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The Determinants of Economic Growth in sub-Saharan Africa (1990 – 2021)

Le Determinanti della Crescita Economica nell'Africa sub-sahariana (1990 – 2021)

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Dedication

I dedicate this Thesis to Me, my Parents, Brothers and late Grandparents (in memoriam)

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LIST OF ACRONYMS AND ABBREVIATIONS

AfCFTA   African Continental Free Trade Area

APF   Aggregate Production Function

BIC   Bayesian Information Criterion

ECP   Economic Complexity Index

FDI   Foreign Direct Investment

GDP   Gross Domestic Product

GFCF   Gross Fixed Capital Formation

GGM   Generalized Method of Moments

IMF   International Monetary Fund

LOOCV   Leave-One-Out Cross-Validation

MSE   Mean Square Error

OLS   Ordinary Least Squares

PGIRF   Panel Generalized Impulse Response Function

PPF   Production-Possibility Frontier

R&D   Research and Development

RSS	Residual sum of squares
SSA	Sub Saharan Africa
TSS	Total sum of squares
VIF	Variance Inflation Factor
WDI	World Development Indicator
WGI	World Governance Indicator

INTRODUCTION

The economic growth[1] of a country is the result of economic, financial, and political strategies that support the most important components of the market. The study of economic growth has gained much attention from researchers and economists over the years and there have been numerous theories and models developed to explain the process of economic growth. The traditional neoclassical growth model, for example, emphasizes the role of capital accumulation and technological progress in driving economic growth. In contrast, the endogenous growth theory stresses the importance of innovation and human capital in promoting economic growth (Sharipov, 2015). According to the same author, despite having various theories and models trying to explain the economic growth, its process is still complex and multifaceted since it involves a range of factors, including political stability, investment in infrastructure, human capital development, and access to finance. Furthermore, economic growth can have both positive and negative impacts on society, and it is critical to examine the trade-offs involved in the pursuit of economic growth.

Henderson (2003) cited by Onjala & Akumu (2016) entails that economic growth is the transformation of each country from a rural agricultural economy to an industrial service-based economy, with the advancing technology leading to introduction of labor-saving technologies that release labor from agriculture to non-agricultural activities.

Economic growth is the most powerful instrument for reducing poverty and improving the quality of life in developing countries because it can generate virtuous circles of prosperity and opportunity, strong growth and employment opportunities improve incentives for parents to invest

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[1] Economic growth is the increase in the production of goods and services per head of population over a stated period of time (Oxford Dictionary).

in their children's education by sending them to school. This may lead to the emergence of a strong and growing group of entrepreneurs, which should generate pressure for improved governance, strong economic growth therefore advances human development, which in turn, promotes economic growth.[2]

For Higgins (2015) cited by Batrancea et al (2021) achieving a stable level of economic growth is a goal that should be listed on the priority agendas of governments around the world. At the end of the day, growing economies generally register higher per capita income, numerous job opportunities due to increased competition among economic agents, higher levels of foreign direct investment, an overall improvement of living standards and citizens' well-being, among other benefits. The authors also emphasize that economic growth increases different indicators of a country's economy. If investment, the production of services and goods, energy expenditure and consumption, for example, increase, it can be said that this country is experiencing economic growth. This growth usually results in an improvement in the quality of life of the population since people have more money available.

Given that economic growth is a critical indicator of a country's development and well-being. In recent years, African countries have demonstrated impressive growth rates, but some countries have seen more progress than others and according to the World Bank, the average GDP growth rate for Sub-Saharan Africa was projected to be 2.7% in 2021, with some countries even achieving growth rates higher than 5%, the example of this is Rwanda who has been one of the fastest-growing economies in Africa in recent years. Its GDP growth rate has been consistently above 7% since 2013, driven by the country's focus on improving infrastructure, education, and technology (Chomen, 2022).

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[2] Available in Economic growth: the impact on poverty reduction, inequality, human development and jobs (oecd.org).

Even though some countries show impressive growth rates, Africa is still the world's poorest continent [Basu et al. (2005) cited by Ndambiri et al (2012)], as the region faces a greater set of development and economic challenges than any other region in the world. Bloom & Sachs (1998) cited by Onjala & Akumu (2016) noted that most of the poverty in Africa comes mostly from sub–Saharan Africa which is one of the most obdurate features of the world economy and that since the industrial revolution era, sub-Saharan Africa has remained the poorest and the slowest growing region in the world. According to shocks Ulku (2004) cited by Ndambiri et al (2012) the economic and social situation in sub-Saharan Africa remains fragile and vulnerable to domestic and external factors, investment remains subdued, limiting efforts to diversify economic structures and boost growth. Furthermore, several countries have only recently emerged from civil wars that have severely set back their development efforts while in other parts of the continent, new armed conflicts have erupted (Basu et al. 2005). These conflicts and other adverse factors, notably poor weather conditions and deterioration in the terms of trade, have led to a loss in economic momentum in the region over the last three decades.

