CONNECTIVITY AS A CATALYST FOR ECONOMIC GROWTH: AN EMPIRICAL EVIDENCE FROM MALAWI

MASTER OF ARTS (ECONOMICS) THESIS

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MA (Economics) Thesis

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DECLARATION

This thesis is my own original work, and it has not been submitted to any other institution for similar purposes. Acknowledgments have been duly made where other people's work has been used. I bear the responsibility for the contents of this paper.

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Full Legal Name

Signature

Date

CERTIFICATE OF APPROVAL

The undersigned certifies that this thesis represents the student's own work and effort and has been submitted with my approval.

Signature: ________________________________ **Date:** ______________________

Name: Dr. Regson Chaweza, PhD, (Lecturer)

Supervisor

DEDICATION

I dedicate this thesis to my three beloved children: Kelvin, Malcolm, and Theodore.

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ABSTRACT

This study investigates the role of connectivity as a catalyst for economic growth in Malawi, a country facing persistent challenges in achieving sustained economic development. Despite significant investments in the telecommunications sector and increasing mobile phone penetration rates, the translation of these advancements into tangible economic growth remains uncertain. Using time-series data spanning 41 years from 1981 to 2021, the study employs telephone subscriptions as a measure for connectivity and annual percentage growth in GDP per capita as well as GDP as a measure of economic growth. Control variables such as population growth, inflation, and exports of goods and services are incorporated to provide a robust analytical framework. Stationarity tests and cointegration analysis are conducted to ensure the reliability of the econometric model.

The findings reveal no statistically significant impact of connectivity on economic growth in Malawi in either the short or long run. This suggests that Malawi's current telecommunications infrastructure may not yet be fully integrated into productive economic activities. Additionally, the control variables presented varied effects: inflation had a positive long-run effect on GDP per capita but a negative short-run impact, exports negatively influenced GDP per capita in the long run, and population growth showed no significant impact on economic growth. These results underscore the importance of targeted policies that enhance mobile infrastructure, promote digital literacy, and integrate telecommunications into high-impact sectors such as agriculture. By addressing these structural challenges, policymakers and stakeholders can better position Malawi to harness the potential of connectivity for long-term, inclusive economic growth.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

ARDL	Autoregressive Distributed Lag
ARIMA	Autoregressive Integrated Moving Average
CMR	Clemente-Montañés-Reyes
CUSUM	Cumulative Sum
DF-GLS	Dickey-Fuller with GLS Detrending
FTS	Fixed Telephone Subscriptions
GDP	Gross Domestic Product
GDPpc	GDP per capita
GMM	Generalized Method of Moments
GSM	Global System for Mobile Communications
ICT	Information and Communication Technology
I(0)	Integrated of Order 0
I(1)	Integrated of Order 1
I(2)	Integrated of Order 2
IMF	International Monetary Fund
LD	Lagged Dependent Variable
L2D	Lagged 2nd Difference
L3D	Lagged 3rd Difference
OLS	Ordinary Least Squares
SIM	Subscriber Identity Module
SMS	Short Message Service
USD	United States Dollar

VECM	Vector Error Correction Model

CHAPTER ONE

INTRODUCTION

1.1 Background

The world is witnessing a significant shift in the way economies operate, with a growing emphasis on leveraging mobile technology to drive economic growth. This trend is driven by the recognition that connectivity has the potential to unlock new opportunities for economic development, job creation, improved efficiency, and financial inclusion. As mobile technology continues to advance and become more ubiquitous, individuals and economies are increasingly seeking to harness its power to stay competitive and thrive in a rapidly changing global landscape.

One of the primary drivers of this shift is the recognition that mobile technology has the potential to create new job opportunities and stimulate economic growth. In many developing countries, mobile technology has already proven to be a powerful tool for entrepreneurship, innovation, and job creation. For instance, mobile money services have enabled individuals to access financial services and participate in the formal economy, even in areas where traditional banking infrastructure is lacking (GSMA, 2022). Similarly, mobile-based platforms have enabled small businesses to reach new customers and access new markets, thereby promoting economic growth and development (World Bank, 2019).

Another significant benefit of mobile technology is its ability to reduce time and space constraints in day-to-day business operations. With mobile devices, individuals can access information, communicate with clients and colleagues, and conduct transactions from anywhere, at any time. This has enabled businesses to operate more efficiently, respond more quickly to changing market conditions, and expand their reach into new markets (ITU, 2014). At the national level, mobile technology has enabled governments to deliver public services more effectively, improve transparency and accountability, and promote economic development (UNDP, 2021).

In addition, mobile technology has been instrumental in promoting financial inclusion, which is critical for economic growth. Mobile money services have enabled individuals to access financial services, save money, and make payments, thereby increasing their financial stability and resilience (Klaus Schwab, 2016). This, in turn, has enabled them to invest in income-generating activities, such as small businesses, which have contributed to economic growth. Moreover, mobile technology has enabled individuals to access credit, insurance, and other financial services, which have further contributed to economic growth (IMF, 2013).

Despite the many benefits of mobile technology, there is still a significant gap in our understanding of its impact on economic growth and development. While some studies have explored the impact of mobile technology on specific industries or sectors (Aker & Mbiti, 2010), there is a need for more comprehensive and rigorous research on its overall impact on economic growth and development. This study aims to contribute to this body of knowledge by exploring the relationship between connectivity and economic growth in Malawi.

1.2 Statement of the Problem

Malawi has been grappling with persistently low and fluctuating economic growth for decades. Despite significant efforts to improve the telecommunication sector, including a growing mobile phone penetration rate, fixed telephone subscriptions, investments in infrastructure in mobile technology, and increased competition in the telecommunication industry, this progress has not translated into sustained economic growth. This lack of observed economic growth presents a puzzle. A vast body of research suggests that mobile telecommunications can be a significant driver of economic growth globally (Amaghionyeodiwe & Annansingh-Jamieson, 2017; Asongu, 2021; Chinoda & Akande, 2019; Gbahabo & Ajuwon, 2019). These studies highlight various mechanisms through which mobile connectivity can contribute to economic development, including improved access to information and communication, financial inclusion, knowledge diffusion and innovation, and business process improvements.

While the potential benefits of connectivity are vast, it is crucial to acknowledge the existence of a digital divide within Malawi. A significant portion of the population still lacks access to mobile technologies or the skills to utilize them effectively (Buckley et al., 2015). This can hinder the overall impact of connectivity on economic growth. Additionally, the effects of connectivity on economic growth might vary depending on contextual factors. According to Sookha (2018), these factors are like the existing institutional framework, the level of economic development, and the specific sectors targeted. The mixed results from studies conducted in other countries further highlight the need for context-specific research. While some studies, like those mentioned earlier, observe positive relationships between connectivity and economic growth, others find insignificant or even negative effects (Mohamed & Nageye, 2022; Sookha, 2018). This underscores the importance of investigating the unique circumstances of Malawi to understand how connectivity influences its economic growth trajectory. While research has explored the benefits of telecommunication in other aspects of the Malawian economy, no study has directly assessed its impact on economic growth. Given the mixed findings in the broader literature and the specific context of Malawi, this study aims to fill this knowledge gap.

1.3 Main Objective

The main objective of this study is to assess whether connectivity has a statistically significant impact on economic growth in Malawi.

1.4 Specific Objectives

The specific objectives to be looked at in order to underscore the study are as follows;

1. To determine the long-run relationship between connectivity and economic growth.
2. To examine the short-run relationship between connectivity and economic growth.

1.5 Test Hypothesis

1. There is no long-run relationship between connectivity and economic growth.
2. There is no short-run relationship between connectivity and economic growth.

1.6 Significance of the Study

The findings of this study will contribute to achieving the goals outlined in Malawi Vision 2063, which emphasizes economic transformation and sustainable development. The research will also inform policy decisions regarding investments in mobile telecommunication infrastructure, digital literacy programs, and initiatives aimed at bridging the digital divide. By understanding the relationship between connectivity and economic growth, policymakers can develop targeted strategies to maximize the potential benefits of mobile technologies for Malawi's economic development.

1.7 Organization of the Paper

The thesis is systematically organized into six chapters, ensuring a coherent narrative flow throughout the study. This chapter has introduced the study, outlined the objectives, and discussed the significance of the study. Chapter 2 provides a contextual background of Malawi's economic growth and connectivity landscape. Chapter 3 critically reviews relevant literature, setting the theoretical and empirical foundation for the study. Chapter 4 details the research methodology and estimation techniques employed in the analysis. Chapter 5 presents and analyzes the findings, while Chapter 6 concludes the study with policy recommendations, discusses study limitations, and suggests directions for future research.

