertation

presented to

The **Development Finance Centre (DEFIC)**
Graduate School of Business
University of Cape Town

In partial fulfilment
of the requirements for the Degree of
Master of Commerce in Development Finance

by

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September 2022

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Declaration

I, **Nelly Mvula**, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university. I authorise the University to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

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Abstract

The telecommunications sector is one of the industries that provide an enabling environment for other sectors to increase efficiency and productivity. With the emergence of Covid-19, which forced the world to adopt a new way of doing things, the telecommunications sector ensured minimum disruption to productivity by enabling remote working, online trading, and providing the connectivity required for online learning. The telecommunications sector is one of the key sectors identified by the Namibian Government as critical to the global and the Namibian economy, and the expansion of which has been included in the government planning documents such as the Vision 2030, Harambee Prosperity Plans, and the National Broadband Policy. However, the country had a low penetration rate of 41% in 2020 and there are interventions required to improve access to telecommunication services.

This study employed the Autoregressive Distributed Lags (ARDL) bound test techniques and the Granger causality test based on secondary data obtained from the World Data Indicators (WDI), covering the period between 1995 and 2020. The results found no evidence of a long-run relationship between the telecommunications variables and economic growth, and this is attributable to the fact that the industry is still at an infant stage. The results of the Vector Autoregression (VAR) also didn’t find a significant relationship between telecommunication variables and economic growth, except for number of individuals using the internet. The Granger causality tests revealed that there is no evidence of Granger causality between telecommunications development and economic growth in Namibia. The government should direct efforts towards implementing policies aimed at encouraging investments in telecommunication infrastructure and by further looking at complementary factors, which include investments in research and development aimed at improving the low internet penetration rate.

Acknowledgement

I would like to thank God, the Almighty for his grace and favour through this process. I give you all the glory and honour, Lord; if it weren't for your righteous right hand upon my life, I would not be where I am today.

To my dearest husband, Tangeni, you have been an absolute rock throughout this entire process. You believed in me even during moments where I doubted myself. God knew I needed you when he gave me you. To our first-born son, Tuamena, your presence in my life gave me that extra urge I needed to finish this. Tunomukumo, you patiently lay in my womb as I sat long hours to finish this; you are an absolute star. Mee Loiny and Tate Mike, the lessons you taught me from the beginning have led me to where I am today, and I am forever grateful for that.

To all my friends and family, thank you for your love and support. To my employer, Telecom Namibia, thank you for the study breaks despite the busy times.

A special thanks to Assoc Prof Abdul Latif Alhassan; I am deeply grateful for your guidance and patience during the completion of this thesis. Your timely and valuable feedback led to the successful completion of this process.

List of acronyms and abbreviations

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criteria
ARDL	Autoregressive Distributed Lags
CRAN	Communications Regulatory of Namibia
GDP	Gross Domestic Product
GSMA	Global System for Mobile Communications
ICT	Information Communications Technology
MTC	Mobile Telecommunication Corporation
NBP	National Broadband Policy
NDP5	Fifth National Development Plan
SSA	Sub-Saharan Africa
PP	Phillips-Perron Test
VAR	Vector Autoregression
VECM	Vector Error Correction Model
WDI	World Development Indicators

Table of Contents

Declaration i

Abstract ii

Acknowledgement iii

List of acronyms and abbreviations iv

List of Tables vii

List of Figures vii

Chapter 1: Introduction 1

1.1 Introduction and Background of the Study 1

1.2 Problem Definition 3

1.3 Research Objectives and/or Hypotheses 4

1.4 Scope and Justification of the Study 5

1.5 Organisation of the Study 6

Chapter 2: Literature Review 7

2.0 Introduction 7

2.1 Definition of Telecommunications Development 7

2.2 Overview of the Telecommunication Industry in Namibia 8

2.3 Theoretical Review: Telecommunication Development and Economic Growth 13

2.4 Empirical Literature: Telecommunication Development and Economic Growth 16

2.5 Conclusion 21

Chapter 3: Methodology 24

3.0 Introduction 24

3.1 Research Approach 24

3.2 Research Design 24

3.2.1 Data, Sample Period and Size 24

3.2.2 Empirical Model 25
3.2.3 Definition and Measurement of Variables 25
3.3 Estimation Technique 28
3.3.1 Unit Root Tests 28
3.3.2 Cointegration Test (ARDL) 29
3.3.3 Vector Error Correction Model 30
3.3.4 Granger Causality 30
Chapter 4: Discussion of Findings 32
4.1 Introduction 32
4.2 Descriptive Statistics 32
4.3 Correlation Results 34
4.4. Stationarity Tests 34
4.5 Optimal Lag Selection Criteria 35
4.6. Cointegration Test Results 36
4.7 Vector Autoregression Estimates 36
4.8 Granger Causality Test 38
4.9 Diagnostics Test Results 40
4.10 Summary 41
Chapter 5: Conclusion and Recommendation 42
5.0 Introduction 42
5.1 Summary of Key Findings 42
5.2 Recommendations 43
5.3 Future Research Directions 44
References 45
List of Appendices 51

List of Tables

Table 1: Aggregated financials from ICT sector........ 9
Table 2: Mobile subscriber numbers in 1000s........ 11
Table 3: Fixed-line subscribers........ 12
Table 4: Summary of the empirical literature on telecommunications and economic growth 22
Table 5: Definition of variables........ 28
Table 6: Descriptive statistics........ 33
Table 7: Correlation results........ 34
Table 8: Unit Root results........ 34
Table 9: ARDL Bounds Test........ 36
Table 10: Short Run VAR (2) estimates........ 37
Table 11: Granger causality test........ 38
Table 12: Diagnostics test results........ **Error! Bookmark not defined.**

List of Figures

Figure 1: Share of Assets........ 8
Figure 2: Share of Revenues........ 9
Figure 3: Individuals using the internet as % of population........ 10
Figure 4: Mobile cellular subscriptions (per 100 people)........ 11
Figure 5: Namibia Post and telecommunications, Gross value added, N$ billions........ 13
Figure 6: Conceptual framework of the impact of broadband on economic output........ 15
Figure 7: Conceptual structure of the digital ecosystem development index........ 15
Figure 8: Lag length selection........ 35

Chapter 1: Introduction

1.1 Introduction and Background of the Study

The world is now an integrated place, and the provision of telecommunication services is one of modes that has made it easier for people and businesses to connect worldwide. The telecommunication industry plays a huge role in creating efficiency and productivity in other sectors, which include the financial services, healthcare, tourism and other businesses (Kaur & Malhotra, 2014).

The emergence of the Covid-19 pandemic has caused disruption in the world at its onset in early 2020 and has changed the global landscape as we know it. As such, it has forced the world to adapt new ways of doing things. The telecommunications sector is one of the key industries that provided the support required by various industries to minimise the disruption caused by the pandemic and ensured that people were still connected to their loved ones. The changes include working from home, virtual learning for students, online purchases, demand for gaming services and virtual meetings. These are some of the things that are now normal (Forest Interactive, 2020). With these changes comes increased demand for reliable and efficient communication supported by fast internet and voice over data and this resulted in the telecommunication industry gaining prominence due to the demand of services required to minimise the global disruption (Gaibi et al., 2021).

Telecommunication is an intrinsic aspect of Information Communication Technologies (ICT), and it includes the provision of mobile services, fixed lines, and the internet. In a study by (Adeleye & Eboagu, 2019), ICT is identified as one of the key factors in shaping the world economy and it has allowed countries to relook at the traditional ways of driving development and assess new approaches of operation driven by technological advancement. Organisations face various challenges which need to be resolved by exploring markets, making processes more efficient and improving access to information and, as such, calls for an effective use of ICT to pave the way for creativity and expansion (United Nations, 2011). The quality of ICT infrastructure, amongst other things, is an increasing determinant of the investment climate and there is pressure on the governments to ensure that infrastructure demands are satisfied through promoting affordable access to ICTs, and facilitating expansion of the ICT sector (United Nations, 2011).

In Africa, the provision of telecommunication services was mainly done by the government; however, this has changed over the last decade or so with the privatisation of some of the firms and getting rid of the monopolies in the sector (Chavula, 2013). According to the latest data available from the World Bank, in 2017, only 19% of the population of Sub-Saharan Africa (SSA) was using the internet and only five countries had a rate above 50%. Those countries are Seychelles, Cabo Verde, South Africa, Mauritius and Gabon. This is an indicator that there is untapped potential in the African continent and access to infrastructure is one of the things that is hindering access to services such as telecommunications to the people of Africa. Sub-Saharan Africa (SSA) is the fastest growing region in Africa in the mobile economy, with an estimated growth of 6.1% between 2016 and 2020 and this is around 50% higher than the global average (GSMA, 2017). The mobile telecommunications sector contributed 7.7% of GDP in the SSA region and it supported 3.5 million jobs in 2016, which indicates that the mobile sector is making a substantial contribution to development.

The Namibian economy is one of the smallest economies in the world and is largely dependent on South Africa. The telecommunications sector is mainly dominated by the government, controlling two major players in the industry. According to (GSMA, 2017), Namibia had 1.2 million unique mobile subscribers, with a penetration rate of 45%, which is considered reasonable in comparison to other African countries. The ICT sector is one of the key sectors in the country (Humavindu & Stage, 2013) and is ranked as part of the top 20 economic activities in the country contributing N$3 billion to GDP in 2013. There are various factors that have been identified as bottlenecks to expanding the ICT sector and it is one of the reasons the country launched the National Broadband Policy (NBP) in 2019 to provide a framework for the holistic development of broadband in Namibia (Ministry of Information and Communication Technology, 2019).

The Namibian Government acknowledged how critical the ICT sector is to the global and the Namibian economy and identified various interventions to expand the investment in ICT infrastructure and services. The interventions are included in the Vision 2030, the Fifth National Development Plan (NDP 5), Harambee Prosperity Plan (both I and II) and the 2019 NBP. The initiatives revolve around achieving an 80% of the population accessibility rate to broadband by 2021 and 95% by 2024. This research will try to establish whether the planned initiatives and opportunities that will drive telecommunication development will or will not result in economic growth in Namibia.

1.2 Problem Definition

The Namibian Government launched the NBP in 2019 with an ambitious plan of increasing the broadband access rate from the baseline of 50% of the population in 2019 to 95% in 2024. To achieve this target, increased investment in telecommunication infrastructure will be required. The investment in telecommunications is not only expected to contribute to the social upliftment of the people of Namibia but it is also expected to increase Namibia's global competitiveness and is a mechanism for accessing information, which is essential for all forms of economic activity (Ministry of Information and Communication Technology, 2019).

The South African Development Community (SADC), which Namibia is part of, has indicated that ICTs have become the lifeblood of the knowledge economy and has been identified as the electricity of the 21st century and is thus a basic human right and while being a significant contributor to economic growth and social well-being. SADC launched a Master Plan to achieve a "Digital SADC" by 2027 (SADC, 2012) and Namibia as a member state is expected to contribute to this Master Plan.

According to (Dzidonu, 2002) in the Blueprint for Developing National ICT Policy in Africa it was indicated that there is a need to go beyond looking at the implications of the digital world purely in terms of access to technology: there is also a need to examine its wider implications in socio-economic development terms. This means looking at the deployment, exploitation and development of ICT and implementing policies that will move the African continent to the other side of the digital divide. One of the principles of economics indicates that one of the key factors that drive economic growth is development and this includes innovation, education, efficiency and infrastructure (Kim et al., 2016).

Despite various studies that have examined the relationship between telecommunications development and economic growth (Shiu & Lam, 2008); (Datta & Agarwal, 2004); Sookha, 2018; (Adeleye & Eboagu, 2019); Nadiri & Nandi, 2003; Handledare & Marmefelt, 2012), the focus has been on the global picture, developed and developing countries, and, to a lesser extent, the African continent. Namibia is a unique country where most of the players in the industry are local companies that are government owned, and therefore characteristics of the telecommunications sector cannot entirely be linked to the current studies performed. For the country to be able to achieve the targets as set out in the developmental goals, policymakers need access to reliable studies that can assist in setting the direction. Furthermore, Namibia ranks 27^{th} in Africa in terms of faster average broadband speed and this has been attributed to state dominance and low competition in the sector, which means low investment in telecommunication service and poor service delivery (CRAN, 2021).

The research didn't detect any empirical research papers written on the Namibian telecommunications sector and therefore this is potentially the first empirical study conducted on the relationship between telecommunication development and economic growth, with a focus on Namibia. Noting the current changes in the digital space, which come with a demand for fast and reliable telecommunications services, there is a need to access empirical evidence on the link between telecommunication development and economic growth and to add to the general body of knowledge. In addition, policymakers need access to reliable research to enable them to make informed decisions to drive the telecommunications sector and grow the economy.