This thesis aims to shed light into the determinants of economic growth in sub-Saharan African countries using a regression analysis, focusing on identifying the factors that have influenced economic growth in the region over the past three decades and try to understand how these factors have influenced the growth trajectory of different countries within Sub-Saharan Africa, as this could lead to a better understanding of the policies and reforms that have worked in promoting economic growth in these countries, by identifying its key determinants. Also, this research will provide valuable insights for policymakers, academics, and development practitioners on how to promote sustainable economic growth and development in the region.

Subsequently the current thesis is divided into six chapters, namely:

I.   In the first chapter, which is designated as **"Contextual framework"**, it corresponds to the comprehensive overview of the importance of economic growth, its complex nature, and it's situation in sub-Saharan Africa. Moreover, it provides a comprehensive background and outlines the context for the research.

II.   In the second chapter, which is designated as **"Literature Review"**, the theoretical framework of the thesis is presented. The most important concepts for the research and the way on how different theories provide explanations for economic growth are emphasized according to certain authors and theories.

III.   In the third chapter, which is designated as **"Empirical Evidence on Economic Growth in Sub-Saharan Africa"**, a comprehensive examination was undertaken to explore the existing empirical studies on economic growth in SSA. This extensive review encompassed research conducted by numerous authors who have contributed to the understanding of this important topic.

IV.   In the fourth chapter, titled **"Methodology"**, its presented a detailed explanation of the research phases and the methodology employed to conduct the study. Additionally, the chapter provided an in-depth explanation of the chosen variables of the research, sampling techniques, research design, data sources, and analytical tools used in the investigation, ensuring transparency, and allowing readers to evaluate the reliability and validity of the research findings.

V.   The fifth chapter, titled **"Presentation and Interpretation of the Results"**, focused on presenting, analyzing, and interpreting the data collected from the World Bank Institution, in accordance with the objectives of the study. Furthermore, the chapter provided a detailed explanation of the interpretation of the results. It delved into the underlying trends, patterns, and relationships discovered within the data, shedding light on their significance in relation to the research objectives.

VI.   The sixth and last chapter, titled **"Discussion of the Results"**, involved the comments and implications of the observed results in the context of the presented literature. Furthermore, the chapter aimed to contextualize the observed results by considering their alignment with the presented literature. By drawing connections and identifying patterns, it contributed to a deeper comprehension of the research outcomes in relation to the broader understanding of the topic. Also, in this chapter recommendations were given based on the findings of the research for improvement in the context of economic growth in sub–Saharan Africa.

VII.   The closing part were reserved for the conclusions inherent to the investigation and, at the same time, respond to the established questions that drove the author to choose this topic and give his theoretical contribution to the academic community in this field. Additionally, bibliographical references are presented, where all the authors referenced and cited throughout the research are listed.

a) Principal Objective

This study has the principal goal to find the best model and main factors that influenced the Economic growth in Sub-Saharan Africa from 1990 to 2021.

b) Alternatives Objectives

Since the main objective is broad, it has been articulated in four main sub-objectives (alternatives):

1. Analyze the macroeconomic and institutional factors that have affected economic growth in the region.

2. Apply empirical regression analysis, to investigate the relationship between economic growth and its determinants.

3. Compare the results of the empirical analysis with the existing literature and draw conclusions about the most important determinants of economic growth in sub-Saharan Africa.

4. Provide policy recommendations based on the findings with the aim of informing future economic policies and strategies in these countries and potentially other developing economies.

CHAPTER I – CONTEXTUAL FRAMEWORK

1.1. THE RELEVANCE OF ECONOMIC GROWTH

Economic growth is often measured by increases in a nation's Gross Domestic Product (GDP), since it serves as a foundational driver of prosperity, enabling countries to enhance living standards, create job opportunities, invest in critical infrastructure etc. Increasing economic growth and improving society is one of the most important topics in economics because well-being goes beyond measuring success solely through GDP growth, it also includes factors that contribute to people's happiness and overall life satisfaction.

According Acemoglu & Robinson (2012), modern societies not only value economic growth for its ability to create material prosperity but also recognize its role in advancing social development. Economic growth provides the financial resources needed to invest in education, healthcare, and infrastructure. As a nation's economy expands, it can allocate more funds to improving public services, thereby enhancing the overall quality of life for its citizens that is why the authors, emphasize that societies with extractive institutions, which concentrate power and resources in the hands of a few, are more likely to experience stagnation and inequality, while those with inclusive institutions that encourage broad participation and competition tend to achieve long-term prosperity.

Furthermore, for Keohane & Nye (2013) economic growth has a profound relevance on international relations meaning that strong and growing economies often have the diplomatic and political influence to negotiate favorable trade agreements, establish alliances, and address global challenges. The interdependence theorem advanced by Keohane and Nye emphasizes how interconnected and dependent on one another's economic security are countries in a globalized world. As nations depend more on peaceful relations to maintain economic growth, this

interdependence promotes cooperation and lowers the likelihood of conflict. Also, nations with robust economies can project their power and interests onto the international stage, shaping the direction of global affairs.