CHAPTER TWO

AN OVERVIEW OF ECONOMIC GROWTH CONNECTIVITY IN MALAWI

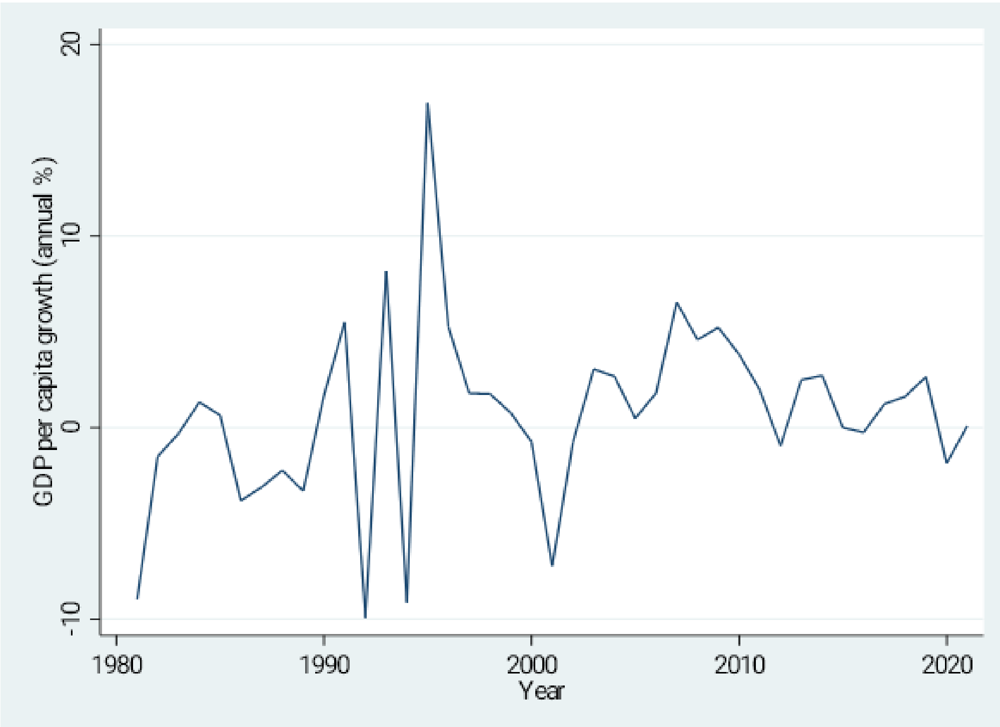
2.1 Trends in Economic Growth in Malawi

Malawi's economy is heavily dependent on agriculture, with limited diversification and primarily agro-based manufacturing. Since independence, the country has faced periodic macroeconomic volatility due to external shocks, poor reform implementation, inadequate fiscal discipline, and severe weather events. These factors have contributed to economic instability, resulting in massive fiscal deficits, government borrowing, and pressure on interest rates, inflation, and exchange rates. Malawi has one of the lowest investment rates in Sub-Saharan Africa (SSA), leading to minimal structural transformation and sustained poor economic growth (IMF, 2019).

Despite these challenges, from 2003 to 2010, Malawi experienced relatively high and stable GDP growth, driven by improved agricultural yields and fiscal space created by the HIPC-MDRI debt relief initiative (Jacob et al., 2022). However, growth declined after 2011 due to macroeconomic instability and climate shocks, with GDP growth slowing to 1.9% in 2012 from an average of 6.4% between 2006 and 2010 (African Development Bank Group, 2019).

In 2012, the government implemented crucial reforms, including a 50% depreciation of the Malawi Kwacha and a floating exchange rate regime. These reforms initially slowed growth but helped GDP rebound to 5.2% in 2013 (Tchereni et al., 2013). Subsequent weather-related challenges, including floods and droughts in 2015 and 2016, negatively impacted agricultural productivity and energy generation. However, the agriculture sector's recovery led to GDP growth rates increasing from 2.5% in 2016 to 4.0% in 2017 (Mangani, 2023; Tchereni et al., 2013). Stronger monetary policy and accumulation of foreign exchange reserves stabilized the exchange rate and inflation. By 2019, GDP growth reached 5.7% but the COVID-19 pandemic caused a significant slowdown in 2020 reducing GDP growth to 1.7%. Economic activity was particularly subdued in tourism, lodging, food services, agriculture, and transportation with manufacturing, and mining also impacted (Kamfose & Agila, 2023; Leman & Pemba, 2023). Overall Malawi's GDP per capita growth has lagged behind other developing countries that were at a similar level of development in the mid-90s. The figure below shows Malawi's trend of growth in per capita GDP.

Figure 1: Historical trend in GDP per capita growth



Source: Author's own computation using World Bank's WDI

2.2 Connectivity in Malawi

2.2.1 ICT and Digitalization

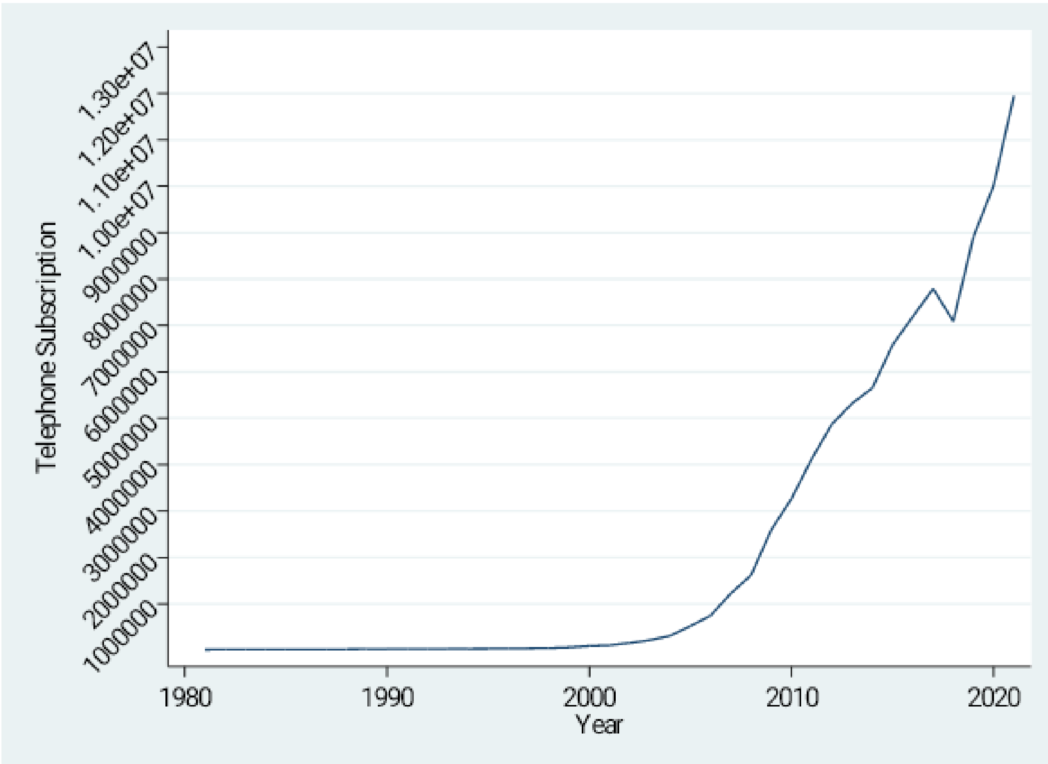
Malawi's ICT and digitalization history is characterized by progressive reforms and policies aimed at enhancing the sector's growth. The 1990s marked the beginning of major changes with the division and commercialization of telecom and postal entities into Malawi Telecommunications Limited (MTL) and Malawi Postal Corporation (MPC) fostering competition and service improvement (ITU Digital Access Index). The Communications Act of 1998 further facilitated this development providing a legal framework for the sector (The Malawi Communications Act, 1998). The National ICT Policy of 2013 aimed to use technology as a development tool although it faced challenges in full implementation. Recognizing the need for a more dynamic policy Malawi introduced the National Digitalization Policy which offers a broader and more flexible strategy to navigate the fast-paced digital. Efforts like the Digitalization Labs in 2022 and the introduction of the Inclusive Digital Economy Scorecard in 2023 demonstrate Malawi's proactive stance in embracing digital transformation to achieve its long-term development (Makoza, 2023).

2.2.2 Mobile Telecommunications in Malawi

Mobile telecommunications in Malawi have been developing over the years, with significant advancements in mobile data services. Operators have been expanding 3G and 4G networks to provide high-speed internet access across both urban and rural areas. This expansion is crucial for digital inclusion and economic growth (GSMA, 2022). As of 2022, under the country code +265, Malawi had approximately 12.28 million connections, with 12.27 million being mobile phones. This equates to an average of 0.60 mobile phones per person (Makoza, 2023). In comparison to countries like the United States, where the average is 1.1 mobile phones per person, Malawi is still developing its telecommunications infrastructure through policies like the national ICT policy and the ICT and Digitalization policy roadmap.

The country's two main mobile network operators, Airtel Malawi and TNM provide the majority of voice and data services. Both have invested in LTE technologies to enhance data service quality. Despite being considered underdeveloped, the telecommunications sector in Malawi has made significant strides towards improvement. Figure 2 below shows the historical trend in fixed telephone subscription rates in Malawi.

Figure 2 Historical Trend in Telephone Subscription (Fixed and Mobile) in Malawi



Source: Author's own computation using World Bank's WDI

CHAPTER THREE

LITERATURE REVIEW

3.1 Introduction

This chapter reviews the literature that best explains the relationship between mobile connectivity and economic growth. To begin with, the chapter discusses the conceptual issues of economic growth and connectivity. Then, it outlines various theories that best explain the relationship in the theoretical review section. Finally, the chapter presents an account of various empirical underpinnings by scholars in the fields of mobile connectivity and economic growth.

3.2 Conceptual Issues

3.2.1 Economic Growth

Economic growth refers to the increase in the production of goods and services in an economy over a period of time, typically measured by the growth rate of Gross Domestic Product (GDP). It is a key indicator of economic growth and development. Sustained economic growth can lead to improved living standards, increased employment opportunities, and enhanced public services. Economic growth is driven by various factors including capital accumulation, labor force growth, and technological advancement. These elements work in tandem to boost productivity and economic output, which in turn stimulates further growth.

Moreover, economic growth is essential for poverty reduction and overall societal well-being. As economies grow, they generate more resources that can be invested in health, education, and infrastructure, thereby improving the quality of life for citizens. Additionally, economic growth can enhance a country's global competitiveness by increasing its capacity to produce and export goods and services. However, it is crucial to ensure that growth is inclusive and sustainable, addressing issues such as income inequality and environmental degradation.