The main aim of the study will be to answer the following question:

i. How has telecommunication development impacted economic growth in Namibia?

1.3 Research Objectives and/or Hypotheses

The objective of this study is to achieve the following:

i. To examine the effect of telecommunication development on economic growth in Namibia

Hypothesis 1:

H_0: There is no relationship between telecommunication development and economic growth.

H_1: There is a relationship between telecommunication development and economic growth.

1.4 Scope and Justification of the Study

The area of telecommunication is of key interest to many stakeholders, which include the governments, the private sector, and the public as it is one of the sectors that enables other sectors and it provides goods and services that are currently high in demand with a call for innovation. This study will assist: (1) The government in determining policies around infrastructure development and will determine the allocation of the infrastructure budget (2) Potential investors and could result in better informed investment decisions (3) Researchers with an interest in area of telecommunication development and economic growth and (4) Policymakers in Namibia by providing insight on the impact of telecommunications development on economic growth.

There is a body of literature on this area with focus on the overall impact on the world economy, the African continent, Sub-Saharan Africa, and other African countries. However, there were no similar studies noted covering telecommunication development and economic growth in Namibia. Given that telecommunication development, which is part of ICT, is one of the key areas identified in the Namibian development goals, there is an interest in analysing whether ICT is contributing to economic growth and, if so, to what extent. This is further justified by the launching of the National Broadband Policy, which aims to improve the access of Namibians to broadband services. To the author's knowledge, this is the first study providing an empirical analysis of whether there is a relationship between telecommunication development and economic growth in Namibia.

According to the regulator of the communications sector in Namibia, the telecommunications sector, the sector's value declined between 2012 and 2021 and this was attributed to government dominance evident from state ownership of 92% of the sector's assets and 82.5% of the revenue. Furthermore, CRAN noted that Namibia's ICT sector was one of the leaders in the African continent five years ago and this position has dropped as a result of government control of the sector (CRAN, 2021). There is therefore a need for documented evidence to support decision-makers in directing the telecommunications sector in Namibia to reclaim its position as one of the leaders in Africa and contribute further to supporting other sectors of the economy.

The impact the sector is making in Namibia is not adequately documented and researched. The scope of the studies will be limited to Namibia and this is to minimise the risk of statistical inference from cross-sectional studies (Mohammed, 2018), by taking into consideration only country-specific data and factors.

1.5 Organisation of the Study

The study will be made up of 5 chapters, split as follows: Chapter 1 is the introduction chapter and will include a background of the study, the problem statement, research questions and research objective, justification of the study and limitations of the study. Chapter 2 is the literature review section and will unpack literature relevant to telecommunication development and economic growth. It will be split between the theoretical and empirical studies and will give an overview of the Namibian telecommunications sector. Chapter 3 is the research methodology where the type of research method (quantitative) will be explained, with sources of data (secondary data), model specifications and the estimation techniques. Chapter 4 is the discussion of the findings, and it will include analysis of the data. Chapter 5 is the conclusion and recommendations for future studies. It will include a summary of key findings of the study, provide policy recommendations and future research directions.

Chapter 2: Literature Review

2.0 Introduction

This chapter contains four sections. The first section is the background of the telecommunications sector in Namibia, which includes a brief history of the sector, the current role players, the regulatory framework, and overall telecommunications coverage in Namibia. The second section is the theoretical framework that provides an overview of existing theories on the link between telecommunications development and economic growth. The third section is the empirical evidence as provided by different studies on the relationship between telecommunication development and economic growth. The final section is the summary of the chapter.

2.1 Definition of Telecommunications Development

ICT is defined as a group of activities which includes publishing, motion picture, video production, television, sound recording and music publication, telecommunications, computer programming and information services (United Nations Development Programme [UNDP], 2011). This indicates that ICT is vast; however, the focus of this study is on one element of ICT and that is telecommunications.

There are various definitions of what telecommunications entail. This study focuses on telecommunications defined as a combination of voice, data, text, sound and video and it is made up of subdivisions based on the nature of the infrastructure. The subdivisions of telecommunications are fixed telecommunication services—also referred to as wired activities, wireless activities, satellite, and the provision of internet, which can be provided by either through wired or non-wired infrastructure (United Nations Development Programme [UNDP], 2011).

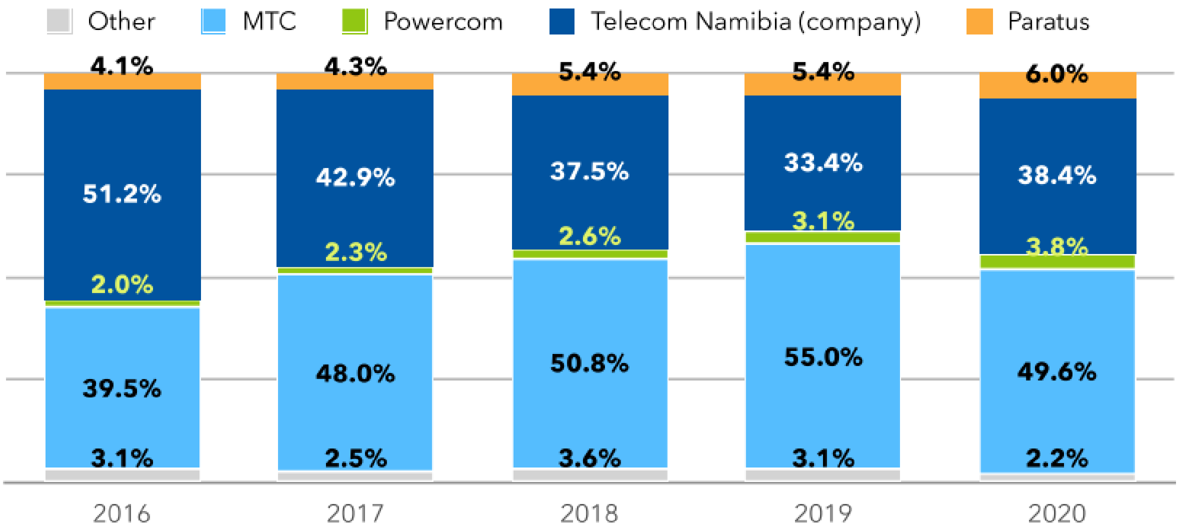
There is no definite definition for the word ‘development’; however, this study will focus on development as a process of change viewed as growth. Combining telecommunication and development, the two words together mean transformation or growth in the various components of telecommunication which is measured through the increase in the number of subscribers, the increase in the utilisation of services, monetary growth in revenue generated and the increase in the telecommunication infrastructure expenditure over time

2.2 Overview of the Telecommunication Industry in Namibia

According to (Sherbourne & Stork, 2010) the commercialisation of the Namibian Telecommunications sector commenced in 1992 with Telecom Namibia as a fixed telecommunication services provider. The mobile telecommunications sector was birthed in 1995 with the formation of the Mobile Telecommunication Corporation (MTC). Up until 2006, the whole sector was government owned, and that is the year the mobile communications company, Leo, was licensed and introduced competition in the sector thus changing the landscape.

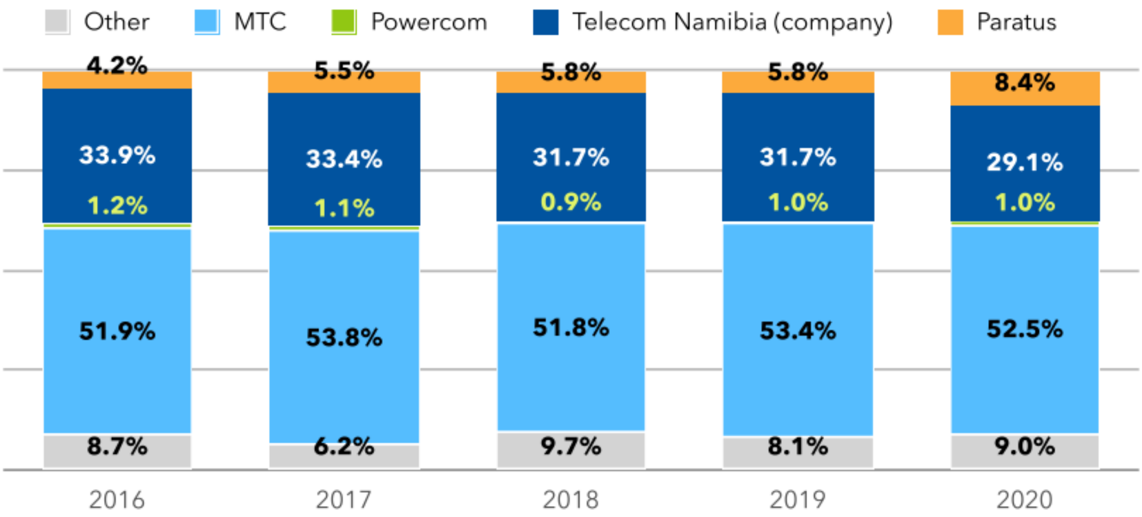
There are three key players in the telecommunication industry in Namibia: Telecom Namibia, MTC and Paratus. Leo ceased to exist in 2013, when it was merged with Telecom Namibia. As of 2019, Namibia awarded 35 telecommunications service licenses (Communications Regulatory Authority of Namibia, 2019a). The market is regulated by the Communications Regulatory Authority (CRAN) and the authority has a mandate to ensure that consumers are not exploited through pricing. Overall CRAN ensures that the consumers are getting value for money through quality services (Communications Regulatory Authority, 2019). The Namibian telecommunications sector is predominantly a monopoly, with Telecom dominating the fixed telecommunication services and MTC dominating the mobile services. With a monopoly, there is a high possibility of inflated prices and CRAN as a regulator ensures that the prices are low while striking a balance for the operators to make profit and invest in infrastructure development. As depicted in Figure 1 and Figure 2 below, it is evident that the state has significant control of the sector, controlling 92% of the assets and 82.5 of the revenue.

Figure 1: Share of Assets



Source: (CRAN, 2021)

Figure 2: Share of Revenues



Source: (CRAN, 2021)

The telecommunication industry in Namibia yields positive financial performance as indicated in Table 1 below. However, there has been a decline in annual revenue growth since 2013, from 19% to 4% in 2020 and this has been attributed to state dominance in the sector. The sector yielded N$5 billion in revenue in 2020 and the total assets were reported as N$6 billion based on the 2020 financial statements.

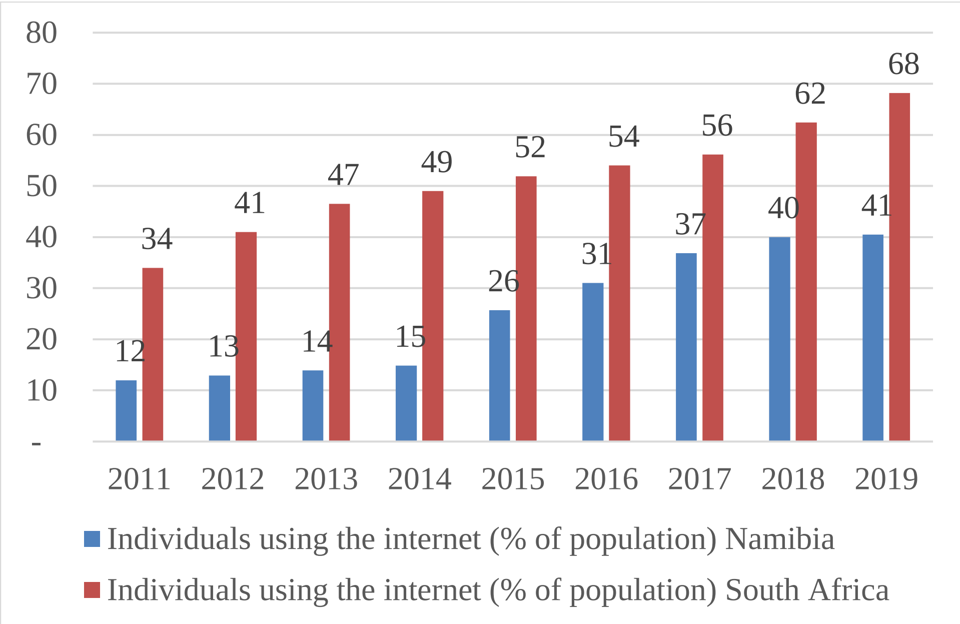
Table 1: Aggregated financials from ICT sector

		2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Change since 2012**
Revenue	NAD million	2,840	3,371	3,770	4,156	4,475	4,499	4,821	4,897	5,116	
	YoY %		19%	12%	10%	8%	1%	7%	2%	4%	
	USD million	345	349	347	325	304	338	364	339	311	-10%
Net Profit	NAD million	409	346	-35	419	552	777	787	837	853	
	USD million	50	36	-3	33	38	58	59	58	52	4%
Assets	NAD million	4,339	4,798	4,762	4,817	4,973	4,856	5,305	5,555	6,577	
	USD million	528	497	438	377	338	365	400	384	399	-24%
Liabilities	NAD million	1,954	2,459	2,924	2,811	3,571	2,965	3,321	3,191	4,271	
Shareholder Equity	NAD million	2,385	2,338	1,837	2,006	1,402	1,891	1,984	2,364	2,306	
	YoY %		-2%	-21%	9%	-30%	35%	5%	19%	-2%	
	USD million	290	242	169	157	95	142	150	164	140	-1%
Profit Margin		14%	10%	-1%	10%	12%	17%	16%	17%	17%	
Return on Equity		17%	15%	-2%	21%	39%	41%	40%	35%	37%	

Source: (CRAN, 2021)

Namibia's biggest trading partner in Africa is South Africa, according to (World Integrated Trade Solution, 2022) and in comparison to South Africa, the internet penetration is lower, at a rate of 41% in 2019 compared to 68% for South Africa. However, the country has experienced growth in the past few years, with an increase in the penetration rate between 2014 and 2019 as illustrated in Figure 3 below.