According to Barro (1996) cited by Loayza & Soto (2002), it is impossible to overstate the significance of economic growth because countries that experience strong, sustained growth are better able to significantly reduce poverty rates. Economic growth and the reduction of poverty are strongly correlated. An expanding economy results in more job openings, higher wages, and easier access to basic services. The interaction of elements is crucial for helping people escape poverty and building a more equitable society.

Moreover, for the authors economic growth is essential for enhancing political and democratic stability, providing governments with resources to address social challenges, maintain law and order, and invest in institutions promoting good governance. This stability fosters a secure environment, reducing the likelihood of political unrest and instability. Advanced economies invest in technologies and practices that mitigate their ecological footprint, allowing nations to allocate funds towards sustainable energy sources, waste management, and eco-friendly policies. Economic growth also reduces crime and violence by increasing opportunities for legal employment, higher education, and improved living conditions. This enables governments to invest in law enforcement agencies and social programs aimed at crime prevention and rehabilitation. Subsequently economic growth also facilitates the implementation of public programs, such as social welfare, healthcare initiatives, and education systems, creating a financial foundation for a more inclusive and prosperous society for all citizens.

Based on the previous concepts it's possible to see that one of the most vital indicators of a healthy economy is the level of economic growth. The fact that long-term growth of a nation has a positive effect on national income and employment levels, raising the standard of living, is one of its most significant effects. The economy of the nation is becoming more productive as a result of the rising GDP, which creates more jobs. Both the country's wealth and its population rise as a result. Additionally, greater economic growth generates more tax revenue for government use, which the government can use to stimulate the economy. The budget deficit can also be reduced with the help of this expansion. Although poverty reduction and higher living standards are supported by economic growth, these advancements are impossible without economic development. Poverty cannot be eliminated by economic growth alone, because when there is economic growth in a country this doesn't mean that there will be a guarantee of equitable distribution of wealth and opportunities within a country. Moreover, economic growth besides improving the standard of living, also creates new economic opportunities and possibilities, new ways of thinking, and new technologies. As society adjusts to the new material (technological progress), as can also encourage the evolution of new types of institutions and social relations.

In developing countries like the ones in sub-Saharan Africa, a large portion of the population is employed in agriculture and subsistence farming, economic growth has opened more job opportunities in the service sector, manufacturing, and various lifestyles. The economic growth is important because it enabled these countries to escape the worst levels of poverty, even a small level of economic growth can facilitate higher living standards and an improvement in life expectancy, which is a different from the developed countries, economic growth is less essential.

1.2. THE COMPLEX NATURE OF ECONOMIC GROWTH

Economic complexity involves interdependence of elements, requiring strategic management for sustainable progress and Tabash et al. (2022) states that:

> Economic complexity is associated with product diversification and a nation's capabilities to utilize accumulated knowledge and endowment to diversify the country's economy. It is a robust index that captures the capabilities of human development, knowledge, innovation, trade, etc.

In the same line of thinking Hidalgo and Hausmann (2009) cited by Stojkoski and Kocarev (2017) stated that this complexity serves as a significant promoter of the wealth of the nations. In fact, it's even possible to suppose that the disparities in the level of complexity create divergence in the rates of economic growth among the countries. According to Tabash et al. (2022), the authors Hidalgo and Hausmann (2009) jointly developed the economic complexity index (ECP) which measures how complex an economy's productive capability is. As a metric, the degree of variation of economic complexity is an indicator that reflects the level of complexity of economic activities in an economy. On this regard, it is evident that in one hand a higher economic complexity index (ECP) implies a more complex and diversified economy which further leads to the stimulation of economic growth. On the other hand, a lower ECP is an indication of a less complex and diversified economy in terms of productive capabilities and thus has less impact on economic growth.

For Stojkoski and Kocarev (2017) the economic complexity index (ECP) can be used to empirically test the importance of knowledge accumulation and diversification of products for economic growth and for the authors this index has both positive and negatives sides.

The positive side of this index is that it supports ancient macroeconomic theories of economic growth, such as Adam Smith's idea for division of labor Smith, or their modern counterparts, for instance the theory of endogenous growth of Paul Romer. The negative side is that through the information contained in the empirical data, economic complexity questions the validity of the Ricardian theory of comparative advantage from David Ricardo and the O-ring Model for economic development from Michael Kremer.

According to Kuznets (1967) cited by Acemoglu (2012) economic growth is highly complex because it's not just about growth of aggregate output, but also about the fundamental transformation of an economy, ranging from its sectoral structure to its demographic and geographic makeup, and perhaps more importantly, to its entire social and institutional fabric. These processes naturally require a much more holistic approach to economic growth and development than in many other areas of economics. Thus, the political, social and demographic elements in the process of growth are paramount as this leads to a rich array of questions and a variety of new approaches to fundamental questions of economic growth.