3.2.2 Connectivity

Connectivity refers to the ability of individuals and devices to access and communicate through both fixed subscriptions and mobile networks. This encompasses fixed telephone lines usage, mobile phone usage, mobile internet access, and the broader mobile telecommunications infrastructure. Connectivity has transformed how people interact, conduct business, and access information. It plays a pivotal role in modern economies by facilitating communication, driving innovation, and enhancing access to services. In many developing countries, Connectivity is a key enabler of economic development, providing access to financial services, educational resources, and healthcare.

The rapid adoption of mobile technology has been a game-changer, especially in regions with limited fixed-line infrastructure. Mobile phones enable users to perform a wide range of activities, from making calls and sending messages to accessing the internet and conducting mobile banking. This connectivity fosters economic participation, empowers individuals with information, and bridges the digital divide.

3.3 Theoretical Literature Review

3.3.1 Endogenous Growth Theory

The Endogenous Growth Theory, proposed by Robert Lucas and Paul Romer, emphasizes the role of technological progress as a key driver of long-term economic growth. Unlike the Solow model, which treats technological advancement as an exogenous factor, the Endogenous Growth Theory posits that technology and innovation are endogenous to the economic system. This means that investments in human capital, innovation, and knowledge can lead to sustained economic growth (Wu, 2024). Governments are encouraged to actively promote technological innovation and education to enhance growth prospects (Amaghionyeodiwe & Annansingh-Jamieson, 2017).

In the context of Malawi, Connectivity can significantly contribute to economic growth by fostering technological innovation and improving human capital. Enhanced access to information and communication technologies (ICTs) can lead to better education and training, which in turn can boost productivity and economic output. By investing in mobile infrastructure and promoting digital literacy, Malawi can harness the benefits of Connectivity to drive long-term economic growth (National ICT Policy, 2013).

3.3.2 Information and Communication Technology for Development (ICT4D) Theory

The ICT4D Theory, popularized by James and Mansell, focuses on the transformative potential of ICTs in developing economies (Nyamaka et al., 2020). This theory highlights how connectivity can drive economic development by improving access to information, markets, financial services, and government services. In Malawi, mobile phones can empower individuals and businesses by streamlining communication and transactions, enabling them to participate more effectively in the economy. This enhanced participation can lead to increased productivity and economic growth.

Moreover, ICT4D Theory underscores the role of Connectivity in addressing development challenges. By providing access to vital information and services, Connectivity can improve health outcomes, enhance educational opportunities, and support agricultural productivity. This holistic impact on various sectors can create a ripple effect, leading to broad-based economic growth and development (Nyamaka et al., 2020).

3.3.3 Diffusion of Innovations Theory

The Diffusion of Innovations Theory, developed by Everett Rogers, explains how new ideas and technologies spread within a population. According to this theory, the adoption of innovations follows a pattern where early adopters influence others, leading to widespread acceptance over time (Conti & Farsari, 2022). In the context of Malawi, mobile connectivity can enhance efficiency and communication, incentivizing its adoption across different sectors. As more individuals and businesses embrace mobile technology, the overall economy can benefit from improved productivity and economic growth.

The theory also suggests that the rate of adoption is influenced by factors such as perceived benefits, ease of use, and social influence (Conti & Farsari, 2022). In Malawi, efforts to demonstrate the tangible benefits of mobile connectivity, such as increased access to markets and financial services, can accelerate its adoption and subsequent economic impact.

3.3.4 Knowledge-Economy Theory

The Knowledge Economy Theory, emphasized by Peter Drucker and Fritz Machlup, posits that knowledge and information are primary drivers of economic growth in the modern era (Conti &

Farsari, 2022). Connectivity in Malawi can facilitate the creation, sharing, and utilization of knowledge by connecting individuals and businesses to vast information resources. This connectivity can fuel innovation, enhance skills, and improve decision-making processes, thereby driving economic expansion.

In a knowledge-based economy, the ability to access and utilize information efficiently is crucial. Connectivity provides a platform for continuous learning and innovation (Boczy & Cordini, 2020; Chu et al., 2020), enabling Malawi to compete in the global economy. By leveraging mobile technology, Malawi can enhance its human capital and boost productivity, leading to sustained economic growth.

3.3.5 Productivity Growth Theory

The Productivity Growth Theory, akin to the Endogenous Growth Theory, underscores the role of technological advancements in propelling economic growth (Boczy & Cordini, 2020). Connectivity can contribute to productivity growth in Malawi by streamlining business processes, enhancing communication and coordination within firms, and providing access to digital tools that improve efficiency. As businesses become more productive, the overall economy can benefit from increased output and economic development.

Enhanced Connectivity can also facilitate better access to markets, enabling businesses to expand their reach and increase sales. This improved market access can drive economic growth by encouraging entrepreneurial activities and investment in new technologies. By fostering a conducive environment for mobile connectivity, Malawi can stimulate productivity growth and achieve sustainable economic development.

3.4 Empirical Review

Internet usage is found to support all economic activities in Somalia which in return translates into economic growth. This is a conclusion based on the work of Mohamed & Nageye (2022) who estimated the nexus between internet usage and economic growth in Somalia utilizing data from 1999 to 2020 where internet penetration and per capita GDP growth were used as measures of internet usage and economic growth respectively. After controlling for export-import, consumption, and investment, the generalized linear model (GLM) was employed alongside the Engle-Granger cointegration approach where internet usage was found to have positively contributed to Somalia's economic growth.

In a study by Amaghionyeodiwe & Annansingh-Jamieson (2017), on the impact of mobile technologies on economic growth and employment in the Caribbean it was found that mobile technology positively influenced economic growth in the Caribbean countries. The paper examined the impact of mobile technologies in ten Caribbean countries which are primarily developing countries. It utilized cross-country panel data and regression analysis to estimate and investigate the impact of mobile technologies on economic growth. In the study, mobile technology was measured by three variables namely the internet user ratio, mobile-cellular telephone subscriptions, and fixed-telephone subscriptions. As a primary model for the study, the generalized method of moments (GMM) was used to estimate the relationship due to its ability to address potential endogeneity hence leading to efficient estimators. Various estimation techniques were utilized for robustness and these techniques are pooled ordinary least squares (OLS), individual random effects; individual fixed effects, time fixed effects, individual random effects, and time fixed effects. Results from the paper showed that all the coefficients of the mobile technology components namely the internet user ratio, mobile-cellular telephone subscriptions, and fixed-telephone subscriptions were all significant and positive across all the regressions.

In contrast to the findings by Amaghionyeodiwe & Annansingh-Jamieson (2017) who observed a positive influence of mobile technologies on economic growth in Caribbean countries, a study by Sookha (2018) investigating the impact of mobile telecommunications investment on economic growth in South Africa yielded different results. Their research employed an autoregressive distributed lags (ARDL) approach with data spanning 1994 to 2016. They used a neoclassical growth model with proxies like mobile operator capital expenditure and gross domestic product (GDP) to analyze the relationship. Interestingly, the study found no statistically significant long-run or short-run relationship between mobile communications infrastructure investment (MCII) and economic growth. Additionally, Granger causality tests indicated a unidirectional causal link from GDP to MCII, suggesting that economic growth might influence mobile network investment but not vice versa. These findings differ from the Caribbean case and highlight the need for further research to understand the context-specific factors influencing the relationship between mobile connectivity and economic growth.

Building on the work of Sookha (2018), who found no direct correlation between mobile network investment and economic growth in South Africa, a separate study by Asongu (2021) explores a broader perspective. Their research investigates the combined effects of mobile phone technology, knowledge creation, and knowledge diffusion on inclusive human development in 49 sub-Saharan African (SSA) countries. The study, spanning 2000-2012, utilizes Tobit regressions to analyze the data. Interestingly, the findings reveal a positive association between mobile phone penetration, knowledge creation/diffusion, and inclusive human development across SSA countries. This suggests that mobile technology when coupled with knowledge creation and dissemination, can act as a catalyst for broader societal progress. Further analysis delving into the economic, legal, religious, and political contexts of these countries revealed that mobile phone advancements fostered inclusive development irrespective of these factors. This indicates that the positive influence of mobile connectivity transcends various national characteristics. The study also highlights the negative impact of high pupil-teacher ratios, underlining the importance of quality education alongside technological advancements

The increasing diffusion of mobile phones has been recognized as a key factor in reducing barriers to financial inclusion in developing economies. A panel study by Chinoda & Akande (2019) explored this relationship in 32 African countries. Their findings suggest that financial inclusion does not directly impact economic growth in Africa, likely due to persistent barriers that lead to financial exclusion. These barriers, projected at around 90% according to Chinoda & Akande (2019), could include a lack of access to traditional banking infrastructure, complex application processes, or high transaction costs. However, the study highlights the positive role of mobile diffusion in overcoming these barriers. Mobile money platforms, a key feature of mobile phone use in Africa, offer convenience, lower transaction costs, and real-time access to financial services, reaching even unbanked populations of rural Africa. They found that when mobile diffusion was considered as an intermediary factor, a positive indirect effect of financial inclusion on economic growth emerged through structural equation modeling. While this study focused on a broader

African context, it provides valuable insights for investigating the specific case of Malawi, where mobile phone penetration is high and mobile money adoption is growing.

Gbahabo & Ajuwon (2019) did a study on mobile broadband and economic growth with a particular emphasis on the Nigerian economy. Here the authors mainly aimed at estimating the growth effect of mobile broadband. Quarterly time series data from the first quarter of 2002 to the fourth quarter of 2016 was used where the autoregressive distributed lag (ARDL) bounds testing approach was employed to achieve the said objective. The study findings indicate that mobile broadband is impacting economic growth positively in the Nigerian economy, and therefore the welfare.