Figure 3: Individuals using the internet as % of population



Source: Chart created by author with data from *https://databank.worldbank.org/*

Out of 44 African countries ranked in 2018, Namibia was in the 24th spot as the cheapest country when it comes to the affordability of mobile services; this means there are 23 African countries cheaper than Namibia. Furthermore, Namibians use less data per month compared to other African countries (Communications Regulatory Authority of Namibia, 2019b) and this could explain the lower penetration as depicted in Figure 3 above. However, the sector has been growing over the past years, with a dramatic increase of 58.6% in 2018 as depicted in Table 2 below.

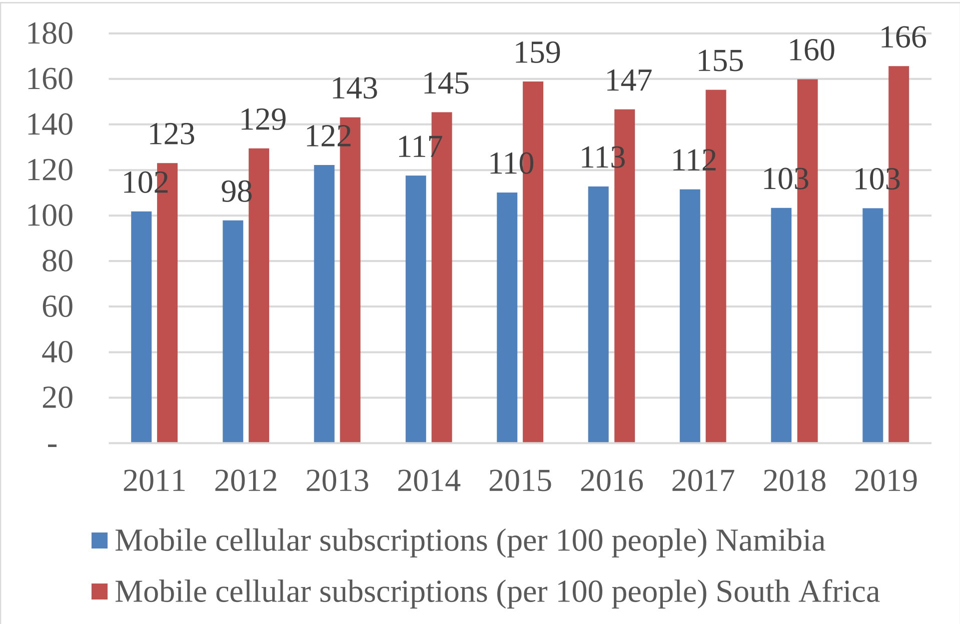
Table 2: Mobile subscriber numbers in 1000s

		2013	2014	2015	2016	2017	2018
Active SIM cards ('000)	Post-paid	152	168	180	191	195	193
	Prepaid	2,308	2,503	2,370	2,469	2,485	2,566
	Total	2,539	2,671	2,550	2,660	2,680	2,759
	Change		5.2%	-4.5%	4.3%	0.8%	3.0%
Mobile Broadband ('000)	Post-paid	67	70	37	31	36	127
	Prepaid	721	732	1,406	1,580	1,377	2,114
	Total	788	802	1,443	1,611	1,413	2,241
	Change		1.8%	80.0%	11.6%	-12.3%	58.6%

Source: (Communications Regulatory Authority of Namibia, 2019b)

The mobile sector is the least competitive telecommunication subsector, with MTC owning 91% (Mobile Telecommunications Limited (MTC), 2019) and Telecom Namibia taking a mere 9% (Telecom Namibia, 2019). The mobile coverage is still underdeveloped, with a 4G coverage rate of only 37% in 2018 compared to 80% in South Africa (Communications Regulatory Authority of Namibia, 2019b). In terms of the number of mobile cellular subscriptions, Namibia has a rate above 100% as illustrated in the chart below; however, the country lags behind South Africa, a country with a rate of 166 subscriptions per 100 people in 2019. This suggests that Namibia has a long way to go and there is potential for growth in the mobile sector.

Figure 4: Mobile cellular subscriptions (per 100 people)



Source: Chart created by author with data from https://databank.worldbank.org/

With regard to the wired services/fixed services, (Communications Regulatory Authority of Namibia, 2019b) reported a significant decrease in the number of fixed-line subscribers between 2017 and 2018, reporting a decline of 27.1% in business customers and an increase of 15.2% in residential customers. This translates to an average decrease of 11.9% as depicted in Table 3 below, and this was attributed to a prevailing recession in the Namibian economy. Despite the decrease in the number of subscribers, data revenue has been increasing since 2012, with Telecom Namibia reporting double revenue between 2012 and 2017 (Communications Regulatory Authority of Namibia, 2019b). This indicates that there is a need for the sector to identify ways to convert the conventional fixed lines into data lines necessitated by the demand for data services and a decline in the demand for landlines for voice calls.

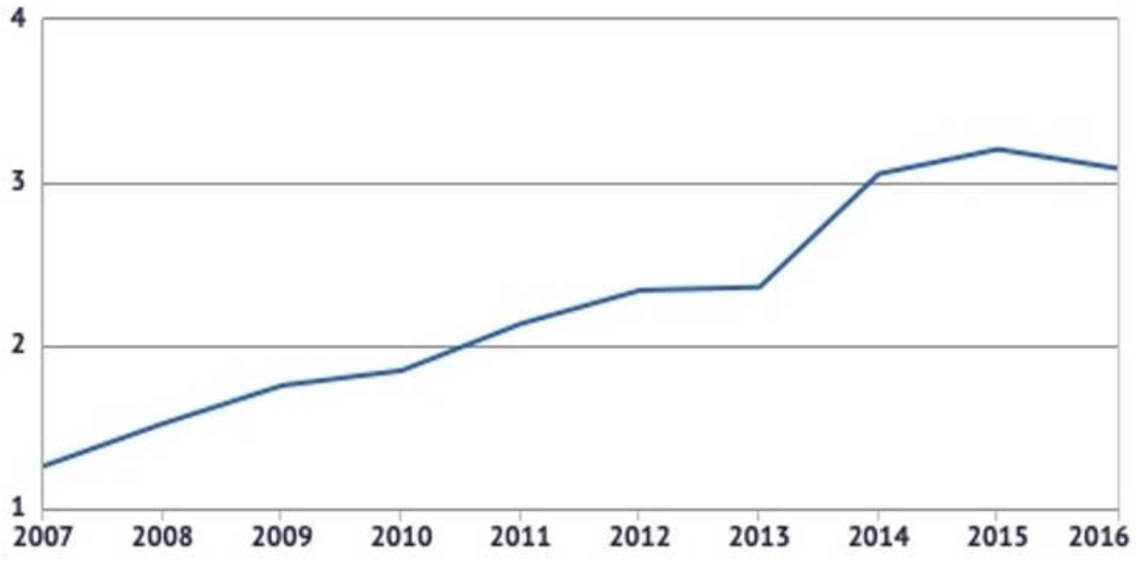
Table 3: Fixed-line subscribers

		2013	**2014**	**2015**	**2016**	**2017**	**2018**
Business	Number	99,107	121,871	119,975	121,517	123,530	90,050
	Change		23.0%	-1.6%	1.3%	1.7%	-27.1%
Residential	Number	84,425	60,722	62,532	66,336	69,213	79,759
	Change		-28.1%	3.0%	6.1%	4.3%	15.2%
Total	Number	183,532	182,593	182,507	187,853	192,743	169,809
	Change		-0.5%	0.0%	2.9%	2.6%	-11.9%

Source: (Communications Regulatory Authority of Namibia, 2019b)

As depicted in Figure 5 below, the post and telecommunications sector in Namibia has seen an increase in the gross value added with the value doubling from N$1 billion in 2007 to a value of N$3 billion in 2016. Evidence in the growth and contribution of the sector to economic development is also evident from the payment of a dividend of N$760 million in total for 2018 and 2019 to the government as the main shareholder in the post and telecommunications sector (Ndjavera, 2020).

Figure 5: Namibia post and telecommunications, gross value added, N$ billions



Source: The World Bank, World Development Indicators

2.3 Theoretical Review: Telecommunication Development and Economic Growth

In line with the definition of telecommunications in section 2.1 above and thus taking into consideration the fact that telecommunications are considered an integral part of ICT, the theoretical concepts discussed below include theory around economic growth, innovation, and technology.

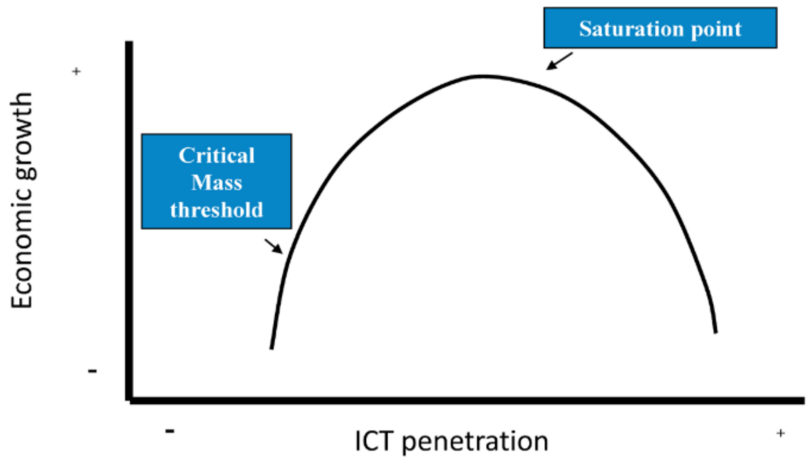
According to the neoclassical growth theory of (Solow, 1956), economic growth is a result of the value added to production due to output from labour, capital and technological advancements. Technology, which is an element of ICT, is thus considered a complementary factor to capital labour and one should expect that less developed countries could catch up with more advanced economies in terms of economic growth, driven by technology (Karlsson & Liljevern, 2017), (Romer, 1990). The neoclassical growth theory suggests that technological progression can potentially drive economic growth and value addition to production is a factor of labour, capital and technology (Wang, 2010).

Despite the fact that the neoclassical growth model has been around for decades, (Venturini, 2007) argues that there was no benefit from the ICT productions in periods prior to the mid-1990s when the world entered the “Information Age” , when the USA, for example, reported a significant increase in productivity. According to (Venturini, 2007), ICT results in an improvement of knowledge which drives efficiency in producing affordable goods and thus increasing consumption which is a driver of economic growth. Human capital being a factor of the neoclassical theory, (Quah, 2001) adds on the argument that technology adds to knowledge, thus improving the quality of the decisions taken and this is expected to positively impact economic growth.

According to (David, 2019) are two opposing trains of thoughts on the positive impact of ICT on economic growth and development, and they are identified as technophiles and technophobes. The technophiles believe that there are unending benefits from the expansion of ICT, and this includes increasing efficiency in production, improving working conditions, upgrading the quality of work across various fields as well as aiding developing countries with accelerating development. On the other side of the seesaw, technophobes feel that technological advancements have a negative impact on economic growth and development. Technophobes find that technology widens the gap between the rich and the poor as it tends to destroy more jobs as opposed to creating more opportunities for the poor and the less literate.

By looking at the various theories underpinning ICT and economic development, (Avgerou, 2003) concluded that the validity of the relationship between ICT and economic development is dubious and misleading but further acknowledges that the most successful economies have better technologies compared to developing economies. She further argues that ICT and economic growth cannot be generalised, and one should look at the context of the particular economy with focus on the history of the institutions and efficiency of market policies. (Dimelis & Papaioannou, 2010) further agrees with (Avgerou, 2003) by arguing that for ICT to affect economic growth, there are certain preconditions that should be present, including the presence of human capital, other infrastructure and a well-developed financial systems. (Vu, 2011) makes reference to Japan, Korea, Hong Kong and Taiwan as examples of countries that have outstanding economic growth as a result of an effective communication framework. (Jorgenson & Vu, 2016) highlights that ICT has changed the way of doing things around the world and this has contributed significantly to growth in world economies.