Barro and Sala-I-Martin (2003) discussed the various factors that contribute to economic growth and its complex nature. According to the authors, there is no one factor or theory that can adequately account for economic growth because it is a complex phenomenon. Instead, they placed their focus on how various factors such as investment, innovation, education, infrastructure, and governance interact. The authors also emphasized how crucial institutions and policies are to promoting economic growth. Nations that have well-functioning institutions that uphold the rule of law, encourage competition, and protect property rights are more likely to experience long-term, equitable economic growth.

Based on the previous concepts is possible to see that economic growth is considered a very complex because for it to happen it doesn't depend on one factor but many others depending on the context of each country as this means the interactions of numerous factors. Its complexity results from its multifaceted nature, which includes GDP growth, technological progress, the growth of human capital, higher living standards, etc. These dimensions operate within institutional frameworks that range from inclusive to extractive, and they are interconnected with factors of production like labor, capital, and entrepreneurship. Growth is accelerated by technological innovation and productivity is increased by investments in human capital and education. Economic decisions have an impact on regional and global economies through complex externalities and spillover effects. Dynamics of income inequality and distribution, influenced by globalization and technological progress, are crucial. Also, this complexity is increased by other factors such as cultural, social, and behavioral factors as well as environmental sustainability concerns, the interaction of cultural, social, and behavioral factors with economic growth also adds another level of complexity. Consumer behaviors, savings rates, and business activities can all be influenced by cultural norms and social attitudes. These variables affect how people perceive risk, approach innovation, and make financial decisions, which might promote or reduce economic growth. Understanding economic growth also involves a complex interplay between domestic and international factors in addition to the previously mentioned factors. The economic growth trajectory of a nation is significantly influenced by globalization, growth prospects can be promoted or reduced also by trade relations, foreign direct investment, and cross-border capital flows. A constant challenge for policymakers is to find the right balance of which factors are the important ones on achieving a sustainable economic growth in their respective countries or regions.

1.3. THE ECONOMIC SITUATION IN SUB-SAHARAN AFRICA

In the preceding sections, the significance of economic growth and its complex nature were discussed. Building upon that foundation, the subsequent section will explore the situation of economic growth in sub-Saharan Africa.

According to the World Bank[3] the region of Sub-Saharan Africa includes 48 countries, with a combined population of more than 1 billion and a total area of 24 million square kilometers. It's a diverse region with abundant natural resources that could lead to inclusive growth and the eradication of poverty in the area. The region is forging a completely new path for development by utilizing the potential of its resources and people. It has the largest free trade area in the world and a market of 1.2 billion people.

According to Batrancea et al (2021) the macroeconomic conditions of Sub-Saharan African countries have significantly improved in recent years, with higher average economic growth, moderate inflation and ample international reserve coverage. Considering a few examples:

- Ethiopia between 2000 and 2019, experienced 9% annual growth, which was driven by investments in manufacturing, infrastructure, and agriculture.

- Through better governance, investments in important industries, and a focus on technology and innovation, Rwanda was able to achieve rapid economic growth.

- The 2007 discovery of oil reserves, economic reforms, and financial restraint all contributed to Ghana's steady growth.

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[3] Africa Overview: Development news, research, data | World Bank

- Since the 2000's, Kenya economy has continued to grow and has established itself as the economic center of East Africa.

However, despite the positive growth most of the countries in sub-Saharan Africa region are still poor and predominantly rural with a low level of industrial development reinforced by failures of economic policy. Problems such as political instability, inequality and many others still affect the region, preventing it from reaching its full growth potential.

The region's economic growth performance was considered slow and erratic compared to other developing regions, Artadi and Sala-i-Martin (2003) cited by Gil-Alana et al. (2021) stated that the factors such as expensive investment goods, low levels of education, poor health, adverse geography, closed economies, excessive expenditure, and many military conflicts were key causes of the region's lower economic growth during the 90's. However, since the beginning of the 2000's, several SSA economies have been among the fastest economic growing in emerging countries. This growth, however, stagnated severely in 2016 and looks set to slow to its lowest level in more than twenty years driven by lower commodity prices and a less supportive global economic environment. (IMF, 2017).

Radelet (2016) argues that the reality of Africa's rise in economic growth is complex and that the outlook over the long run is varied. The author states that the commodity prices helped many sub-Saharan African countries in their rise, the development gains of the past two decades were rooted in more fundamental factors such as improved governance, better policy management, and a new generation of better leaders in government and business. The author also contends that in the long run, the outlook for continued broad development is still solid for many countries in the region especially for those that embrace diversification, enhance competitiveness and strengthen governance institutions.

According to Michalowski (2012) Sub-Saharan African economies suffer from various weaknesses which constitute serious obstacles for growth improvement and poverty reduction. One of the most important problems is limited diversification of production, exports and budget revenues. The region's economies are much more dependent on primary commodities than the rest of the world. Although the shares of services, industry and manufacturing in region's GDP have been rising, traditional agriculture sector tends to absorb the majority of labor force in many countries. Besides agricultural products, Sub-Saharan African countries rely heavily on fuels, minerals and metals. The example of this was in 2009, in the Sub-Saharan Africa, excluding South Africa and Nigeria, exports of primary commodities accounted for 73% of total merchandise exports. In every fifth Sub-Saharan African country, one or two products accounts for at least three fourths of total exports.