On the contrary, Sule (2016) in a study where the effect of the internet on economic growth was assessed by utilizing the generalized method of moment (GMM) technique it was found that internet penetration was detrimental to economic growth. The study utilized panel data which spanned from 1990 to 2015 and pooled ordinary least squares technique was used alongside the GMM technique for robustness purposes.

In recognition of the benefits that come with mobile connectivity, the Malawi government is found, in a study by Mtingwi & Van Belle (2012) to be ready for mobile governments. In this qualitative study where more than 20 government and non-government stakeholders were interviewed, it was found that Malawi is, to a large extent, ready to embrace mobile government. This is an indication that efforts are being made in Malawi to utilize the existing mobile connectivity to its advantage by shifting away from the usual electronic government. The study employed a combination of the technology-organization-environment (TOE) framework and the task-technology fit (TTF) model to assess the government's readiness.

3.5 Conclusion

In conclusion, the reviewed literature presents a mixed picture regarding the impact of mobile technology on economic growth. While Amaghionyeodiwe & Annansingh-Jamieson (2017) observed positive effects in Caribbean countries, Sookha's (2018) study on South Africa found no significant relationship. This underscores the importance of context-specific analyses. Malawi's unique economic structure and mobile broadband penetration rate necessitate a dedicated investigation. Given the rising mobile penetration and usage in Malawi, yet the absence of research on its economic impact, this study aims to bridge this knowledge gap. By employing a suitable econometric framework, it will explore whether mobile broadband and fixed telephone subscriptions act as a catalyst for economic growth in the Malawian context. The findings will contribute to the ongoing debate on connectivity's role in fostering economic development, particularly in sub-Saharan Africa. Additionally, the research will offer valuable policy recommendations for the Malawian government to leverage mobile connectivity for sustainable economic growth.

CHAPTER FOUR

METHODOLOGY

4.1 Introduction

The methods used in the study are described in this chapter. The research's theoretical framework and empirical model are given. This chapter also covers data description, data source, and analysis method.

4.2 Measure of Connectivity and Economic Growth

Economic development (growth) is a multifaceted concept that can be measured using various indicators, including per capita GDP, the inequality-adjusted Human Development Index, and the Net per capita Food Production Index, among others. However, this study employs the growth rate in per capita GDP as a measure of economic growth. GDP as a measure of growth has also been employed to ensure robustness.

To capture connectivity, this study utilizes telephone subscriptions which is a summation of mobile subscriptions and fixed subscriptions. While there are several indicators used in the literature to measure connectivity, such as mobile cellular subscriptions, internet penetration rates, and broadband subscriptions, the choice of telephone subscriptions in this study is primarily motivated by data availability and consistency.

4.3 Theoretical Framework and Model Specification

In line with Gbahabo & Ajuwon (2019), Mohamed & Nageye (2022), and Sookha (2018) the study adopts the endogenous growth model in an attempt to explain the effects of connectivity on Malawian economic growth. As pointed out in the above section, this theory suggests that economic growth is primarily driven by endogenous factors rather than relying solely on external influences. It emphasizes the role of technology, innovation, and knowledge in driving productivity and growth. In the study, therefore, mobile connectivity can be seen as the technological advancement that enhances communication, access to information, and efficiency in various sectors of the economy. This, in turn, can lead to higher productivity and economic growth.

Under this model, the production function is

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} \text{ ………………………… equation 1}$$

Where:

- Y_t is the output (GDP or GDP per capita) at time t.
- A_t represents the level of technology
- K_t is the capital.
- L_t is the labor.
- α and β are the output elasticities of capital and labor, respectively

Assuming that technological progress is (A_t) is a function of mobile connectivity:

$$A_t = A_0 e^{\lambda \text{Mobile}} \text{ …………………………………… equation 2}$$

Where:

- A_0 is the initial level of technology.
- λ Represents the responsiveness of technology to mobile connectivity.

Substituting A_t into the production function:

$$Y_t = A_0 e^{\lambda \text{Mobile}} K_t^{\alpha} L_t^{\beta} \text{ ……………………………………… equation 3}$$

Taking the natural logarithm to linearize the model:

$$In(Y_t) = In(A_0) + \lambda \text{Mobile}_t + \alpha In(K_t) + \beta In(L_t)$$

We then divide by the population (P_t) to focus on per capita terms:

$$In\ In\left(\frac{Y_t}{P_t}\right) = In\ In(A_0) + \lambda Mobile_t + \left(\frac{K_t}{P_t}\right) + (\beta - 1)In(P_t) \text{ ………….... equation 4}$$

The per capita GDP growth rate ($\Delta In\left(\frac{Y_t}{P_t}\right)$) can then be expressed as:

$$\Delta In\ In\left(\frac{Y_t}{P_t}\right) = \lambda Mobile_t + \left(\frac{K_t}{P_t}\right) + (\beta - 1)\Delta In(P_t) \text{ ……………………….. equation 5}$$

In empirical terms, this translates to:

$$GDP_{pc\_growth} = \beta_0 + \lambda Mobile_t + \left(\frac{K_t}{P_t}\right) + \alpha_2 In(L_t) + control\ variable + \mu_t \text{ .... equation 6}$$

The empirical model to be estimated, therefore, is:

$$GDP_{pc\_growth} = \beta_0 + \beta_1 Mobile_t + \beta_2 Pop_t + \beta_3 Inflation_t + \beta_4 Exports_t + \mu_t \text{ .... equation 7}$$

For robustness, the model below is also estimated:

$$GDP_t = \beta_0 + \beta_1 Mobile_t + \beta_2 Pop_t + \beta_3 Inflation_t + \beta_4 Exports_t + \mu_t \text{ .... equation 8}$$

4.4 Modelling Framework and Econometric Specification

The study employs Autoregressive Distributed Lag (ARDL) models to investigate the influence of mobile connectivity on economic growth in Malawi. The choice of the ARDL model is informed by stationarity tests, which indicate the presence of non-stationary variables. These tests reveal a mix of I(0) and I(1) variables, making the ARDL approach particularly suitable. The ARDL model is advantageous as it accommodates both levels and first-difference stationary variables, thereby avoiding the issue of spurious regressions that would arise if Ordinary Least Squares (OLS) were applied.

The following are the econometric specifications of ARDL models with per capita GDP as the dependent variable. The ARDL approach is utilized to capture the dynamic relationship between mobile connectivity and economic growth in Malawi. Given the mixed order of integration [I(0) and I(1)] among the variables, the ARDL model is suitable for this analysis.

The econometric specification of the ARDL model in reduced form is given as follows:

$$\Delta GDPpc_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta GDP_{t-i} + \sum_{j=0}^{q} \beta_1 \Delta TS_{t-j} + \sum_{k=0}^{q} \beta_2 \Delta Inflation_{t-k} + \sum_{l=0}^{q} \beta_3 \Delta Exports_{t-l} + \sum_{m=0}^{q} \beta_4 \Delta Pop_{t-m} + \mu_t$$

Where:

- GDP_t: The growth rate of GDP per capita at time t, which is the dependent variable.
- TS_t: Telephone subscription (which includes both fixed and mobile subscriptions), the primary independent variable measuring **connectivity**.
- $Inflation_t$: Inflation rate (control variable).
- $Exports_t$: Exports of goods and services (as a percentage of GDP) (control variable).
- Pop_t: The percentage of the population aged 15-64 (control variable).
- Δ: Represents the first difference of the variable (to handle stationarity).
- α_0: Constant term
- $\alpha_1, \beta_1, \beta_2, \beta_3, \beta_4$: Short-run coefficients associated with the lagged differences of the variables.
- μ_t: Error term.
- p and q: Optimal lag orders, which are determined through lag length criteria like AIC or SBC.

The key advantage of the Toda-Yamamoto procedure is that it can be applied even if the variables are integrated of different orders, or if they are not cointegrated. This flexibility allows for a robust causality analysis between **connectivity** (telephone subscriptions) and **economic growth** without the strict assumption of stationarity.

4.5 Definition of Variables and their Expected Signs

4.5.1 Dependent Variable

4.5.1.1 GDP Per Capita Growth Rate (GDP)

This variable represents the rate at which the gross domestic product per capita grows. GDP per capita is the total value of all final goods and services produced within the boundaries of a country divided by its population, measured over a specific period of time. The growth rate of GDP per capita is used as a proxy for economic growth, reflecting the overall economic performance and development of the country.

4.5.1.2 GDP

To ensure the robustness of the results, an alternative model is estimated using **GDP in current US dollars** as the dependent variable. This serves as an additional measure of economic growth, complementing the primary model, which uses GDP per capita growth.

4.5.2 Independent Variables

4.5.2.1 Telephone Subscription (TS)

This variable represents the total number of telephone subscriptions (both fixed and mobile) in the population. It is used in this study as a measure of **connectivity**, capturing the broad infrastructure of communication in Malawi and its potential impact on economic growth. By combining fixed and mobile telephone subscriptions, TS provides a more comprehensive view of connectivity than fixed or mobile lines alone.

A positive relationship is expected between TS and GDP, as increased telephone subscriptions indicate improved communication infrastructure. Enhanced connectivity facilitates business operations, improves access to information, and increases productivity. These improvements in telecommunications infrastructure can contribute to higher economic growth by enabling more efficient transactions and information dissemination.

4.5.2.2 Population Ages 15-64 (% of Total Population)

This variable represents the percentage of the total population that falls within the working-age group (ages 15-64). This demographic is critical for economic productivity and growth, as it constitutes the majority of the labor force hence it is included in the study as a proxy for labor. The *apriori* expectation is a positive sign. A higher proportion of the working-age population is generally associated with increased labor supply, higher productivity, and economic growth. This demographic is typically more economically active, contributing to the production of goods and services and driving economic development.