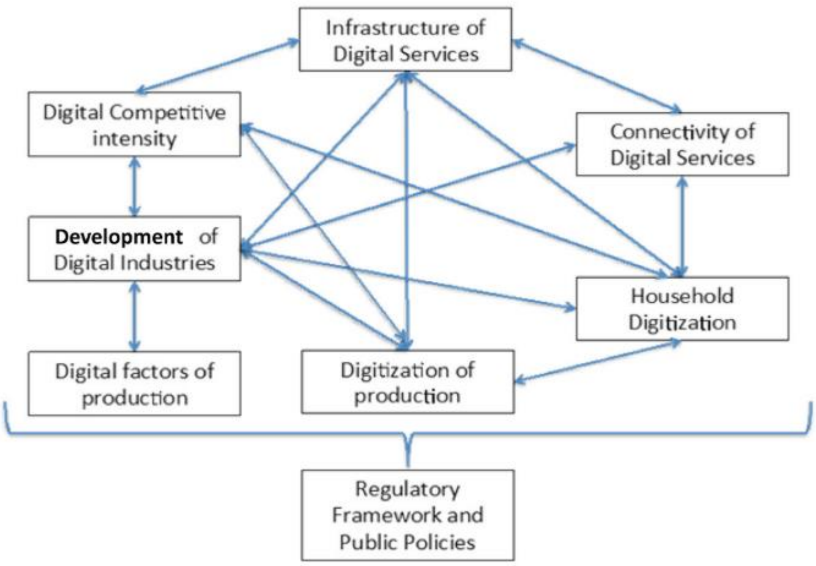
Figure 6: Conceptual framework of the impact of broadband on economic output



Source: (Raul & Fernando, 2018)

According to (Raul & Fernando, 2018), fixed and mobile broadband penetration have a saturation and diffusion returns effect as depicted in Figure 6 above. According to the diffusion theory, early adopters of technology tend to benefit from high broadband penetration and there shouldn't be a linear relationship as the earliest adopters get the highest benefits and the late adopters get a lesser benefit. According to the saturation theory, the strength of the relationship between telecommunications and economic growth is high until the achievement of a certain critical mass and it weakens as soon as the saturation point is reached (Raul & Fernando, 2018).

Figure 7: Conceptual structure of the digital ecosystem development index



Source: (Raul & Fernando, 2018)

Digital connectivity is defined as a measure of the adoption of computers, smartphones and other terminals in terms of which provide a conduit for the provision of telecommunication services (broadband, wireless telephony) (Raul & Fernando, 2018) and is thus used as a measure of "digitization". Figure 7 above illustrates the various components of digitization and the interconnectivity of the ecosystem.

2.4 Empirical Literature: Telecommunication Development and Economic Growth

This section provides an overview of studies on the impact of ICT and ICT development on economic growth, as telecommunications are a key component of ICT. The empirical review also include studies on the role of broadband penetration and mobile communications development as these are major elements of telecommunications.

Alleman et al., (1994) in applying a macro economical statistical approach, looked at the relationship between telecommunications and economic development in the SADC region. The study concluded telecommunication infrastructure alone will not contribute to economic growth unless supported by human and capital resources, quality of service, plus other infrastructure investments.

S. Lee et al., (2012) conducted a study to examine the effect of telecommunications and economic growth in sub-Saharan Africa, with focus on the effect of mobile cellular phones. By employing a special linear Generalized Method of Moments (GMM) estimator, covering 44 SSA countries and analysing data covering the period 1995 to 2006, the study found the impact of traditional landline phones on economic growth negligible in SSA, while the impact of mobile cellular phones was found to be significant to economic growth.

One of the most recent studies on telecommunications and economic growth in Africa is (David, 2019), with focus on 46 African countries between 2000 and 2015. The study employed the Neoclassical theory of growth, modified to include telecommunications as the main actor of technology. With more than 99% confidence level, the study found that an increase in telecommunication operations will achieve innovation which will translate to sustainable economic growth and development in both developing and developed countries. The study utilised the economic variables of gross fixed capital formation, employment to population ratio, enrolment in secondary education for both sexes and the net inflow of FDI as determinants of economic growth.

Adeleye & Eboagu (2019) evaluated the effect of ICT on economic growth across 54 African countries between 2005 and 2015. The study adopted the Cobb-Douglas production function and found compelling and robust evidence supporting the hypothesis that ICT has a significance impact on economic growth in Africa. In addition to the significant positive relation found between ICT development and economic growth, the study found that the output elasticities of the three ICT indicators are significantly different, the "leapfrogging" hypothesis – which is the notion that poorly developed countries can move themselves forward through adoption of new technologies – holds for Africa, and that mobile subscription has the highest output elasticity.

Chavula (2013) conducted a study to assess the impact of telecommunication development on economic growth in Africa in the period 1990 to 2007. The study employed the endogenous growth model to estimate the effect of mobile, fixed telephone main lines and the use of internet on GDP per capita across 49 selected countries. The sample was divided across upper-middle, upper-low, and low-income countries based on the 2008 World Bank classifications. The study found that both variables have a material impact on economic growth in upper-middle-income countries while only mobile telephone penetration has a significant impact on growth in both the upper-low-income and low-income countries. This highlights that internet access is not yet fully utilised in Africa for the continent to reap the benefits through economic growth.

Despite the fact that (Chavula, 2013), (Adeleye & Eboagu, 2019) and (David, 2019) focused their studies on the African continent, the results are conflicting depending on whether the researcher grouped the sample according the geographical regions or according to the World Bank income classifications. The ICT sector goes through various changes over time and therefore the period which the study covered possibly influenced the results obtained.

Röller & Waverman (1996) investigated how telecommunications infrastructure affects economic growth and in their model they utilised endogenous growth model, similar to (Chavula, 2013) and (Adeleye & Eboagu, 2019). The study was based on 21 OECD countries over a period of 20 years between 1970 and 1990. After accounting for simultaneity and country-specific effects, the study found evidence of a positive and significant link provided that a critical mass in a country's telecommunication infrastructure has been achieved. The study indicated that an increase in telecommunication infrastructure is expected to create greater value in developed OECD countries rather than in less-developed non-OECD countries. (Röller & Waverman, 1996) indicates that the impact is different from country to country depending on the level of infrastructure development. This confirms the earlier argument that there is a need for country-specific study to determine the actual impact and mitigate the risk from cross-sectional studies.

Nair et al., (2020) conducted a study on the relationship between R&D, ICT infrastructure development and economic growth in the OECD countries in the period between 1961 and 2018. The results of the study found that R&D and ICT development do significantly result in economic growth in the long term. The results were not conclusive with regard to the short-term impact, as the empirical study found a series of complex relationships. The study further suggests that the strength of the relationship further depends on the strategies that the countries implement to get the best results out of R&D and ICT, to drive economic growth. The study contradicts the results of (Handledare & Marmefelt, 2012), who found that information and technology only contribute to economic growth in on the short term and there is insufficient evidence to indicate that ICT contributes to sustainable economic growth.

Czernich et al., (2011) analysed the effects of telecommunication infrastructure with focus on broadband infrastructure on economic growth using a panel of annual data for OECD countries and the study found that GDP per capita was 2.7-3.9% higher on average than before the introduction of broadband.

Chakraborty & Nandi (2011) assessed the impact of telecommunications infrastructure investment in developing countries by subjecting country-specific data on mainline telephone density and per capita growth to a Granger causality test within a panel of cointegration framework. The findings of the study confirmed the results of (Röller & Waverman, 1996) that investment in telecommunication infrastructure has a potential to generate high growth returns in developed countries and less in less developed countries. In testing for bi-direction, (Chakraborty & Nandi, 2011) found that there is weak evidence of bi-directional casual links between telecommunication infrastructure investment on developed countries, opposing the results of (Röller & Waverman, 1996) who found strong evidence of a bi-directional causal link.

A study by (Dutta, 2001) on telecommunications and economic activity in 22 OECD countries found reasonable evidence of a causal relationship between telecommunications infrastructure and economic growth. In contrast, the study found that the causal relationship between economic activity and economic growth is slightly weaker. The study looked at 15 developing countries and 15 industries countries, by running a Granger causality test on data between 1970 and 1993. In conclusion, (Dutta, 2001) found that the relationship between telecommunications and economic activity is a complicated one but it plays a critical role in contemporary finance.

Using data for the years 2001 to 2012, (Ghosh, 2016) analysed the relationship between mobile telephony and economic growth in Middle East and North Africa (MENA) countries and the study found a significant relationship between the mobile telephony variables and economic growth. The conclusion of the study is in line with the findings of (Farid, 2012) who found a positive impact between broadband infrastructure and economic growth in some Arab countries and emerging countries.

Shiu & Lam (2008) studied the casual relationship between telecommunications and economic growth in China and its regions. The results found that there is a non-directional relationship between telecommunications development and GDP at national level. However, the study found evidence of bi-directional casual links between telecommunication development and GDP in affluent regions but not in the low-income regions. The study confirms the results of (Chakraborty & Nandi, 2011), who found evidence of causality in developed countries. The study only investigated the relationship between telecommunications and economic growth without looking at the direction of the casual relationship.

On a country-specific study, (Handledare & Marmefelt, 2012) investigated whether there is a casual relationship between GDP and ICT with focus on Sweden between 1980 and 2009 as this period represented an evolution based on innovation and technological knowledge in the country. The results indicated that ICT on its own is not sufficient to stimulate economic growth but is identified as a factor that can influence economic growth. The study further explained that as much as previous studies conducted by other researchers concluded that ICT investments contribute positively to economic growth, country-specific factors need to be taken into consideration. The study further found that there is no evidence of long-term benefits from telecommunication infrastructure towards economic growth and assumed that information and technology only contributed for a short period to economic growth.

Employing the Granger-causality technique, (Pradhan et al., 2021a), conducted a study on the dynamics between financial inclusion, ICT development, and economic growth in India. The study focused on 20 Indian states, utilising data between 1991 and 2018. The conclusion from the empirical study was that a good combination of ICT infrastructure development, financial inclusion initiatives, and economic growth strategies is critical in attaining economic development. Another study conducted on the Indian region is that of (Kaur & Malhotra, 2014) who looked at the impact of telecommunication on development of other sectors of the economy. By analysing data extracted for the period between 1995 and 2005, (Kaur & Malhotra, 2014) found a long-run relationship between telecommunication growth and economic growth at aggregate level and at sectoral level.

Hong (2017) conducted a study on the causal relationship between ICT R&D investment and economic growth in Korea and found a bidirectional Granger-causality and thus concluded that ICT R&D investment drives economic growth and vice versa. The study utilised data for a period between 1988 and 2013. The observation for Korea is similar to the findings of (Vu, 2013) who employed data extracted between 1990 and 2008 and found a strong positive relationship between ICT and an increase in productivity and estimated to have contributed 1 percentage point to Singapore's economic growth.

Sookha (2018) modelled the relationship between mobile communications infrastructure investment (MCII) on economic growth in South Africa, by utilising the neoclassical growth model by using GDP as a measure of economic growth. The study didn't find a relationship between mobile infrastructure development and economic growth. The author utilised data extracted between 1994 and 2016.

With focus on Ghana, (Atsu et al., 2014) investigated the long-run impact of telecommunications revenue on economic growth in the country, utilising data between 1976 and 2007. The study found a positive but negligible impact of telecommunications revenue on economic growth, and this has been attributed to the level of development in the telecommunications sector.

Similar to (Atsu et al., 2014), (Oyeniran & Onikosi-Alliyu, 2016) employed a autoregressive distributed lag (ARDL) bounds testing approach to examine the role of telecommunication infrastructure on economic growth in Nigeria. In utilising data from 1980 to 2012, the study found a long-run relationship between telecommunications development and economic growth, with foreign direct investment proving to be more effective than government investment.

2.5 Conclusion

In conclusion, most of the previous studies indicate that there is a positive relationship between telecommunication development and economic growth. There are a few studies on the African continent that provided contradicting results depending on whether the researchers grouped the countries according to the geographical locations or according to the World Bank categories of high, upper-middle, lower-middle, and low. There are also studies done with focus on developed versus developing countries, with most evidence indicating that there is stronger evidence of a causal link between telecommunication development and economic growth in developed countries and not so strong in developing countries. There were no similar studies done on the Namibian market and considering the inconclusive results from the previous studies, this study is considered relevant.