The problem that affects the economic growth in SSA according to Kalema (2011) is underdevelopment and poor quality of infrastructure. A large deficit of infrastructure is found in the power sector. The amount of power generated by all Sub-Saharan African countries is comparable to that of Spain. Poor road infrastructure increases the costs of transport and doing business and inhibits trade in the region. With the exception of South Africa, railway systems that can enable much more efficient transportation of goods and passengers do not practically exist.

Another issue regards the poor governance and dysfunctional political institutions. These weaknesses lower the efficiency of any development strategy and bear at least partial responsibility for the bad economic performance of sub-Saharan Africa in the past.

Considering the prior concepts, it's possible to see that in sub-Saharan Africa, a key factor contributing to the improved economic growth performance has been the reforms that these countries have undertaken to strengthen macroeconomic stability by liberalizing their foreign exchange regimes. The factors that motivated the author of this thesis to analyze economic growth in sub-Saharan Africa is attributed to the fact that economic growth is at the center of economic policy attention, which directly affects the quality of life of the African population and the economic situation of the region. Thus, also give a theoretical contribution to the academic community in this field.

This context was also stimulated by the researcher's desire to understand what are the forces behind economic growth in sub-Saharan Africa during the period from 1990 to 2021, as it was during this period that the economy of most countries in the sub-Saharan economy recorded high rates of economic growth, which reached 9% and 8% and high foreign direct investment. Despite the high rates of economic growth and FDI that attracted worldwide attention, these positive indicators often failed to translate into substantial improvements in the lives of most of the African population. The region faced a numerous of challenges that hindered the equitable distribution of economic gains, while economic growth in sub-Saharan Africa appears impressive only on paper, it often primarily favored a small, privileged portion of the population (the higher ranks and elite society), thereby marginalizing and excluding a considerable part of the population from the benefits of advancement.

CHAPTER II – LITERATUR REVIEW

According to Samuelson and Nordhaus (2009) **Economic growth** represents the expansion of a country's potential GDP or national output. For the authors economic growth occurs when a nation's production-possibility frontier (PPF) shifts outwards, but Solow (1956) defined economic growth as the sustained increase in the output of goods and services per person in an economy over a long period of time.

On the other hand, Schumpeter (2013) defined economic growth as the process of creative destruction, whereby new industries and products replace old ones, leading to a net increase in economic output over time. Smith (1776) who's considered the father of modern economics defined as the increase in the wealth of a nation, which is the accumulation of capital and the division of labor. Another well-known author Lucas (1988) defined economic growth as the process whereby an economy's potential output is expanded by increasing its resources, improving its technology, and enhancing the efficiency of its institutions.

Based on the previous definitions is possible to see that an increase in output of products and services is referred to as economic growth and it can be influenced by changes in capital goods, labor force, technology, and human capital. Also, this involves a Long-term potential production growth as a necessary component for an economy to grow, that is why governments should focus on increasing output per person because it´s linked to raising real average wages and quality of living.

2.1. THEORIES OF ECONOMIC GROWTH

According to Samuelson and Nordhaus (2009), virtually everyone is in favor of economic growth, but there are strong disagreements about the best way to accomplish this goal. Some economists and policymakers stress the need to increase capital investment, others advocate measures to stimulate research and development and technological change, still a third group emphasizes the role of a better-educated workforce.

In addition, the same authors state that economists who have examined economic growth have discovered that regardless of a country's wealth or poverty, the key components of progress must rely on four fundamental factors of growth. These factors can be referred to as the "four wheels" of economic growth:

- **Human resources** (labor supply, education, skills, discipline and motivation).

- **Natural resources** (land, minerals, fuels and environmental quality).

- **Capital** (factories, machinery, roads and intellectual property).

- **Technological change and innovation** (science, engineering, management and entrepreneurship)

The economic theory wrote this relationship in terms of an aggregate production function (APF), which relates total national output to inputs and technology. Algebraically, the APF is:

$$Q = AF(K, L, R)$$

Where:

Q – is the output

A – represents the level of technology in the economy

F – is the production function

K – is the productive services of capital

L – is the labor inputs

R – represents the natural-resource inputs

That is why in this section we will show how different theories explain the economic growth, despite their divergences they will provide some hints on which are the factors that drive the forces behind the growth.