4.5.2.3 Inflation, Consumer Prices (Annual %)

This variable captures the annual percentage change in consumer prices, reflecting the inflation rate. Inflation indicates the rate at which the general level of prices for goods and services is rising, thereby eroding purchasing power. High inflation erodes purchasing power, creates uncertainty, and can lead to lower investment and economic instability. It can also distort pricing mechanisms and reduce the real value of money, negatively impacting economic growth. Therefore, higher inflation is expected to be associated with lower economic growth. The inclusion of this variable as a control was based on the findings of Mangani (2023) and Tchereni et al. (2013) that inflation heavily determines the level of growth in Malawi.

4.5.2.4 Exports of Goods and Services (As a Percentage of GDP)

This variable measures the value of all goods and services exported as a percentage of the country's GDP. Exports are a crucial component of economic growth, as they contribute to foreign exchange earnings, job creation, and overall economic development. Higher exports contribute to economic growth by generating foreign exchange earnings, increasing production, and creating jobs. Strong export performance indicates a competitive economy and helps in balancing trade deficits, thus promoting overall economic stability and growth. Here, a positive effect is expected as well.

4.6 Data Source and Study Design

The study utilized data sourced from the World Bank Group's World Development Indicators (WDI). The dataset includes information on the growth rate in per capita GDP, fixed telephone subscriptions per 100 people, the percentage of the population aged 15-64, the annual inflation rate (consumer prices), and exports of goods and services as a percentage of GDP. The study employed a time series design spanning from 1981 to 2021.

4.7 Diagnostic Tests

4.7.1 Stationarity Tests

A time series is considered stationary if its mean and variance remain constant over time. Since this study utilizes time series data, testing for stationarity is crucial. Analyzing and interpreting non-stationary data can lead to spurious regressions (Gujarati & Porter, 2009; Wooldridge et al., 2016). These regressions exhibit high R-squared values with t-statistics that appear significant but lack economic meaning. Additionally, least squares estimates from such regressions are inconsistent, and conventional significance tests become unreliable (Wooldridge et al., 2016).

To investigate stationarity in the various series, this study employed the Clemente-Montañés-Reyes (CMR), Perron-Vogelsang, and Dickey-Fuller with GLS Detrending (DF-GLS) tests. The first two tests address the potential presence of structural breaks within the series themselves (Türsoy, 2017). Both tests utilize Additive Outlier (AO) and Innovation Outlier (IO) models. The AO model assumes sudden or rapid changes in the data structure, allowing for a break in the slope. Conversely, the IO model assumes gradual changes, allowing for breaks in both the intercept and slope.

The CMR test was applied initially to assess the existence of two structural breaks across all variables. Subsequently, the Perron-Vogelsang test, which considers one structural break, was employed for variables where the CMR test did not detect significant evidence of two breaks. Finally, for variables where neither one nor two breaks were significant, the Augmented Dickey-Fuller with GLS detrending test was conducted**.**

4.7.2 Cointegration

The Bounds test approach developed by Pesaran et al. (2001) was utilized to investigate the presence of a long-run relationship between economic growth and the independent variables. This test is suitable for models where variables are integrated of order I(0) or I(1). If the Bounds test indicated significant cointegration, it confirmed the presence of a long-run equilibrium relationship between the variables.

4.7.3 Parameter Stability

The parameters estimated in the study's analysis were considered reliable only if they exhibited stability over time. To assess this, recursive modeling with CUSUM tests was employed.

4.7.4 Autocorrelation

Autocorrelation arises when there is a significant correlation between the errors of a series at different points in time (Gujarati, 2004). While the presence of autocorrelation does not necessarily bias the estimators, it can make them inefficient and render usual hypothesis tests unreliable, leading to potentially misleading findings. The study employed Breusch-Godfrey tests to assess the autocorrelation of all orders for this purpose.

4.7.5 Model Specification and Selection

Ramsey's Regression Specification Error Tests (RESET) were employed to verify that the three models used for analysis were correctly specified. This test offers a general approach for detecting misspecification without requiring the specification of an alternative model (Gujarati, 2004). For appropriate model selection, the Akaike Information Criteria (AIC) was used to determine the optimal number of lags to include in each of the three regression models. Models with the lowest AIC values were chosen for estimation.

4.7.6 Heteroskedasticity

Heteroscedasticity occurs when the error variances following estimation are not constant (Gujarati, 2004). In such cases, while the parameter estimators remain unbiased and consistent, they do not achieve minimum variance. Therefore, the Breusch-Pagan-Godfrey test was employed to assess heteroscedasticity to ensure efficient results.

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1 Introduction

This chapter presents the findings of the study, which were derived from the analyses conducted based on the study objectives outlined in the previous chapter. To provide a concise overview of the data characteristics, descriptive statistics, including measures such as the mean, standard deviation, minimum, and maximum, are presented in the following section. Subsequently, we delve into the examination of relationships between connectivity and economic growth using multivariate regression techniques. Additionally, various diagnostic tests are presented and discussed to validate the results.

5.2 Descriptive Statistics

This section provides summary statistics for all variables used in the study. Table 1 below presents relevant information, including the number of observations, means, standard deviations, and maximum and minimum values.

Table 1: Descriptive statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
Per capita GDP	41	.752	4.788	-9.933	16.948
GDP	41	5.301m	3.526m	1.646em	1.260m
Telephone Subscription	41	2218492.5	3356039.9	15438	11952545
Inflation	41	19.176	13.909	7.412	83.326
Exports	41	15.29	3.131	9.275	23.092
Population	41	50.725	.99	49.581	54.146

Through the period, per capita GDP growth ranged from -9.933 to 16.948 with an average value of 0.752%. GDP ranged from $1.646 million to $12.6 million with an average value of $5.301 million while telephone subscriptions ranged from 14, 438 subscriptions to 11, 952, 545 subscribers with a mean value of 2, 218, 493 subscriptions.

Inflation rate and exports as a percentage of GDP ranged from 7.12% to 83.326% and from 9.275% to 23.092% respectively with mean values of 19.176% and 15.29% respectively. Lastly, the population ranged from 49.581 to 54.146 with a mean value of 50.725.

5.3 Unit Root Analysis

In this section, unit root tests are conducted on the variables to determine their order of integration. Initially, the approach proposed by Clemente, Montañés (CMR), and Reyes (1998) is employed to test for stationarity. This method accommodates two endogenous structural breaks in the mean of the series. If the results reject the hypothesis of the presence of two break dates, the Perron-Vogelsang test is applied, allowing for one endogenous structural break. Finally, if the single structural break is also insignificant, the Dickey-Fuller with GLS detrending (DF-GLS) test is used.

5.3.1 Clemente-Montañés-Reyes tests for stationarity

After applying CMR tests, GDP and inflation were found to have two significant break dates (BD1 and BD2) whereas the rest of the variables were found not to have 2 structural breaks. Their stationarity results are given in Table 2.

Table 2: Clemente-Montañés-Reyes tests for stationarity

Level	Coeff. (rho – 1)	T-Stat. (rho - 1)	Structural Break Dates				Results
			BD1		BD2		
			Date	Coeff.	Date	Coeff.	
GDP	-0.47186	-3.190	2003	4.00531e+09* (0.000)	2009	3.35131e+06* (0.000)	Unit root
Telephone Subscription	-0.04010	-3.302	1983	1.69868e+06* (0.279)	2018	-8.57959e+06* (0.000)	-
Per capita GDP	-1.09365	-4.055	1992	5.65579* (0.012)	1999	-2.32658 (0.240)	-
Exports	-1.14549	-5.782	1991	1.73675 (0.170)	1999	-4.26307* (0.000)	-
Population	-0.05810	-6.052	1983	-0.60798 (0.479)	1986	0.20707 (0.741)	-
Inflation	-0.95171	-3.822	1993	19.35079 (0.001)	2001	-22.82002 (0.000)	Unit root
First Difference							
GDP	-1.11314	-3.716	1999	5.9902 (0.112)	2009	-3.43170 (0.395)	Stationary
Inflation	-1.81676	-0.333	1993	-1.81676 (0.743)	2010	1.07801 (0.849)	Stationary

*Note: *5% critical value is -5.490*

The results in Table 2 indicate that at 5% significance level, the t-statistics for GDP and inflation are insignificant. This implies that per capita real GDP and the share of Population are nonstationary or are unit root processes at level. After first differencing, the t-statistics become significant and we conclude that the two series are stationary after first differencing. They are thus I(1) processes or integrated of order 1 as given by the IO model.

5.3.2 Perron-Vogelsang tests for stationarity

Going forth, after applying the Perron-Vogelsang test, telephone subscription and exports were found to have one significant break date and their stationarity results are presented in Table 3. The Perron-Vogelsang test results revealed that GDP per capita has no optimal breakpoint. In contrast, telephone subscription, with an optimal breakpoint in 2007, shows a t-statistic of 3.743 and a p-value of 0.003, indicating it is stationary. Similarly, exports, which have an optimal breakpoint in 2000, have a t-statistic of -3.418 and a p-value of 0.002, also confirming its stationarity. This is shown in Table 3 below.

Table 3: Perron-Vogelsang tests for stationarity

Level	Coeff. (rho – 1)	T-Stat.	Structural Break Date		Results
Variable name			Date	Coefficient	
GDP per capita	1.31961	-4.514	1995	1.31961 (0.418)	-
Telephone subscription	15.346	6.807	2007	484492.594 (0.003)	Stationary
Exports	-0.90552	-5.759	2000	-3.35203 (0.002)	Stationary

This approach also uses t-statistics to test null hypotheses of unit roots in the series. Results in Table 4.3 show that at 5% significance level t-statistics for the telephone subscription and exports are significant. This tells us that are stationary at level or they are thus I(0) processes.