Table 4: Summary of the empirical literature on telecommunications and economic growth

	Author	Period	Country(ies)	Estimation technique	Conclusion
1	Alleman *et al.* (1994)	1983 to 1989	SADC	Macroeconomic statistical approach	Positive relationship
2	Röller & Waverman (1996)	1970 to 1990	21 OECD countries	Nonlinear three-stage least squares estimate of equations	Positive and significant link
3	Dutta (2001)	1970 to 1993	Developing and industrialised countries	Granger causality	Positive but complex
4	Shiu & Lam (2008)	1978 to 2004	China	Unit root tests, Granger causality	Mixed results
5	Czernich et al. (2011)	1996 to 2007	OECD	Instrumental variable model	Positive relationship
6	Chakraborty & Nandi (2011)	1985 to 2007	Developing countries	Granger causality with a panel cointegration framework	Mixed results
7	S. Lee et al. (2012)	1995 to 2006	44 SSA countries	Generalized Method of Moments (GMM) estimator	Mixed results
8	Handledare & Marmefelt (2012)	1980 to 2009	Sweden	Unit roots, Cointegration and Granger Causality	Not significant
9	Farid (2012)	1998 to 2008	22 emerging countries	Panel data techniques of fixed and random effects	Positive relationship
10	Chavula (2013)	1990 to 2007	49 African countries	Ordinary least squares (OLS)	Mixed results
11	Vu (2013)	1990 to 2008	Singapore	Generalized Method of Moments (GMM)	Positive relationship
12	Kaur & Malhotra (2014)	1995 to 2005	India	Unit root tests, cointegration tests, vector error-correction model (VECM), Granger causality	Positive relationship
13	Atsu et al. (2014)	1976 to 2007	Ghana	Ordinary linear least squares, Engle and Granger two-step methodology, unit root tests	Positive but negligible impact
14	Oyeniran & Onikosi-Alliyu (2016)	1980 to 2012	Nigeria	Unit root tests, cointegration tests, vector error-correction model (VECM), Granger causality	Positive relationship
15	Ghosh (2016)	2001 to 2012	MENA	Simultaneous equation model	Positive relationship
16	Hong (2017)	1988 to 2013	Korea	Unit root tests, cointegration tests, vector error-correction model (VECM), Granger causality	Positive relationship
17	Sookha (2018)	1994 to 2016	South Africa	Unit root tests, cointegration tests, vector error-correction model (VECM), Granger causality	No relationship
18	David (2019)	2000 to 2015	46 African	Generalized Method of Moments (GMM), Endogeneity test, stationarity tests	Positive relationship

	Author	Period	Country(ies)	Estimation technique	Conclusion
19	Adeleye & Eboagu (2019)	2005 to 2015	54 African countries	Pooled ordinary least squares, random and fixed effects and system generalised method of moments models.	Positive relationship
20	Nair et al. (2020)	1961 to 2018	OECD countries	Granger causality, cointegration test	Not conclusive
21	Pradhan et al. (2021)	1991 to 2018	India	Unit root tests, cointegration tests, vector error-correction model (VECM), Granger causality	Positive relationship

Chapter 3: Methodology

3.0 Introduction

This chapter provides an overview of the methodology utilised to establish the relationship between telecommunications development and economic growth in Namibia, thus addressing the research questions and hypothesis in chapter one. The first part of the chapter is the research approach and design, which includes a discussion on the data source, the sample size and period, the empirical model and the definition of the various variables used in the empirical model. The second part of the chapter is the description of the estimation techniques, which includes the unit root test, cointegration analysis, vector error correction model and the Granger causal test.

3.1 Research Approach

A quantitative research method will be utilised to evaluate telecommunication development and economic growth as the study aims to perform an econometric arithmetical examination to draw conclusions of whether there is a relationship between telecommunication development and economic growth. Economic growth is measured using GDP which is a numerical figure and telecommunication development is measured using different numerical variables and therefore a quantitative study is considered appropriate. (Mohammed, 2018) identified some of the advantages of a quantitative study which includes providing useful analysis and as an efficient and inexpensive study. However, the model requires good understanding of statistical tools however there are various tools available that can be utilised to do the analysis and provide useful information (Mohammed, 2018).

3.2 Research Design

3.2.1 Data, Sample Period and Size

The study is a quantitative study and the secondary data to be tested in the study will be obtained from the World Development Indicators (WDI) and the Financial Development and Structure Database (FDSD) of the World Bank for a period between 1995 and 2020. This period was selected due to the availability of data on the telecommunications variables, which is only available from 1995. Prior to 1995, the country only had one telecommunications operator, Telecom Namibia, which only provided fixed internet service and mobile services were only introduced from the year 1995. WDI data has been utilised in various studies and is considered a credible source. The data available on WDI will be compared to the information on the Namibia Statistics.

The World Bank database is considered a reliable and accurate source for secondary data that has been utilised in similar studies such as (Sookha, 2018), (Atsu et al., 2014) and (Adeleye & Eboagu, 2019). In addition, WDI provides secondary data collected from credible source that can be accessed with ease and provide for cost-effective research, that covers a long period, and in the Namibian context, data could be accessed from as far back as 1990.

3.2.2 Empirical Model

The study utilises the neoclassical growth model as it the model commonly used in similar studies and takes into consideration various factors such as capital investments, labour and technological advancements ((Adeleye & Eboagu, 2019); (Saidi et al., 2015); (Sookha, 2018). The model is represented by the following natural logarithm derived from (Adeleye & Eboagu, 2019) :

$$\ln Y_t = \alpha_0 + \alpha_1 \ln L_t + \alpha_2 \ln K_t + \alpha_3 Z'_t + u_t \qquad (1)$$

With $\ln Y_t$ being the natural logarithm of GDP; $\ln K_t$, the natural logarithm of gross fixed capital formation (% of GDP); $\ln L_t$, the natural logarithm of labour participation, Z' is the vector of natural logarithms of telecommunication variables (internet consumption, mobile subscription, and fixed telephone subscribers); and u_t the general error term.

3.2.3 Definition and Measurement of Variables

This subsection provides the list as well as the definition of the variables and how they are measured. In addition, the section includes a theoretical overview of how the variables are expected to impact the independent variable, gross domestic product, and reference to empirical evidence in support of the theories established.

3.2.3.1 Dependent Variable: Economic Growth

Economic growth is defined as an increase in real Gross Domestic Product (GDP) and is measured as increase in the value of goods and services produced in the country. (Soubbotina & Sheram, 2000) explains that GDP is calculated by either summing together all the income in the country or by adding together all the expenditure and the two methods are expected to yield the same value based on the expectation that one's income is another person's expenditure. There is, however, another measure of economic growth and that is the Gross National Product (GNP), which is calculated by taking GDP plus income from residents in foreign countries less income derived by foreign nationals in that country. GDP is the most common measure of economic growth, and therefore this study will look at economic growth measured as GDP.

3.2.3.2 Independent Variable

In line with similar studies and theoretical literature, the following independent variables were identified.

a) Labour Participation

This is the proportion of the population aged 15 and older, who can provide labour to produce goods and services. With reference to the neoclassical growth theory of (Solow, 1956), labour is one of the factors that is expected to result in economic growth and is considered a key production factor in developing countries due to the high cost of capital acquisition (Jones Zulu & Mattondo Banda, 2015), (Adeleye & Eboagu, 2019). Therefore, a positive relationship is expected between labour participation and economic growth.

b) Gross Fixed Capital Formation

This is the net increase in fixed assets, excluding depreciation and land additions, and is considered as an indicator of the country's ability to produce. This factor is further included as investment in telecommunications services in the form of expansion of infrastructure is expected to result in an increase in fixed assets, which are a component of gross fixed capital formation. According to the neoclassical growth theory of (Solow, 1956), economic growth is a result of the value added to production due to output from labour, capital and technological advancements. This is also supported by (Onyinye et al., 2017) who argued that a country cannot achieve substantial growth without a significant investment in capital formation and that capital formation is expected to result in an increase in productivity, which will in essence result in economic growth. Therefore, a positive relationship is expected between gross fixed capital formation and economic growth.

c) Individuals Using the Internet

This is the proportion of the population that have access to the internet which includes access to emails, online news, entertainment, and data. Internet is provided through investments in broadband infrastructure which is expected to contribute to economic growth in various ways (Koutroumpis, 2009). This is achieved through the investments in equipment, an increase in the labour force and an increase in communication between various industries and is thus expected to contribute to a growth in revenue and profits in other sectors thus contributing to economic growth both directly and indirectly. This variable is expected to have a positive significant impact economic growth in line with the findings of (Koutroumpis, 2009) and (Adeleye & Eboagu, 2019).

d) Mobile Cellular Subscribers

This is the number of individuals who have access to cellular technology for voice communication and is measured by the number of mobile cellular subscriptions per 100 inhabitants according to World Development Indicators. According to (Andrianaivo & Kpodar, 2011), an increase in mobile telephony provides a number of benefits, which includes access to financial services, to the less privileged in developing countries and the increase in financial inclusion is expected to result in economic growth. In addition, the investments in infrastructure utilised to provide the mobile services is expected to generate employment, generate revenue, which results in an increase in government revenue and an increase in productivity which facilitates financial development (Andrianaivo & Kpodar, 2011). This variable is expected to have a positive impact economic growth and this is consistent with the findings of (Waverman et al., 2005) and (Bahrini & Qaffas, 2019) who found a positive relationship between mobile subscriptions and economic growth and this is partially explained by the theory that mobile devices are seen as a substitute for fixed telephones which require extensive infrastructure, especially in developing countries.

e) Fixed Telephones Subscribers

This is the number of active analogue telephones, Voice over Internet Protocol (VoIP), fixed wireless local loop, ISDN voice-channel equivalents and fixed public payphones (Adeleye & Eboagu, 2019). With reference to (Bahrini & Qaffas, 2019), fixed telephone lines is expected to have a significant yet negative impact on economic growth in line with the evolution in the sector, which indicates that as the countries are developing, fixed telephones are replaced by mobile phones. The negative relationship is further expected in developing countries as fixed telephones require extensive infrastructure and this is one of the reasons they are being substituted by mobile phones (Waverman et al., 2005).

f) Subscriptions (S)

This variable represents the number of the total number of mobile and fixed telephone subscriptions. In accordance with various studies (Bahrini & Qaffas, 2019), (Venturini, 2007), (Quah, 2001), (Jorgenson & Vu, 2016) and supported by the neoclassical growth theory of (Solow, 1956), ICT is expected to result in economic growth. It is therefore expected that an increase in total subscriptions will result in an increase in economic growth: directly through increasing government revenues and contributing to domestic output and employment creation, and indirectly through improving productivity of other sectors and deepening financial inclusion amongst other benefits (Andrianaivo & Kpodar, 2011).

Table 5: Definition of variables

Variable	**Definition**
Dependent Variable	
Economic growth	(GDP) (current US$)
Independent variables	
Telecommunication Variables	Individuals using the internet (% of population)
	Mobile cellular subscriptions (per 100 people)
	Fixed telephone subscriptions (per 100 people)
	Subscriptions
Control variables	
L (PR)	Labour force participation rate for ages 15-24, total (%)
K (FCF)	Gross Fixed Capital Formation (Current US$)

Note: The data related to the variables is sourced from the World Development Indicators

3.3 Estimation Technique

3.3.1 Unit Root Tests

Time series is a series of observations indexed in time order, generally time series is a sequence taken at successive equally spaced points in time, (Gujarati & Porter, 2009). Time series data are generally assumed to be non-stationary and thus stationarity needs to be tested for, due to the nature of the data. The unit root test is used to determine the order of integration of the data. For the data to be stationary, it means that the data fluctuates about a mean or constant level and as such has a constant mean, variance, and covariance over time. To avoid the spurious results, non-stationary data can be made stationary through either differencing or detrending, (Shifotoka, 2015) .

Stationarity testing is done to avoid the issue of spurious results and provides for long-run stability in the data. In order to test for stationarity, based on the reasons provided above, the researcher will utilise the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) employed by (Atsu et al., 2014), (Kaur & Malhotra, 2014) , (S.-Y. T. Lee et al., 2005) & (Beil et al., 2005). The following ADF test will be utilised as expressed in (S.-Y. T. Lee et al., 2005):

$$\Delta Yt = \alpha Yt\text{-}1 + \sum_{i=1}^{m} \beta_i \, \Delta Y_{t-1} + \delta + \gamma t + \varepsilon_t \quad (2)$$

ΔY is defined as the first difference of the series, δ is a constant, *m* is the number of legs and *t* is the time trend. If the null hypothesis which is expressed as $\alpha = 0$ can be rejected the time series variables is considered stationery and the series, is *I(0)* which means it has zero integration. If the null hypotheses are not rejected, the time series variable is considered non-stationery and the ADF test is repeated to establish the order of integration.