2.1.1. Classical Theory: The Dynamics of Smith and Malthus

The classical models of Smith and Malthus describe economic development in terms of land and population, in the absence of technological change, increasing population exhausts the supply of free land.
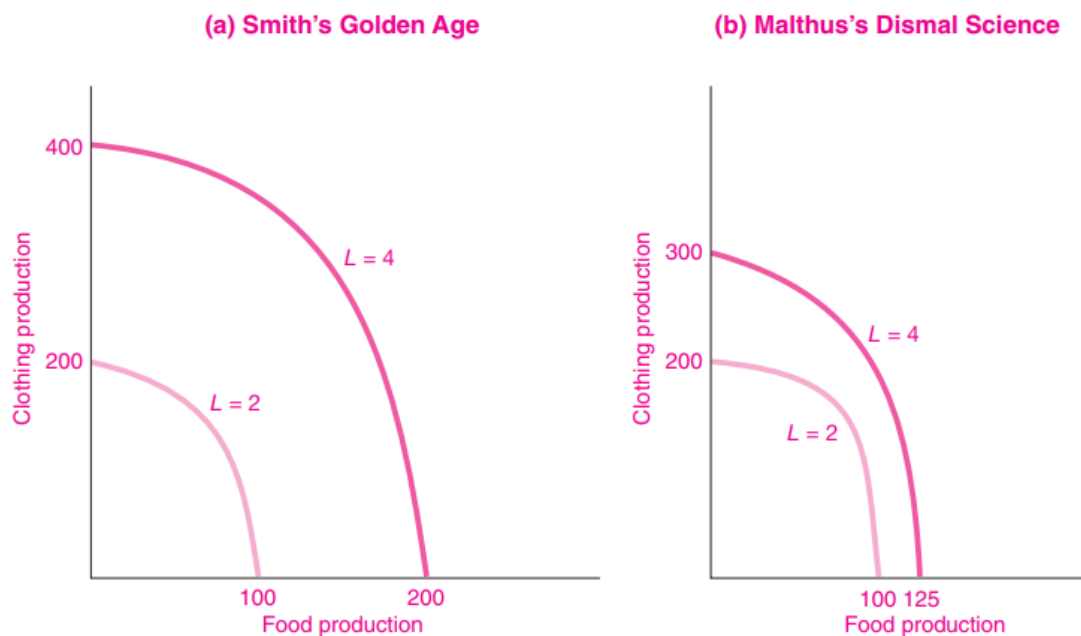
Figure 2.1: *The classical dynamics of Smith and Malthus*
Source: *Samuelson and Nordhaus (2009)*

According to Smith (1776) cited by Samuelson and Nordhaus (2009) the graphic ``**a**´´ indicates that if there is an infinite amount of land on the frontier, then it is possible for labor to expand and generate double the amount of food and clothing when the population increases. This means that production can be increased simply by spreading out the labor force. On the other hand, Malthus (1798) cited by Samuelson and Nordhaus (2009) stated that the graphic ``**b**´´ indicates that when land is scarce, a population increase from 2 million to 4 million leads to diminishing returns. In this scenario, doubling the labor inputs results in only a 25% percent increase in potential food production.

From this point of view, it's possible to see that in Smith's golden age, there was a doubling of the population and a shift in the production-possibility frontier (PPF) by a factor of 2. This indicates that the economy can grow without external restrictions, allowing for optimal expansion, meaning that there are no limitations on growth caused by land or resources. As for the pessimistic Malthusian case, an increase in population results in a less-than-proportional increase in food and clothing production. This is due to diminishing returns and a decrease in output per person, leading to a decrease in per capita output.

The outcome of an increasing population density triggers the law of diminishing returns, so growth produces higher land rents with lower competitive wages, in other words the economic growth is driven by increases in the factors of production, such as capital and labor. According to Smith cited by Samuelson and Nordhaus (2009), specialization and the division of labor are key drivers of productivity, which in turn drives economic growth.

2.1.2. Neoclassical Growth Theory: The Solow Model

The Neoclassical Growth Theory is an economic model of growth that outlines how a steady economic growth rate results when three economic forces come into play: labor, capital, and technology. The simplest and most popular version of the Neoclassical Growth Model is the Solow Growth Model based on the Cobb-Douglas aggregate production function, and it's represented in the following way:

$$Y = AF(K, L) = AK^\alpha L^{1-\alpha}$$

Where:

Y – represents the income which can also be considered as real GDP

A – represents the technology progress [4]

F – represents the production function

K – represents the stock of capital

L – represents the supply of labor

α – represents the share of capital in the production function, which means the relative importance of capital accumulation in economic growth