5.3.3 Augmented Dickey-Fuller with GLS detrending test

The stationarity properties of the remaining variables were investigated using the Augmented Dickey-Fuller test with GLS detrending, and the results are presented in Table 4. The stationarity properties of GDP per capita and population, which did not exhibit any significant structural break, were also examined using the same test.

Table 4: Augmented Dickey-Fuller with GLS detrending tests for stationarity

Level	Optimal lags	Tau statistic	5% CV	10% CV	Result
GDP per capita	1	-1.869	-2.337	-2.033	Unit root
Population	1	-5.003**	-3.264	-2.952	Stationary
		First Difference			
D.GDP per capita	1	-3.499**	-2.346	-2.041	Stationary

*Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$*

The DF-GLS test checked for unit roots in variables of GDP per capita and population. For GDP per capita, the test found it likely has a unit root, meaning it is nonstationary which after taking its first difference becomes stationary. In contrast, the population variable is stationary, as indicated by its statistic of -5.003, which is well below the critical value.

This section's unit root tests revealed that some variables are stationary at their level (I(0)), while others require first differencing to achieve stationarity (I(1)). This distinction is crucial because applying Ordinary Least Squares (OLS) regression to non-stationary data can lead to spurious regressions, producing misleading results (Granger & Newbold, 1974). However, the presence of both I(0) and I(1) variables, with no evidence of series integrated to a higher order (I(2) or above), suggests the possibility of cointegration analysis using Autoregressive Distributed Lag (ARDL) models.

5.4 ARDL Bounds Test for Cointegration

To assess the existence of a long-run relationship between the variables, we employed the ARDL Bounds Test as proposed by Pesaran, Shin, and Smith (2001). The null hypothesis of no cointegration was tested against the alternative hypothesis of a long-run relationship. The results of the ARDL Bounds Test, including both the F-test and t-test statistics, are summarized in Table 5. These results provide strong evidence of cointegration among the variables in the model.

Table 5: ARDL Bounds Test for Cointegration

	Model 1		Model 2	
Significance	I (0)	I (1)	I (0)	I (1)
10%	4	2.45	2.45	3.52
5%	3.52	2.86	2.86	4.01
1%	3.74	5.06	3.74	5.06
F-statistic	4.949		7.900	

Accept the null hypothesis if F < critical value for I(0) regressors; reject if F > critical value for I(1) regressors. Accept the null hypothesis if t > critical value for I(0) regressors; reject if t < critical value for I(1) regressors.

The computed F-statistic of 4.949 in the first model and of 7.900 in the second model exceeds the upper bound critical values at all levels of significance, indicating strong evidence against the null hypothesis of no long-run relationship. Therefore, based on the ARDL Bounds Test results in Table 5 above, it is concluded that the variables examined exhibit long-run cointegration. This suggests a stable and significant relationship among the variables over time in the context of this study and hence allows the estimation of both the short-run and long-run ARDL results.

5.5 Diagnostic Tests

To ensure the reliability of the regression results, several diagnostic tests were conducted to check for heteroskedasticity, serial correlation, model specification, and normality for both **GDP per capita** and **GDP** as dependent variables. The results of these tests are summarized in Table 6.

Table 6: Diagnostic Test Result

		Dep Var: GDP per capita			Dep var: GDP		
Test	H_0	Chi2	P-value	Result	Chi2	P-value	Result
Heteroscedasticity	Constant variance	0.91	0.3396	Fail to reject H_0	6.82	0.009	Fail to reject H_0
Serial Correlation	No serial correlation	1.466	0.226	Fail to reject H_0	0.016	0.9008	Fail to reject H_0
Model Specification	No omitted variables	3.81	0.0347	Fail to reject H_0	4.76	0.0172	Fail to reject H_0
Normality	Normality	10.72	0.0047	Reject H_0	10.14	0.0054	Reject H_0

5.5.1 Breusch–Godfrey LM Test

The Breusch-Pagan/Cook-Weisberg test was used to check for constant variance in the residuals. For GDP per capita, the Chi-square value of 0.91 and a p-value of 0.3396 indicate that we fail to reject the null hypothesis of constant variance. Thus, no evidence of heteroscedasticity was found. However, for GDP, the test result shows a Chi-square value of 6.82 with a p-value of 0.009, leading us to reject the null hypothesis, suggesting the presence of heteroscedasticity. As a remedy, the model was re-estimated with robust standard errors.

5.5.2 Serial Correlation Test

The Breusch-Godfrey LM test was employed to detect the presence of autocorrelation in the residuals. For GDP per capita, the F-statistic is 1.466 with a p-value of 0.226, meaning we fail to reject the null hypothesis, indicating no evidence of serial correlation. Similarly, for GDP, the test result (F-statistic = 0.016, p-value = 0.9008) also leads to a failure to reject the null hypothesis, suggesting that there is no serial correlation in the model.

5.5.3 Jarque-Bera Test

The Jarque-Bera test for normality returned a chi-square statistic of 10.72 with a p-value of 0.0047 for the GDP per capita regression model and returned a chi-square statistic of 10.14 with a p-value of 0.0054 for the GDP regression model. This significant result leads us to reject the null hypothesis of normality, indicating that the residuals from our model do not follow a normal distribution.

5.5.4 CUSUM test for model stability

The cumulative sum (CUSUM) of residuals was used to test parameter stability. As depicted in the figure in the appendix, the parameters appear to be stable over time at 5% significance level as the cumulative sums did not go beyond the area between the critical lines for both models.

5.6 ARDL Estimation Results

The Autoregressive Distributed Lag (ARDL) model was estimated to analyze the short-run and long-run relationships between GDP per capita and GDP with the independent variables which include telephone subscriptions, inflation, exports, and population. The results for both the short-run and long-run estimations are presented in Table 7 below.

Table 7: ARDL Estimation Results

Variables	Dep Var: GDP per capita		Dep var: GDP	
	Coefficient	P-Value	Coefficient	P-Value
ECM (-1)	-1.336091	0.002	-0.17345057	0.652
Long Run				
Telephone Subscription	1.92E-07	0.743	15.37221	0.975
Inflation	0.4037856	0.028**	2.64E+07	0.584
Exports	-1.342999	0.022**	-3.02E+08	0.147
Population	-0.7767662	0.498	-1.64E+08	0.827
Short Run				

GDP per capita				
LD.	-0.1247618	0.709	-0.0877278	0.8
L2D.	0.1482047	0.559	-0.369321	0.235
Telephone Subscription				
D1.	7.21E-07	0.753	868.4909	0.24
Inflation				
D1.	-0.6002208	0.004**	-3.33E+07	0.453
LD.	-0.2945491	0.15	-4.01E+07	0.437
L2D.	-0.2694293	0.031**	-1.83E+07	0.581
L3D.	-0.0295555	0.815	-2819088	0.901
Exports				
D1.	1.786027	0.005**	9.81E+07	0.577
LD.	1.741511	0.006**	1.87E+08	0.177
L2D.	0.694188	0.101	6.62E+07	0.585
Population				
D1.	41.60507	0.386	2.04E+09	0.84
LD.	-106.7847	0.145	-2.18E+09	0.89
L2D.	122.4787	0.055*	2.52E+08	0.983
L3D.	-63.6494	0.055*	6.40E+08	0.912
Constants	69.43978	0.413	1.33E+10	0.736
R-square	0.7201		5.54E-01	
Adjusted R-squared	0.4072		0.5241	

*Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$*

5.6.1 Error Correction Term (ECM)

The error correction term (ECM) measures the speed of adjustment toward long-run equilibrium. For the GDP per capita model, the coefficient of ECM (-1) is negative and statistically significant at the 1% level (-1.336091, p-value = 0.002), indicating that 133.6% of any deviation from the long-run equilibrium is corrected within a year. However, in the case of the GDP model, the ECM (-1) is not significant (-0.17345057, p-value = 0.652), suggesting a weak adjustment to long-run equilibrium for this variable.

5.6.2 Long Run Results

5.6.2.1 Telephone Subscription

In the long run, telephone subscriptions have no statistically significant effect on either GDP per capita (coefficient = 1.92E-07, p-value = 0.743) or GDP (coefficient = 15.37221, p-value = 0.975). This suggests that changes in telephone subscriptions are not a significant driver of long-run GDP or GDP per capita growth in this model.

5.6.2.2 Inflation

Inflation has a significant positive long-run effect on GDP per capita (coefficient = 0.4037856, p-value = 0.028), indicating that rising inflation may boost GDP per capita. However, inflation does not have a significant impact on GDP (coefficient = 2.64E+07, p-value = 0.584).

5.6.2.3 Exports

Exports negatively impact GDP per capita in the long run, with a significant coefficient of -1.342999 (p-value = 0.022), indicating that higher exports are associated with lower per capita GDP. For GDP, the effect of exports is negative but not statistically significant (coefficient = -3.02E+08, p-value = 0.147).

5.6.2.4 Population

The population variable is not statistically significant in the long run for both GDP per capita (coefficient = -0.7767662, p-value = 0.498) and GDP (coefficient = -1.64E+08, p-value = 0.827).

5.6.3 Short Run Results

5.6.3.1 GDP Per Capita (Lagged Differences)

In the short run, neither the first (LD.) nor second lag (L2D.) of GDP per capita is statistically significant, with coefficients of -0.1247618 (p-value = 0.709) and 0.1482047 (p-value = 0.559) respectively. For GDP, the lagged effects also show no statistical significance in the short run.