The PP is a simplified version of the ADF test that is considered for more suitable for smaller samples and is expressed as follows according to (Kaur & Malhotra, 2014):

$$\Delta Yt = \alpha_0 + \gamma y_{t-1} + \gamma t + \varepsilon_{t.} \quad (3)$$

ΔY is defined as the first difference of the series, γ is a constant, y_{t-1} and *t* is the time trend.

3.3.2 Cointegration Test (ARDL)

Once stationarity is confirmed, the data would be tested for cointegration, to determine the long-run equilibrium of the data, (Gujarati & Porter, 2009) and this is essential in determining whether there is any relationship between the variables in question. Cointegration is a property of a collection of time series variables, it states that if two or more variables do converge to some long-run equilibrium then they are said to be integrated and as such, they move together, (Shifotoka, 2015). According to (Gujarati & Porter, 2009), cointegration means that individually nonstationary variables can form a linear combination of two or more time series can be stationary.

With reference to (Shahiduzzaman & Alam, 2014), the Autoregressive Distributed Lags (ARDL) bounds test will be utilised as it was suitable for that particular time series study that only had 21 observations and this research is aligned as there only 24 observations. In addition, the ARDL bound test is considered appropriate as it can be used regardless of whether the data is integrated or not. The ARDL as used in (Shahiduzzaman & Alam, 2014) is expressed as follows:

$$\Delta \ln Y = \beta_0 + \sum_{i=0}^{m} \beta_1 \Delta \ln Y + \sum_{i=0}^{m} \beta_2 \Delta \ln Kc + \sum_{i=0}^{m} \beta_3 \Delta \ln Ko + \sum_{i=0}^{m} \beta_4 \Delta \ln L + \sum_{i=0}^{m} \beta_5 \Delta \ln A + \sum_{i=0}^{m} \beta_6 \Delta \ln Y_{t-1} + \sum_{i=0}^{m} \beta_7 \Delta \ln Kc_{t-1} + \sum_{i=0}^{m} \beta_8 \Delta \ln Ko_{t-1} + \sum_{i=0}^{m} \beta_9 \Delta \ln L_{t-1} + \beta_{10} \ln At_{-1} + \varepsilon_t \quad (4)$$

3.3.3 Vector Error Correction Model

When the data series is not cointegrated, the unrestricted Vector Autoregressions (VAR) is used to estimate the regression, while the restriction is imposed in the presence of cointegration, and the next option would be the Vector Error Correction Model (VECM). The VAR is used for forecasting systems of interrelated time series and for analysing the dynamic impact of random disturbances on the system of variables, (Startz, 2013) and VECM is used to test the short-run relationship between the variables. The VECM allows for the estimation of the Granger causality test, the impulse response function and the variance decomposition tests.

3.3.4 Granger Causality

Granger causality is used to test whether the lagged values of one variable can be used to predict/forecast the value of another variable. The Granger causality test is used to determine causal relationships between the variables. Determining the direction and level of causality between variables is essential for decision-making. Policymakers need to be aware of the consequences of their policy directions. Given the dynamic systems of economies, one variable can have a simultaneous effect on a number of other variables and in the same vein, many variables can have a simultaneous impact on a single variable. As such, it is important to know how the different variables interact and hence the importance of the continuous need for research (Shifotoka, 2015).

The following model as employed by (Shiu & Lam, 2008) will be used to test whether there is a causal relationship between telecommunication development and economic growth:

$$GDP_{it} = \alpha_1 + \sum_{m=1}^{M} \alpha_m TEL_{i,t-m} + \sum_{m=1}^{M} C_m GDP_{i,t-m} + \mu_i + \eta_i + \nu_{it} \quad (5)$$

$$TEL_{it} = \alpha_2 + \sum_{n=1}^{N} b_n GDP_{I,t-n} + \sum_{n=1}^{N} d_n TEL_{i,t-n} + \varpi_i + T_i + e_{it} \quad (6)$$

The hypothesis is specified as H_1 = TEL does not cause real GDP growth and H_2 = GDP does not cause TEL. If the F-statistic for either of the above hypothesis exceeds the selected level, the null hypothesis can be rejected (Shiu & Lam, 2008) and the conclusion would be that there is no causal relationship between telecommunications development and economic growth in Namibia.

Chapter 4: Discussion of Findings

4.1 Introduction

In this chapter, the researcher presents the empirical results of the study. It includes descriptive statistics, stationarity test results, cointegration test, short-run regression estimates, Granger causality results and diagnostic test results.

4.2 Descriptive Statistics

The data in Table 6 provides a descriptive analysis of the variables in the regression model. The mean value of GDP, individuals using the internet, mobile cellular subscribers, labour force participation rate, subscriptions, telephones subscribers and fixed capital formation are 0.039270, 0.352052, 0.250952, -0.009469, 0.005438, -0.008102 and 0.027562 respectively. These values represent the average growth rates in the GDP per capita, number of individuals using the internet, gross fixed capital formation, mobile cellular subscribers, labour participation rate, number of subscriptions and number of fixed telephone subscribers, grounded on the data from 1995 to 2020.

Over the period in question, Namibia has recorded a positive average GDP per capital growth of 3.9% and a maximum growth rate of 38.6%. The lowest rate is a negative growth of 16.2%. Regarding the independent variables, individuals using the internet, fixed capital formation, mobile cellular subscribers and subscriptions all indicate an average positive growth rate over the study period, while labour participation rate and fixed telephone subscribers have reported an inverse average rate of growth. The individuals using the internet and the mobile subscribers have reported a double digit average growth rate over the period and this could be attributable to the substitution of fixed telephones with mobile devices as explained by (Waverman et al., 2005). The standard deviation results indicate that the number of individuals using the internet is the most volatile, while the labour participation rate is the least volatile.

Table 6: Descriptive statistics

	DLNGDP	DLNIUTI	DLNMCS	DLNPR	DLNS	DLNTS	DLNFCF
Mean	0.039270	0.352052	0.250952	-0.009469	0.005438	-0.008102	0.027562
Median	0.032042	0.124348	0.246278	0.000778	0.008531	-0.011246	0.091077
Maximum	0.385906	1.872513	0.988260	0.164313	0.134501	0.189765	0.339480
Minimum	-0.162808	0.012270	-0.064507	-0.141747	-0.327539	-0.158815	-0.406117
Std. Dev.	0.130515	0.525839	0.254240	0.059028	0.079211	0.080665	0.178009
Skewness	0.960442	2.038043	0.940898	0.289357	-2.917329	0.221363	-0.552288
Kurtosis	3.605213	5.725477	3.919818	5.481450	13.91474	3.289174	2.820815
Jarque-Bera	4.225083	25.04447	4.570026	6.763025	159.5570	0.291279	1.304369
Probability	0.120930	0.000004	0.101773	0.033996	0.000000	0.864469	0.520907
Sum	0.981759	8.801296	6.273805	-0.236722	0.135945	-0.202551	0.689059
Sum Sq. Dev.	0.408820	6.636148	1.551312	0.083624	0.150585	0.156164	0.760492
Observations	25	25	25	25	25	25	25

Note: GDP= Gross Domestic product ; FCF=Fixed Capital Formation; IUTI= Individuals Using The Internet; MCS= Mobile cellular subscribers; PR= Labour Force Participation Rate; S= Subscriptions; TS= Telephones subscribers; Source: EViews 9

The kurtosis statistic for GDP, individuals using the internet, mobile cellular subscribers, labour force participation rate, subscriptions, telephones subscribers and fixed capital formation is calculated at 3.605213, 5.725477, 3.919818, 5.481450, 13.9147, 3.289174 and 2.820815. Since all the variables except for fixed capital formation posted kurtosis of more than 3, the distribution is peaked.

The Jarque-Bera statistic is reported at 4.225083, 25.04447, 4.570026, 6.763025, 159.5570, 0.291279, 1.304369 with probabilities 0.120930 for GDP, 0.000004 for individuals using the internet, 0.101773 for mobile cellular subscribers, 0.033996 for labour force participation rate, 0.000000 for subscriptions, 0.864469 telephones subscribers and lastly 0.520907 for fixed capital formation. Under the null hypothesis of a normal distribution, the reported probability indicates that we can reject the hypothesis of normal distribution at 10% level of significance for individuals using the internet, labour force participation rate and subscriptions.

4.3 Correlation Results

The table below presents the correlation results in the form of a matrix. Correlation is measured on a scale of 0 to 1 with 0 indicating no correlation among variables and 1 indicating perfect correlation. Positive correlations are from 0.0134 to 0.6179 while negative correlations are from -0.009 to -0.2444. The dependent variable is positively correlated with fixed capital formation and mobile cellular subscribers but is negatively correlated with individuals using the internet, labour force participation rate, subscriptions, and telephone subscribers. With reference to (Kennedy, 2008), a high correlation coefficient of about 0.80 or 0.90 is an indicator of multicollinearity. The correlation coefficient between the variables is below 0.80 for all variables and therefore there are no concerns over multicollinearity.

Table 7: Correlation results

	DLNGDP	DLNIUTI	DLNFCF	DLNMCS	DLNPR	DLNS	DLNTS
DLNGDP	1	-0.0758	0.6042	0.0865	-0.235	-0.009	-0.244
DLNIUTI	-0.076	1	-0.22	0.6200	-0.095	0.32	-0.203
DLNFCF	0.604	-0.223	1	0.069	-0.0470	0.0727	0.2155
DLNMCS	0.0864	0.6179	0.0695	1	0.0134	0.3634	0.1065
DLNPR	-0.2352	-0.0952	-0.0471	0.0134	1	0.421	0.0540
DLNS	-0.00916	0.31525	0.07279	0.36312	0.4209	1	-0.0474
DLNTS	-0.2444	-0.2035	0.21553	0.107	0.054	-0.0474	1

Note: GDP= Gross Domestic Product; FCF=Fixed Capital Formation; IUTI= Individuals Using The Internet; MCS= Mobile Cellular Subscribers; PR= Labour Force Participation Rate; S= Subscriptions; TS= Telephones Subscribers;

4.4. Stationarity Tests

To test for unit root, the study used the Augmented Dickey-Fuller (ADF) test ADF and Phillips-Perron (PP) tests. The bounds test approach can yield positive defensible outcomes when the variables in the model are either I (0), I (1), or a combination of the two. The existence of I (2) variables invalidates the bounds testing approach. The stationarity results is presented in Table 8.

Table 8: Unit Root results

Name of variable	**Model Specification**	**Unit root test**				**Order of integration**
		ADF test		**PP test**		
		I(0)	**I(1)**	**I(0)**	**I(1)**	
GDP	Intercept and trend	-3.322*	-4.718***	-2.741	-11.11***	I (0)
FCF	Intercept and trend	-3.3925*	-22.31***	-3.3925*	-22.31***	I (0)
IUTI	Intercept and trend	-4.49***	-8.88***	-4.545***	-18.902***	I (0)
MCS	Intercept and trend	-6.12**	-6.681***	-8.79***	-18.77***	I (0)
PR	Intercept and trend	-4.72***	-3.49*	-4.71***	-17.3***	I (0)
S	Intercept and trend	-5.06***	-4.98***	-5.10***	-20.09***	I(0)
TS	Intercept and trend	-3.36*	-4.81***	-3.36*	-7.27***	I (0)