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[4] In the Solow model its assumed that the technological progress its exogenous, meaning that technological progress is independent of other factors and is not influenced by economic conditions or policies.
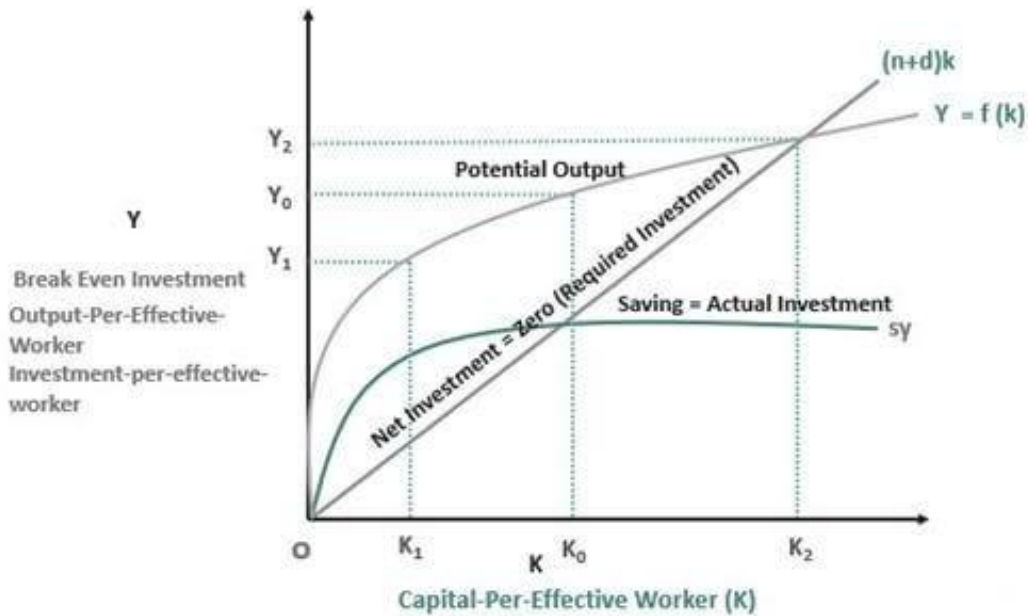
Figure 2.2: *The Solow growth model*
Source: *Froyen (2013)*

The Solow model can be understood best in terms of steady state. The output-per-effective-worker for an economy during a certain period is represented on the Y-axis of the graph, which also shows the steady state at the intersection of the line (n+d) k and the sY curve, there will always be a steady state for the economy. There is a depreciation curve that is directly related to the amount of capital. When capital increases, so does depreciation, labor and capital both grow at the same rate (Froyen, 2013).

According to the same Author, the model assumes that there are constant returns to scale, meaning that real output grows at the same rate, while output per worker remains constant, if there is additional investment, it will lead to an increase in output. When capital per worker increases, output per worker also increases.

However, due to the law of diminishing returns, the production function line, i.e., $Y = f(K)$ shows that the output per worker increases at a decreasing rate as capital K (capital) increases.

The assumed fixed saving rates are equal to the real investment rate, i.e., sY. Thus, firms increase their investments through savings. Initially, investment exceeds depreciation, leading to an increase in capital. However, in the next phase, investment is lower than depreciation, resulting in a decrease in capital. At the steady-state, investment equals depreciation, which means that all investment is used to maintain the depreciation, and there is no further growth in the economy as it has reached its maximum capacity.

According to Jones (1998), capital accumulation with complementary labor forms the core of modern growth theory in the neoclassical growth model. This approach uses a tool known as the aggregate production function, which relates inputs and technology to total potential GDP. In the absence of technological change and innovation, an increase in capital per worker (capital deepening) would not be matched by a proportional increase in output per worker because of diminishing returns to capital, this postulates that short-term economic equilibrium is a result of varying amounts of labor and capital that play a vital role in the production process. The theory explains that technological progress is not driven by increases in inputs, but by exogenous technological change.

2.1.3. Endogenous Growth Theory: The Romer Model

This theory states that economic growth is the result of all internal forces, the concept of this model contrasts with the Neoclassical growth model, which explained growth with exogenous factors. Based on the Solow Growth Model and assuming the Cobb-Douglas function but with a fundamental difference, H (Human Capital) replaces L (Labor), the Romer's endogenous growth model is disclosed in the subsequent form:

$$Y = AF(K, H) = AK^\alpha H^{1-\alpha}$$

Where:

Y – represents the income which can also be considered as real GDP

A – represents the technology progress [5]

F – represents the production function

K – represents the stock of capital

H – represents the human capital [6]

α – represents the share of knowledge or ideas in the production function, which means the relative importance of knowledge accumulation (or innovation) in economic growth.

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[5] In this theory, technological progress came to be regarded as endogenous (contrasts with the Neoclassical growth model, which explained growth with exogenous factors.) factor of economic growth, generated by internal causes, such as investment in technological development and in human capital.

[6] It is intrinsically different from L because H is a reproducible factor: the economy can save and invest in H^1 (as in K), this "small" change produces a completely different outcome in term of economic growth.

Paul Romer (1955) and Robert Lucas (1937) cited by Sharipov (2015) hypothesized about the endogenous character of the most important technological innovations based on investment (contribution) in technological development and in human capital. Endogenous growth models look like the neo-classical ones, but they differ significantly in initial assumptions and conclusions, because the Solow model was not being completely endogenous, since it failed to answer why countries have different technologies and also to explain the long-run economic growth. According to the same authors endogenous growth theory overcomes the shortcoming of neoclassical theory, as they reject the neoclassical premise of diminishing marginal productivity of capital and assume the possibility of production scale effect throughout the economy, and often focus on the impact of external effects on the profitability of investments, positive externalities act as an important prerequisite.