5.6.3.2 Telephone Subscription

The short-run effect of changes in telephone subscriptions is insignificant for both GDP per capita (coefficient = 7.21E-07, p-value = 0.753) and GDP (coefficient = 868.4909, p-value = 0.24).

5.6.3.3 Inflation

Inflation has a significant short-run impact on GDP per capita. The first difference (D1.) of inflation shows a significant negative effect (coefficient = -0.6002208, p-value = 0.004). Additionally, the second lag (L2D.) of inflation also shows a significant negative effect (coefficient = -0.2694293, p-value = 0.031). In contrast, inflation does not have a significant effect on GDP in the short run.

5.6.3.4 Exports

Exports have a statistically significant positive short-run impact on GDP per capita. The first difference (D1.) of exports shows a coefficient of 1.786027 (p-value = 0.005), and the lagged difference (LD.) shows a coefficient of 1.741511 (p-value = 0.006). These results suggest that exports contribute positively to GDP per capita growth in the short run. However, exports do not have a significant short-run effect on GDP.

5.6.3.5 Population

The population variable shows mixed short-run effects on GDP per capita, with the second (L2D.) and third lags (L3D.) of population being marginally significant at the 10% level (coefficient = 122.4787, p-value = 0.055; coefficient = -63.6494, p-value = 0.055, respectively). However, population does not significantly affect GDP in the short run.

5.6.4 Goodness of Fit

The model for GDP per capita explains a substantial proportion of the variation in the dependent variable, with an R-squared value of 0.7201 and an adjusted R-squared of 0.4072. On the other hand, the GDP model has a lower explanatory power, with an R-squared of 0.554 and an adjusted R-squared of 0.5241.

5.7 Discussion

In line with the findings of Sookha (2018) in South Africa which found no correlation between mobile telecommunications investment and economic growth using an ARDL approach, this study's findings have shown that there is no short-run or long-run relationship between connectivity and either GDP per capita or GDP. This finding might suggest that Malawi's telecommunications infrastructure might still be too infantile to translate into productive sector integration to drive measurable economic growth. This, therefore, leads to the conclusion that connectivity alone may not yield economic benefits without significant supporting infrastructure and policies as it is the case with Malawi's economy. This is also in line with the findings by Sule (2016) who noted that internet penetration did not consistently translate to economic growth in a broader panel context. This study's findings do not align with those found by Amaghionyeodiwe & Annansingh-Jamieson (2017) and Mohamed & Nageye (2022) who found that mobile technology and internet connectivity influenced economic growth in the Caribbean and Somalia respectively suggesting a high level on infrastructure investment and policies to support the telecommunication sector making it effective enough to translate into economic growth.

On the other hand, the findings show that inflation has a complex relationship with economic growth, exerting a significant positive effect on GDP per capita in the long run but a negative effect in the short run. This suggests that moderate inflation may support growth over time, consistent with theories that link controlled inflation to economic expansion, yet it can suppress short-term purchasing power, echoing concerns raised by Mangani (2023). Exports exhibited a significant negative long-run effect on GDP per capita, aligning with research on developing economies where primary exports can hinder growth due to volatility and low-value addition, underscoring the need for diversification in the export sector. Finally, population showed no significant impact on economic growth, suggesting that Malawi's growing working-age population does not translate into higher economic productivity, likely due to limited employment and educational opportunities, as highlighted by Asongu (2021) in the broader Sub-Saharan African context.

CHAPTER SIX

CONCLUSION AND IMPLICATIONS

6.1 Chapter Overview

This study aimed to examine the impact of connectivity on Malawi's economic growth by analyzing the relationship between telephone subscriptions, inflation, exports, population, and economic growth indicators. Given the increasing adoption of mobile technology in Malawi, this study sought to assess whether this growth in connectivity contributes to economic performance. This chapter summarizes the primary findings, outlines policy implications, and suggests directions for future research.

6.2 Conclusion

The study's findings reveal that telephone subscriptions, as a measure of connectivity, did not have a statistically significant effect on Malawi's GDP or GDP per capita in either the short or long run. This result contrasts with studies in other developing regions, where connectivity has been linked to economic growth, and suggests that Malawi's current level of telecommunications infrastructure may not yet be fully integrated into productive economic activities. Additionally, the control variables presented distinct influences: inflation showed a complex relationship with growth, having a positive long-run effect on GDP per capita but a negative short-run effect, while exports negatively impacted GDP per capita in the long run. Population growth (working-age population) was found to have no significant effect on economic growth, indicating that demographic expansion alone does not drive productivity gains without sufficient economic opportunities. These findings underscore the need for tailored policies that enhance the productive use of connectivity within the Malawian economy and address structural challenges in other key areas influencing growth.

6.3 Policy and Analytical Implications

To begin with, the findings from the study have the following implications for policymaking:

Enhance Mobile Connectivity for Economic Integration. Although telephone subscriptions did not show a direct impact on growth, the potential of mobile technology to support economic activities remains significant. Policymakers should focus on expanding mobile infrastructure and reducing service costs, especially in underserved rural areas, to increase connectivity. Additionally, promoting digital literacy and providing incentives for the productive use of mobile technology could help integrate telecommunications into Malawi's economic fabric, especially in areas such as finance, trade, and services.

Leverage Mobile Technology in Key Economic Sectors. The government should consider policies that facilitate the integration of mobile technology into high-impact sectors, such as agriculture, which employs much of Malawi's population. Mobile-based solutions can support farmers by providing timely market information, weather updates, and financial services, improving productivity and income levels. Supporting initiatives that connect mobile platforms to agricultural value chains would allow a broader segment of the population to benefit from the digital economy, indirectly supporting overall growth.

Manage Inflation and Strengthen Export Diversification. The findings indicate that inflation has a mixed impact on economic growth, emphasizing the need for effective monetary policies that stabilize inflation while supporting long-term growth. Furthermore, the negative impact of exports on GDP per capita suggests the importance of diversifying Malawi's export base to reduce dependence on primary commodities. Policies that promote value addition and resilience in export sectors can mitigate the adverse effects of external shocks on economic stability and improve income distribution.

Promote Human Capital Development. The non-significant impact of population growth on economic performance highlights the importance of investing in human capital. Education, vocational training, and health services are essential for transforming Malawi's working-age population into a productive workforce. This approach will help the country harness its demographic dividend and ensure that economic gains are more equitably distributed across the population.

6.4 Directions for Future Research

Future studies should consider more direct measures of connectivity, such as mobile phone penetration rates, internet usage, and mobile broadband access, to capture the current landscape of mobile connectivity. As this study used fixed telephone subscriptions as a proxy, future research could yield more relevant insights by focusing on mobile and internet connectivity metrics, especially in light of technological advancements and increased mobile use.

Further research could also benefit from incorporating variables like investment in mobile infrastructure, digital literacy rates, and sector-specific connectivity impacts. This would offer a more comprehensive understanding of how connectivity influences economic growth across different sectors of Malawi’s economy. Additionally, examining the role of intermediary factors, such as financial inclusion and regulatory environment, may provide valuable insights into how connectivity can be optimized to support sustainable growth. Finally, a comparative analysis between Malawi and similar economies in Sub-Saharan Africa could deepen understanding of regional differences and inform policies tailored to Malawi’s unique economic landscape.

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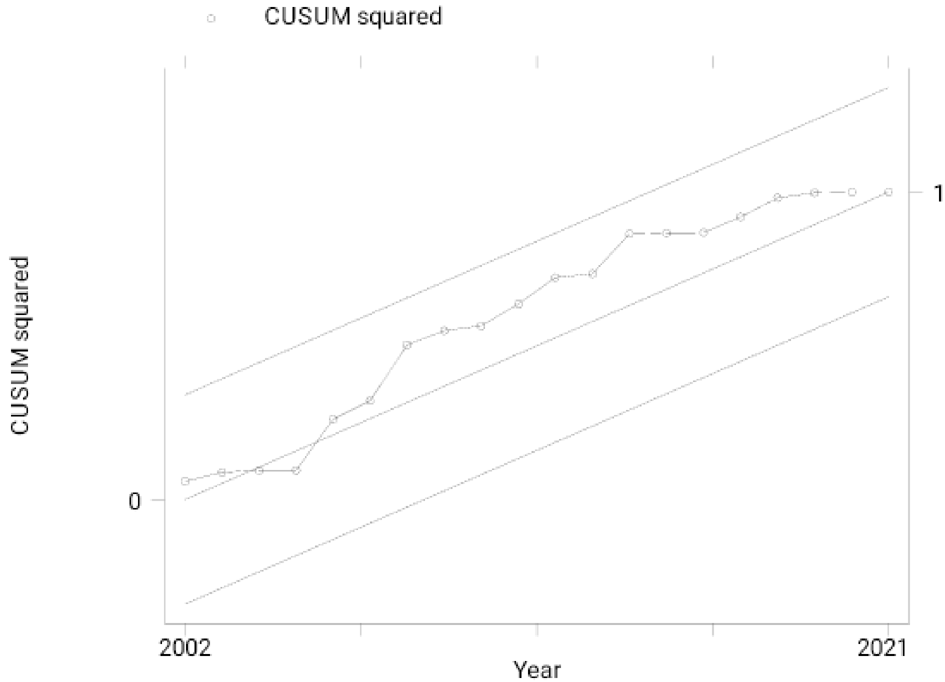
APPENDIX