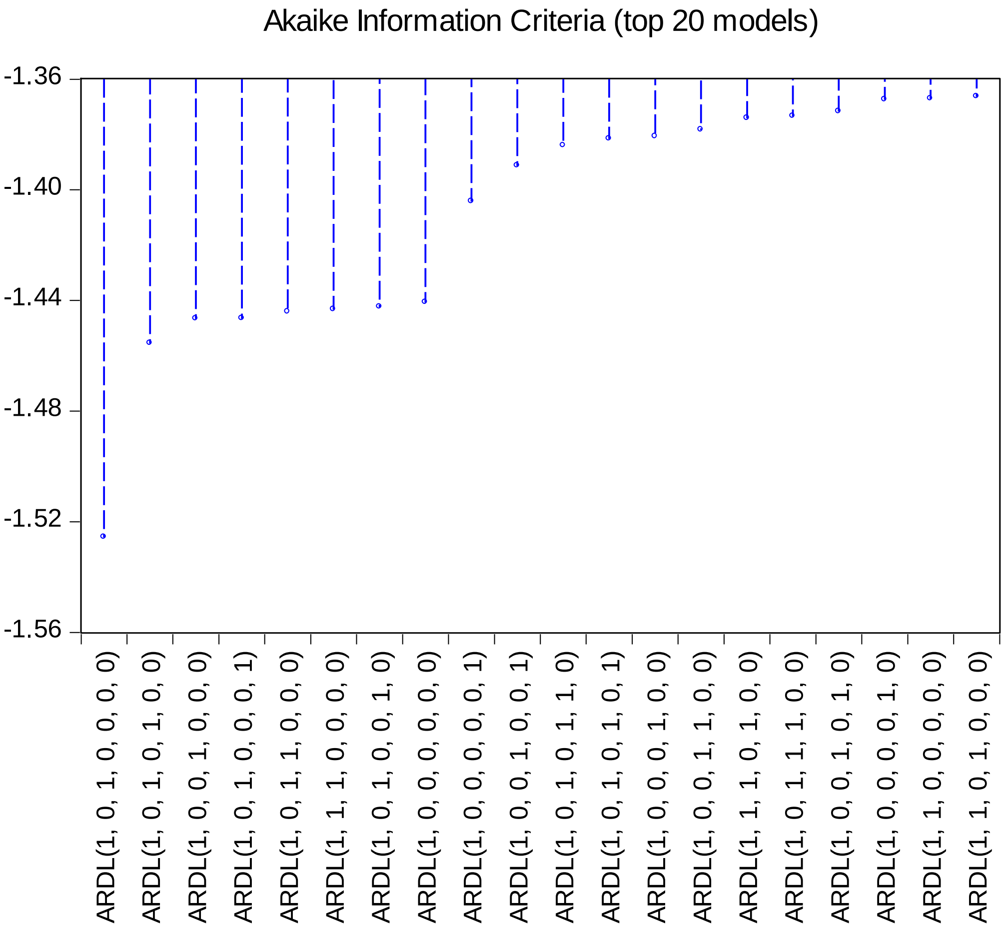
Note: GDP= Gross Domestic Product ; FCF=Fixed Capital Formation; IUTI= Individuals Using The Internet; MCS= Mobile Cellular Subscribers; PR= Labour Force Participation Rate; S= Subscriptions; TS= Telephones Subscribers; ADF=Augmented Dickey-Fuller; PP= Phillips-Perron; I(0)= Levels; I(1)= First differences; Source: Author's computation

Based on the results in Table 8, all variables are stationary in levels. More so, there are no I(2) variables which makes the use of ARDL models possible. Prior to that, the study reports on the optimal lag.

4.5 Optimal Lag Selection Criteria

The Akaike information criterion was utilized to provide the optimal lag length. EViews has the capacity to automatically select the suitable lag length. Figure 8 indicates that the model (1. 0. 1. 0. 0. 0. 0) reduces the AIC value and is therefore implemented by the study.

Figure 8: Lag length selection



Source: EViews 9

4.6. Cointegration Test Results

In Table 9 below, the computed F-stat is 2.135811 is less than the upper and lower bounds at 1% and 5% significance levels and at 10%, the computed F-stat is inconclusive. The study did not reject the null hypothesis of no cointegration and concludes that there are no long-run relationships between the variables. The results proves contradictory to those by (Atsu et al., 2014) and (Oyeniran & Onikosi-Alliyu, 2016) who found a long-run relationship between telecommunication infrastructure and economic growth in Nigeria. According to (S.-Y. T. Lee et al., 2005) it seems countries which experience long-term equilibrium of economic growth as a result of ICT have created favourable conditions in the long term to promote ICT growth. In addition, (S.-Y. T. Lee et al., 2005) found that countries lagging behind in technological advancements, with low internet penetration rate, have lagged behind in terms of yielding long term benefits between economic growth and telecommunications development. In the Namibian context, it can be assumed that the country is not yet at a level where it can experience benefits in the long term given the low internet penetration rate and that the industry is still young and up until 1995, there was only one telecommunication service provider which was providing fixed telephony services and is 100% state owned.

Table 9: ARDL Bounds Test

Test Statistic	Value	K
F-statistic	2.135811	6
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

Source: Author's computation using EViews

4.7 Vector Autoregression Estimates

Since there is no cointegration, it is imperative to estimate the short-run model to examine the nature of the relationship between variables in the short run. The table short-run estimates estimated using VAR (2) is presented in Table 10.

From the short-run results, the only significant variable is DLNIUTI(-2), which is the second lag of the natural logarithm of number of individuals using the internet, which is significant at 10%. The results indicate that there is negative relationship between the number of individuals using the internet and gross domestic product. There is an insignificant negative relationship between fixed capital formation and gross domestic product. The results further indicate that there is positive yet insiginicant relationship between the mobile cellular subscribers, subscriptions and fixed telephone subscribers. Labour force participation rate shows a positive insignificant relationship with gross domestic product for the first lag but a negative insignificant relationship for the second lag. According to the World Bank classifications, Namibia is classified as an upper middle income country and the results contradict the findings of (Chavula, 2013) who found that all telecommunications variables have a material impact on economic growth in upper-middle-income countries.

The number of lags of variables was choosen using the Akaike Information Criteria. Overall, the adjusted R-squared of 0.17 and the fact that the F-stat is not significant at 10% indicates the incomplete robustness of the model.

Table 10: Short Run VAR (2) estimates

	Coefficient	**T statistics**	**Probability**
DLNGDP(-1)	0.610805	1.66138	0.36765
DLNGDP(-2)	-0.233705	-0.64811	0.36059
DLNFCF(-1)	-0.422581	-1.49140	0.28334
DLNFCF(-2)	-0.123110	-0.49892	0.24675
DLNIUTI(-1)	-0.254898	-2.45609	0.10378
DLNIUTI(-2)	-0.010919	-0.12056	0.09057*
DLNMCS(-1)	0.184861	1.09007	0.16959
DLNMCS(-2)	0.044765	0.198	0.22584
DLNPR(-1)	0.311993	0.468	0.666
DLNPR(-2)	-0.822901	-1.075541	0.76520
DLNS(-1)	0.480594	0.8352	0.575
DLNS(-2)	1.176732	2.184	0.538
DLNTS(-1)	0.076527	0.158	0.4842
DLNTS(-2)	0.308667	0.6769	0.45599
C	0.070629	1.3517	0.0522*
R-squared	0.699062		
Adj. R-squared	0.172422		
Sum sq. resids	0.122610		
S.E. equation	0.123799		
F-statistic	1.327399		
Log likelihood	27.55821		
Akaike AIC	-1.092018		
Schwarz SC	-0.351478		
Mean dependent	0.040798		
S.D. dependent	0.136086		

*Note: GDP= Gross Domestic product; FCF=Fixed Capital Formation; IUTI= Individuals Using The Internet; MCS= Mobile cellular subscribers; PR= Labour Force Participation Rate; S= Subscriptions; TS= Telephones subscribers. * Significant @ 10%. Source: Author's computation using EViews 9;*

4.8 Granger Causality Test

Literature states that there exist Granger causality if the probability value is less than 10%. Notably, unidirectional causality is established if variables Granger cause each other, and bidirectional causality is established if causality runs from each variable to the other. The null hypothesis that a variable does not Granger cause the other is rejected if the probability value is less than 10%. There is no evidence of Granger causality between Telecommunications development and GDP growth in Namibia, and this means that neither fixed capital formation, individuals using the internet, mobile cellular subscribers, labour force participation, subscriptions and telephone subscribers cause GDP growth nor does GDP cause growth in any of the telecommunication variables. The results of the test indicate that there is a unidirectional Granger causality between mobile cellular subscribers (MCS) and fixed capital formation (FCF) with a probability below 5%. A weaker Granger causality is identified between fixed capital formation and labour force participation rate, between individuals using the internet and mobile cellular subscribers, and between labour participation rate and subscriptions which is significant at 10%.

Table 11: Granger causality test

Null Hypothesis:	Obs	F-Statistic	Prob.
DLNFCF does not Granger Cause DLNGDP	23	0.50032	0.6145
DLNGDP does not Granger Cause DLNFCF		0.51709	0.6048
DLNIUTI does not Granger Cause DLNGDP	23	1.03212	0.3764
DLNGDP does not Granger Cause DLNIUTI		0.93522	0.4108
DLNMCS does not Granger Cause DLNGDP	23	0.34199	0.7149
DLNGDP does not Granger Cause DLNMCS		0.02374	0.9766
DLNPR does not Granger Cause DLNGDP	23	1.90996	0.1769
DLNGDP does not Granger Cause DLNPR		0.40515	0.6728
DLNS does not Granger Cause DLNGDP	23	0.85875	0.4403
DLNGDP does not Granger Cause DLNS		1.45067	0.2605
DLNTS does not Granger Cause DLNGDP	23	0.31025	0.7371
DLNGDP does not Granger Cause DLNTS		1.88051	0.1813
DLNIUTI does not Granger Cause DLNFCF	23	0.49206	0.6194
DLNFCF does not Granger Cause DLNIUTI		0.84033	0.4478
DLNMCS does not Granger Cause DLNFCF	23	4.82399	0.021**
DLNFCF does not Granger Cause DLNMCS		0.34725	0.7113
DLNPR does not Granger Cause DLNFCF	23	0.70804	0.5058
DLNFCF does not Granger Cause DLNPR		3.25659	0.0621*

DLNS does not Granger Cause DLNFCF	23	2.01504	0.1623
DLNFCF does not Granger Cause DLNS		4.76833	0.0218
DLNTS does not Granger Cause DLNFCF	23	0.04570	0.9554
DLNFCF does not Granger Cause DLNTS		0.96657	0.3993
DLNMCS does not Granger Cause DLNIUTI	23	0.56168	0.5799
DLNIUTI does not Granger Cause DLNMCS		3.32448	0.0591*
DLNPR does not Granger Cause DLNIUTI	23	0.36601	0.6985
DLNIUTI does not Granger Cause DLNPR		0.28500	0.7553
DLNS does not Granger Cause DLNIUTI	23	0.31268	0.7354
DLNIUTI does not Granger Cause DLNS		0.17122	0.844
DLNTS does not Granger Cause DLNIUTI	23	0.56117	0.5802
DLNIUTI does not Granger Cause DLNTS		0.56796	0.5765
DLNPR does not Granger Cause DLNMCS	23	0.12865	0.8801
DLNMCS does not Granger Cause DLNPR		0.49318	0.6187
DLNS does not Granger Cause DLNMCS	23	0.04055	0.9604
DLNMCS does not Granger Cause DLNS		1.05034	0.3703
DLNTS does not Granger Cause DLNMCS	23	0.35926	0.7031
DLNMCS does not Granger Cause DLNTS		0.77397	0.4759
DLNS does not Granger Cause DLNPR	23	0.04705	0.9542
DLNPR does not Granger Cause DLNS		2.85032	0.0841*
DLNTS does not Granger Cause DLNPR	23	0.46316	0.6366
DLNPR does not Granger Cause DLNTS		0.03741	0.9634
DLNTS does not Granger Cause DLNS	23	0.81743	0.4573
DLNS does not Granger Cause DLNTS		0.54576	0.5887

*Note: GDP= Gross Domestic product ; FCF=Fixed Capital Formation; IUTI= Individuals Using The Internet; MCS= Mobile cellular subscribers; PR= Labour Force Participation Rate; S= Subscriptions; TS= Telephones subscribers. ** and * denotes rejection of null hypothesis at 5% and 10% respectively Source: Author's computations using EViews 9;*

With reference to some of the empirical literature reviewed as part of this study, the results have been contradictory for both country-specific as well as panel studies conducted. By looking at various regions in China, the results of the empirical study by (Shiu & Lam, 2008) indicate a unidirectional relationship between economic growth and telecommunications level and a causal relationship between telecommunications development and economic growth was only noted for the wealth regions of the country. With specific focus on India, (Kaur & Malhotra, 2014) found that there exists a long-run relationship between telecommunications development and economic growth, using data between 1995 and 2005 and this period is also covered as part of this study. The results of (Kaur & Malhotra, 2014) are further supported by (Pradhan et al., 2021b) who found a strong temporal causality between ICT development and economic growth in India.

In terms of regional studies conducted, (Chakraborty & Nandi, 2011) found that the effect of telecommunications on economic growth varies from country to country depending on the level of development and in terms of the less developed and emerging economics the category in which Namibia was classified, the study found robust bi-directional causal links between tele-density and GDP per capita in both the long run and the short run. The findings by (Dutta, 2001) indicate strong evidence of causality between telecommunications and economic activity in industrialised and developing countries.

4.9 Diagnostics Test Results

The test results below indicate a probability greater than 5%. Therefore, the study does not reject the null hypothesis of the absence of heteroskedasticity and of serial correlation. The residuals are therefore homoscedastic and are not autocorrelated. The Ramsey test indicates a probability value greater than 5%, which leads to the conclusion that the null hypothesis of model stability is not rejected, which indicates that the model is stable. A p-value of 0.350 for the J Bera test indicates a normal distribution for the residuals.

Table 12: Diagnostics test results

Test	**T- Statistics**	**P-value**
B-Pagan-Godfrey	0.6683	0.1074
B-G Serial Correlation LM Test	0.55174	0.4699
Ramsey Reset test	3.405447	0.0043
J-Bera test	2.0959	0.35

Source: EViews 9

4.10 Summary

In this chapter the researcher aimed at establishing the direction of the feedback effect between telecommunication development and GDP growth. The ADF and Phillip-Perron tests were employed to study the integration order of the variables and the results indicate that the variables are integrated of first order. The optimal lag length chosen by the AIC criterion for all differenced variables was 4. The model failed to establish a long-run relationship between the variables in question. The model was further modelled to be stable as it didn’t suffer from autocorrelation and heteroskedasticity. The short-run estimates were done using Vector Autoregression (VAR), and the results indicated that telecommunications variables did not influence GDP in the short run, except for number of individuals. The next chapter presents the conclusion and recommendations of the study.

Chapter 5: Conclusion and Recommendation

5.0 Introduction

This chapter presents a summary of the major findings of this study, and the conclusions reached. This includes a highlight of the research objectives and results of the empirical study conducted. The chapter further includes recommendations for future policies to promote economic growth and recommendations for further research.

5.1 Summary of Key Findings

The study was an empirical study that investigated the impact of telecommunications development on economic growth in Namibia, with the main objective of analysing the development of telecommunications in Namibia and to assess the effect the various variables that are part of telecommunications development on economic growth, measured as gross domestic product. The empirical formula employed in the study is based on the neoclassical growth model, which considers capital investments, labour, and technological advancements as drivers of growth.

The study employed the ARDL bound test techniques and the Granger causality tests based on the annual data as obtained from WDI, covering the period between 1995 and 2020, and found no evidence of a causal relationship between telecommunications development and economic growth in Namibia. The Augmented Dickey-Fuller and Phillip-Perron tests found that the variables were integrated to the first order. In addition, there was no evidence of a long-run relationship between the variables analysed in this study. The short-run estimates were done using Vector Autoregression (VAR), and the results indicated that telecommunications variables did not influence GDP in the short run, except for the number of individuals using the internet, which was significant at 10%. The results were contrary to the empirical findings of (Chavula, 2013), who concluded that telecommunications development has a significant impact on economic growth in upper-middle-income countries of which Namibia is a part.

The Granger causality tests revealed that there is no evidence of Granger causality between telecommunications development and economic growth in Namibia. The causality test revealed a unidirectional causality from mobile cellular subscribers to gross fixed capital formation, gross capital formation to labour force participation rate, gross fixed capital formation to subscriptions, from individuals using the internet to mobile cellular subscribers and from labour force participation rate to subscriptions. With regard to empirical studies reviewed as part of this study, there is no definite conclusion on whether there is a causal relationship between telecommunications development and economic growth, and (Chakraborty & Nandi, 2011) found that the effect of telecommunications on economic growth varies from country to country depending on the level of development.

According to the data on WDI, only 41% of the Namibian population is using the internet, which is significantly below the 68% that is recorded for South Africa. In addition, the industry is young and up until 1995, the country only had one telecommunications operator which only provided fixed services. Therefore the findings that telecommunications developments doesn't have a significant on economic growth aligns with some of the observations by (Atsu et al., 2014) that the country might not have reached a level yet where it can benefit significantly from telecommunications development and that there might be a need for the telecommunications infrastructure to reach a certain critical threshold for it to experience economic growth from telecommunications.

5.2 Recommendations

From the findings of this study, it can be concluded that the Namibian telecommunications sector is underdeveloped, and this is evident from the low internet penetration rates. The results further indicate that the industry is still young and has not yet reached the expected critical threshold where the impact of telecommunications development on economic growth is significant. The industry is under the control of the government, and it is therefore recommended that policymakers explore the option of privatisation as one of the ways of promoting investments in telecommunications infrastructure and thus improve access to telecommunications services.

In accordance with the empirical studies examined as part of this research, for countries to yield the benefits of telecommunications development, there is a need for specific policies directed towards creating a conducive environment that attracts investments in telecommunications infrastructure. This should include efforts to encourage new players to come in through foreign direct investment, domestic investments and through encouraging existing plays to re-invest profits back in the sector.

Some of the complementary factors that enable economic growth from telecommunications development identified by various studies include investments in research and development and implementing low tax tariffs on technological-related products. Government policies should therefore be directed towards looking into the complementary factors and driving further research in identifying why there is low internet penetration countries as well identifying ideal and efficient technologies that can accelerate development through expanding the telecommunications sector.

5.3 Future Research Directions

Future studies can look at the impact of telecommunications development on other sectors such as the financial services, agriculture, education, and the tourism sector as this study was limited to looking at overall economic growth. This could assist policymakers in directing developmental efforts towards key industries. Further research can also look at the impact of telecommunications infrastructure investments on economic growth in Namibia and this can further be broken down into research on the impact of investment on broadband infrastructure and the impact of mobile infrastructure on investments. A study that will focus on the relationship between telecommunications development and economic growth on various regions and on rural and remote areas is also recommended, as this can assist the government in developing complementary factors such as skills and developing other infrastructures which compliment telecommunications development.

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List of Appendices

APPENDIX A

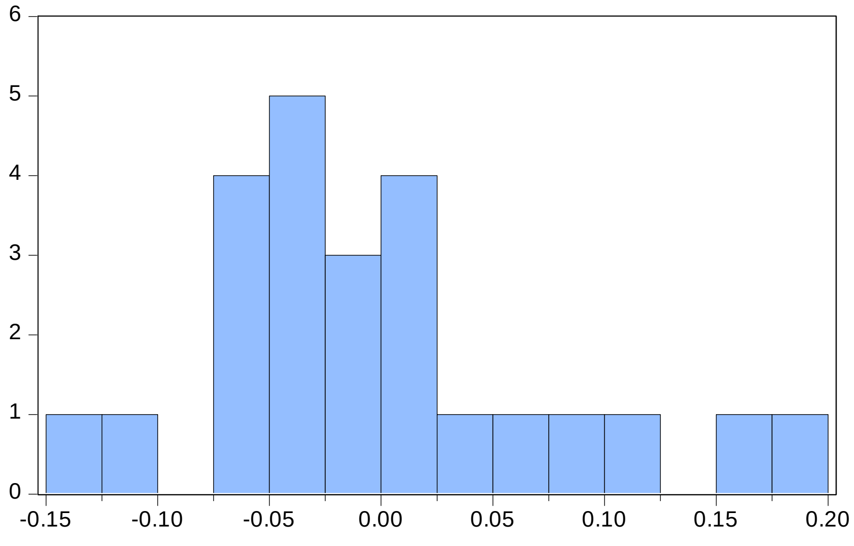
Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.551740	Prob. F(1,14)	0.4699
Obs*R-squared	0.909978	Prob. Chi-Square(1)	0.3401

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.724964	Prob. F(8,15)	0.6683
Obs*R-squared	6.692065	Prob. Chi-Square(8)	0.5702
Scaled explained SS	2.795416	Prob. Chi-Square(8)	0.9465

APPENDIX B: NORMALITY TESTS



Series: Residuals
Sample 1997 2020
Observations 24

Mean	1.04e-17
Median	-0.011335
Maximum	0.184744
Minimum	-0.137635
Std. Dev.	0.079225
Skewness	0.720532
Kurtosis	3.138731
Jarque-Bera	2.095915
Probability	0.350653

Ramsey RESET Test
Equation: UNTITLED
Specification: DLNGDP DLNGDP(-1) DLNFCF DLNIUTI DLNIUTI(-1) DLNMCS DLNPR DLNS DLNTS C
Omitted Variables: Squares of fitted values

	Value	Df	Probability
t-statistic	3.405447	14	0.0043
F-statistic	11.59707	(1, 14)	0.0043

APPENDIX C : ARDL MODEL AND BOUNDS TEST

Dependent Variable: DLNGDP
Method: ARDL
Date: 05/12/22 Time: 20:02
Sample (adjusted): 1997 2020
Included observations: 24 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (1 lag, automatic): DLNFCF DLNIUTI DLNMCS
DLNPR DLNS DLNTS
Fixed regressors: C
Number of models evaluated: 64
Selected Model: ARDL(1, 0, 1, 0, 0, 0, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
DLNGDP(-1)	0.033107	0.189728	0.174499	0.8638
DLNFCF	0.457309	0.136713	3.345023	0.0044
DLNIUTI	-0.025176	0.060491	-0.416198	0.6832
DLNIUTI(-1)	-0.068264	0.041169	-1.658130	0.1181
DLNMCS	0.119821	0.118853	1.008148	0.3294
DLNPR	-0.545455	0.416064	-1.310989	0.2096
DLNS	0.079487	0.339150	0.234371	0.8179
DLNTS	-0.627767	0.280453	-2.238400	0.0408
C	0.022064	0.031858	0.692573	0.4992

R-squared	0.645675	Mean dependent var	0.040795
Adjusted R-squared	0.456702	S.D. dependent var	0.133095
S.E. of regression	0.098102	Akaike info criterion	-1.525615
Sum squared resid	0.144361	Schwarz criterion	-1.083845
Log likelihood	27.30738	Hannan-Quinn criter.	-1.408413
F-statistic	3.416758	Durbin-Watson stat	1.615652
Prob(F-statistic)	0.019324		

*Note: p-values and any subsequent tests do not account for model selection.

Bounds test

ARDL Bounds Test
Date: 05/12/22 Time: 20:03
Sample: 1997 2020
Included observations: 24
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	2.135811	6

Critical Value Bounds

Significance	I0 Bound	I1 Bound

10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

APPENDIX D: PAIRWISE GRANGER CAUSALITY TESTS

Pairwise Granger Causality Tests
Date: 05/12/22 Time: 20:17
Sample: 1995 2020
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
DLNFCF does not Granger Cause DLNGDP	23	0.50032	0.6145
DLNGDP does not Granger Cause DLNFCF		0.51709	0.6048
DLNIUTI does not Granger Cause DLNGDP	23	1.03212	0.3764
DLNGDP does not Granger Cause DLNIUTI		0.93522	0.4108
DLNMCS does not Granger Cause DLNGDP	23	0.34199	0.7149
DLNGDP does not Granger Cause DLNMCS		0.02374	0.9766
DLNPR does not Granger Cause DLNGDP	23	1.90996	0.1769
DLNGDP does not Granger Cause DLNPR		0.40515	0.6728
DLNS does not Granger Cause DLNGDP	23	0.85875	0.4403
DLNGDP does not Granger Cause DLNS		1.45067	0.2605
DLNTS does not Granger Cause DLNGDP	23	0.31025	0.7371
DLNGDP does not Granger Cause DLNTS		1.88051	0.1813
DLNIUTI does not Granger Cause DLNFCF	23	0.49206	0.6194
DLNFCF does not Granger Cause DLNIUTI		0.84033	0.4478
DLNMCS does not Granger Cause DLNFCF	23	4.82399	0.0210
DLNFCF does not Granger Cause DLNMCS		0.34725	0.7113
DLNPR does not Granger Cause DLNFCF	23	0.70804	0.5058
DLNFCF does not Granger Cause DLNPR		3.25659	0.0621
DLNS does not Granger Cause DLNFCF	23	2.01504	0.1623
DLNFCF does not Granger Cause DLNS		4.76833	0.0218
DLNTS does not Granger Cause DLNFCF	23	0.04570	0.9554
DLNFCF does not Granger Cause DLNTS		0.96657	0.3993
DLNMCS does not Granger Cause DLNIUTI	23	0.56168	0.5799
DLNIUTI does not Granger Cause DLNMCS		3.32448	0.0591
DLNPR does not Granger Cause DLNIUTI	23	0.36601	0.6985
DLNIUTI does not Granger Cause DLNPR		0.28500	0.7553
DLNS does not Granger Cause DLNIUTI	23	0.31268	0.7354
DLNIUTI does not Granger Cause DLNS		0.17122	0.8440

DLNTS does not Granger Cause DLNIUTI	23	0.56117	0.5802
DLNIUTI does not Granger Cause DLNTS		0.56796	0.5765
DLNPR does not Granger Cause DLNMCS	23	0.12865	0.8801
DLNMCS does not Granger Cause DLNPR		0.49318	0.6187
DLNS does not Granger Cause DLNMCS	23	0.04055	0.9604
DLNMCS does not Granger Cause DLNS		1.05034	0.3703
DLNTS does not Granger Cause DLNMCS	23	0.35926	0.7031
DLNMCS does not Granger Cause DLNTS		0.77397	0.4759
DLNS does not Granger Cause DLNPR	23	0.04705	0.9542
DLNPR does not Granger Cause DLNS		2.85032	0.0841
DLNTS does not Granger Cause DLNPR	23	0.46316	0.6366
DLNPR does not Granger Cause DLNTS		0.03741	0.9634
DLNTS does not Granger Cause DLNS	23	0.81743	0.4573
DLNS does not Granger Cause DLNTS		0.54576	0.5887