Appendix 1: The Cumulative Sum (CUSUM) for Parameter Stability



Appendix 2: Data Used for Analysis

Table 8: Description of Variables

Name	Variable Label
Year	Year
POPN1	Population ages 15-64, total
Population	Population ages 15-64 (% of total population)
FTS	Fixed telephone subscriptions (per 100 people)
GDP	GDP per capita growth (annual %)
Inflation	Inflation, consumer prices (annual %)
Exports	Exports of goods and services (% of GDP)

Table 9: List of Variables

Year	POPN	GDP	GDPpc	INFL	TS	EXP
1981	51.37738	1.80E+09	-8.95833	11.8147	15438	17.55542
1982	51.10342	1.72E+09	-1.49216	9.821162	16445	15.57889
1983	50.85437	1.78E+09	-0.30715	13.50251	17100	15.44529
1984	50.65126	1.76E+09	1.330729	20.0263	18233	19.27347
1985	50.49036	1.65E+09	0.647711	10.51898	19856	16.48534
1986	50.36962	1.72E+09	-3.80691	14.04687	21228	15.58708
1987	50.2812	1.72E+09	-3.10536	25.1551	22466	17.77103
1988	50.23971	2.01E+09	-2.22964	33.91217	23600	16.52935
1989	50.23864	2.31E+09	-3.29583	12.44636	25960	12.93277
1990	50.25264	2.74E+09	1.650918	11.82354	26640	16.18784
1991	50.28419	3.21E+09	5.501818	12.61532	28564	16.0296
1992	50.3332	2.62E+09	-9.93319	23.75135	30804	16.359
1993	50.40193	3.01E+09	8.175279	22.77271	32767	11.5291
1994	50.49617	1.72E+09	-9.12893	34.64964	33081	20.29958
1995	50.65614	2.03E+09	16.94793	83.32578	34720	23.09238
1996	50.86295	3.32E+09	5.258805	37.60205	39171	16.45632

1997	51.04815	3.88E+09	1.796578	9.137352	43754	14.9404
1998	51.16827	2.55E+09	1.767698	29.74865	47871	22.41623
1999	51.12545	2.58E+09	0.774663	44.80416	64062	19.25632
2000	50.97594	2.54E+09	-0.73444	29.58149	95444	17.23947
2001	50.81609	2.50E+09	-7.20151	22.7	110337	18.87718
2002	50.60826	5.09E+09	-0.76541	14.74464	159147	9.275224
2003	50.38603	4.67E+09	3.051911	9.576798	220114	13.26517
2004	50.17099	5.06E+09	2.673771	11.42981	315135	11.31265
2005	49.95502	5.32E+09	0.481252	15.41035	523887	11.44064
2006	49.76629	5.82E+09	1.805541	13.97429	750163	13.5013
2007	49.6343	6.45E+09	6.537023	7.95221	1226061	13.59805
2008	49.58122	7.74E+09	4.58664	8.712602	1619017	13.2307
2009	49.58472	9.01E+09	5.225687	8.422044	2596979	14.95525
2010	49.62942	1.01E+10	3.828046	7.411591	3269472	12.0714
2011	49.71939	1.17E+10	1.969743	7.622823	4125053	13.7727
2012	49.86245	8.77E+09	-0.94589	21.27127	4874189	15.75135
2013	50.08167	8.03E+09	2.492866	27.28333	5323613	17.3738
2014	50.37657	8.80E+09	2.720274	23.79207	5651477	18.65734
2015	50.74527	9.22E+09	0.002403	21.86735	6581169	13.77624
2016	51.1877	7.91E+09	-0.24824	21.71111	7189618	14.91975
2017	51.69132	8.94E+09	1.234159	11.54339	7789840	12.42186
2018	52.2444	9.88E+09	1.625496	12.42018	7091898	11.88444
2019	52.84328	1.10E+10	2.656769	9.370836	8914128	13.12138
2020	53.48328	1.21E+10	-1.8516	8.625515	1.00E+07	10.51947
2021	54.14612	1.26E+10	0.102867	9.330144	1.20E+07	12.20775

APPENDIX 3: ARDL Model Estimation Results

Dependent Variable: GDP Per Capita

ARDL (3,1,4,3,4) regression		Dep Var: GDP per capita			Sample: 1985-2021	
Variables	Coefficient	Std. Error	t	P>|t|	[95% conf. interval]	
ADJ						
GDPpc						
L1.	-1.336091	.3682936	-3.63	0.002	-2.113123	-.5590595
			Long Run			
TS	1.92e-07	5.75e-07	0.33	0.743	-1.02e-06	1.41e-06
INFL	.4037856	.168582	2.40	0.028	.0481087	.7594626
EXP	-1.342999	.5331429	-2.52	0.022	-2.467832	-.2181653
POPN	-.7767662	1.122271	-0.69	0.498	3.14455	1.591018
			Short Run			
GDPpc						
LD	-.1247618	.3288615	-0.38	0.709	-.818599	.5690754
L2D.	.1482047	.2487444	0.60	0.559	-.3766001	.6730095
TS						
D1.	7.21e-072	.25e-06	0.32	0.753	-4.04e-06	5.48e-06
INFL						
D1.	-.6002208	.1784037	-3.36	0.004	-.9766196	-.223822
LD.	-.2945491	.1952127	-1.51	0.150	-.7064118	.1173136
L2D.	-.2694293	.1142025	-2.36	0.031	-.5103755	-.028483
L3D.	-.0295555	.1240891	-0.24	0.815	-.2913606	.2322497
EXP						
D1.	1.786027	.5590864	3.19	0.005	.6064578	2.965596
LD.	1.741511	.5572478	3.13	0.006	.5658207	2.917201
L2D.	.694188	.4005613	1.73	0.101	-.1509226	1.539299
POPN						
D1.	41.60507	46.77661	0.89	0.386	-57.08496	140.2951
LD.	-106.7847	69.93317	-1.53	0.145	-254.3308	40.76137

L2D.	122.4787	59.52681	2.06	0.055	-3.111862	248.0693
L3D.	-63.6494	30.82679	-2.06	0.055	-128.6882	1.389431
_cons	69.43978	82.76052	0.84	0.413	105.1697	244.0492
Log-likelihood = -86.085112	R-squared= 0.8835	Adj R-squared= 0.7533		No of Obs= 37	Root MSE= 3.6566	

Dependent Variable: GDP

Dep Var: GDP						
Variables	Coefficient	Std. Error	t	P>|t|	[95% conf. interval]	
D.GDP						
GDP						
L1.	-.1734057	.3779953	-0.46	0.652	-.970906	.6240946
Long Run						
TS	15.37221	491.464	0.03	0.975	-1021.526	1052.271
INFL	2.64e+07	4.73e+07	0.56	0.584	-7.34e+07	1.26e+08
EXP	-3.02e+08	1.98e+08	-1.52	0.147	-7.20e+08	1.17e+08
POPN	-1.64e+08	7.38e+08	-0.22	0.827	-1.72e+09	1.39e+09
Short Run						
GDP						
LD	-.0877278	.3410968	-0.26	0.800	-.8073791	.6319236
L2D.	-.369321	.299705	-1.23	0.235	-1.001643	.2630012
TS						
D1.	868.4909	713.5562	1.22	0.240	-636.9812	2373.963
INFL						
D1.	-3.33e+07	4.34e+07	-0.77	0.453	-1.25e+08	5.82e+07
LD.	-4.01e+07	5.04e+07	-0.80	0.437	-1.46e+08	6.62e+07
L2D.	-1.83e+07	3.26e+07	-0.56	0.581	-8.72e+07	5.05e+07
L3D.	-2819088	2.23e+07	-0.13	0.901	-4.98e+07	4.41e+07
EXP						
D1.	9.81e+07	1.73e+08	0.57	0.577	-2.66e+08	4.62e+08
LD.	1.87e+08	1.33e+08	1.41	0.177	-9.33e+07	4.67e+08
L2D.	6.62e+07	1.19e+08	0.56	0.585	-1.85e+08	3.17e+08
POPN						
D1.	2.04e+09	9.95e+09	0.20	0.840	-1.90e+10	2.30e+10
LD.	-2.18e+09	1.56e+10	-0.14	0.890	-3.50e+10	3.07e+10
L2D.	2.52e+08	1.19e+10	0.02	0.983	-2.49e+10	2.54e+10

L3D.	6.40e+08	5.69e+09	0.11	0.912	-1.14e+10	1.26e+10
_cons	1.33e+10	3.89e+10	0.34	0.736	-6.87e+10	9.53e+10

Appendix 4: ARDL Bounds Test Results

Dep Var: GDP per capita

	F		t	
Significance	I (0)	I (1)	I (0)	I (1)
10%	4	2.45	4	-2.57
5%	3.52	2.86	3.66	-2.86
1%	3.74	5.06	-3.43	-4.60
F-statistic	4.949			
t-statistic	-0.371			

Dep Var: GDP

	F		t	
Significance	I (0)	I (1)	I (0)	I (1)
10%	2.45	3.52	-2.57	-3.66
5%	2.86	4.01	-2.86	-3.99
1%	3.74	5.06	-3.43	-4.60
F-statistic	7.900			
t-statistic	-4.266			

Appendix 5: Diagnostic Tests Results

Appendix 5A: Autocorrelation

Dep Var: GDP per capita		Dep Var: GDP	
chi2	Prob > chi2	chi2	Prob > chi2
1.466	0.226	0.016	0.9008

Appendix 5B: Heteroskedasticity

Dep Var: GDP Per Capita		Dep Var: GDP	
chi2(1)	Prob > chi2	chi2(1)	Prob > chi2
0.91	0.3396	6.82	0.0090

Appendix 5C: Model specification

Dep Var: GDP Per Capita		Dep Var: GDP	
F (3, 14)	Prob > F	F (3, 14)	Prob > F
3.81	0.0347	4.76	0.0172