This model also supports the role of government policies that can increase growth, but most importantly, this model emphasizes the role of R&D and knowledge for technological progress. Romer described "ideas" or "knowledge" from a different perspective than ordinary goods, but these ideas or knowledge can be produced with the internal factors of labor and capital just like other ordinary goods. Romer identifies two main properties for Ideas: First, it is non-rival, such as used by one person's ideas will not become non-usable like other products, other people can use it. Second, ideas are partially excludable, the person who has a patent for a particular idea can receive the full monopolistic benefit by excluding others from its benefits [Zhao (2018) cited by Abdullah (2022)].

2.1.4. Semi Endogenous Growth Theory: The Jones Model

In this theory, the famous economist Jones (1995) developed a broader concept of endogenous growth model that combines elements of endogenous and exogenous factors. This theory suggests that some aspects of economic growth are endogenous (determined by internal factors and policies), while others remain exogenous (determined by external factors), meaning that technological change itself is endogenous through R&D, but long-run growth is restrained by an exogenous population growth, this contrasts with the Romer' model and other AK models, where long-run growth is fully endogenous. The Jones semi-endogenous growth model is based on the knowledge production function, and it can be disclosed in the subsequent form:

$$\gamma Y = \gamma A = \frac{\sigma * n}{1 - \theta}$$

Where:

γY – represents the growth rate of income which can also be considered as the growth rate real GDP

γA – represents the growth rate of technology progress[7]

σ – represents the measure of extent of duplication of externalities

n – represents the growth rate of population

θ – represents a parameter that quantifies the relationship between the existing stock of knowledge and the rate at which a researcher generates new ideas or discoveries

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[7] In this model it is assumed that the growth rate of GDP is equal to the growth rate of technologies because the economy is driven by the discovery of new ideas through R&D, leading to productivity growth and higher output. The rate of economic growth is directly tied to the rate of growth of technologies, which is determined by the rate of innovation in the economy.

According to Jones (1995) in the semi-endogenous growth model, technological progress is the main engine of economic growth where sustainability of economic growth is determined by technological innovation and stock of knowledge. Achievements in industrial and academic research play an important role in accomplishing technological innovation and progress in knowledge meaning that the availability and a certain level of human capital thus guarantee those achievements.

In contrast to Romer's idea that technological progress emerges as a result of ongoing R&D powered by an existing human capital and knowledge. Jones (1995) challenges the validity of endogenous growth models focusing solely on R&D, as he argues that these models fail to meet this criterion. Instead, semi-endogenous growth models gain prominence by emphasizing human capital and technological progress as the primary drivers of economic growth.

In his findings Jones (1995) stated that R&D and capital accumulation have no long-run growth effects in the modified extended endogenous growth model. Instead, these policies affect growth only along the transition path to the new steady state. Therefore, the author suggests that governments seeking to promote economic growth through R&D subsidies should focus on policies that increase the growth rate of the labor force, which is an exogenous variable in the model, this could include policies that encourage immigration, education, and training programs.

Additionally, Jones (1995) emphasized the importance of promoting the discovery of new designs through R&D, which is the critical input into productivity growth meaning that he suggests that governments should take a more nuanced approach to R&D subsidies and focus on policies that address the specific factors that drive economic growth in their respective countries.

Nugroho et al. (2019) state that developing countries depend on knowledge and technology created in the developed countries in order to accumulate their stock of knowledge. The quantity and the quality of R&D workers in developing countries are low or much worse non-existent due to no R&D or no available workers. This problem of R&D workers can be rooted from the quality of education. Low quality of education hence low quality of human capital is a problem every developing country needs to resolve. According to the same author there are other significant factors that contribute to the knowledge and technology gap between developed and developing countries, in addition to the difficulties caused by the low number and quality of R&D workers in developing countries. The inadequate funding of infrastructure for research and development in developing countries is one important factor, these countries struggle to set up the research facilities, labs, and technological centers required to promote innovation and knowledge creation without sufficient funding and resources.

2.2.   THE INDERCT FACTORS OF ECONOMIC GROWTH

In the previous section, the analysis on different theories regarding determinants of economic growth gave important insights into the elements directly affecting economic growth according to different economic theories. Shifting the focus to this section, the exploration delves into the realm of indirect variables. Overlooked from the previous theories, these indirect factors also play an equally crucial role in shaping economic growth trajectories, particularly within the context of Sub-Saharan Africa.

2.2.1. Evolutionary Theory of Economic Growth: The Institutional Theory

The evolutionary approach to economic growth draws attention to three aspects that were neglected in Classical, neo-classical, and endogenous growth theories. They don't consider the institutional framework that presumably contributes strongly to an explanation of cross–country differences in economic growth. North (1990) cited by Chomen (2022) described that the quality of institutions, such as property rights, rule of law, and government effectiveness, play a critical role in driving economic growth. Economies with strong institutions tend to have more efficient markets, higher levels of investment, and greater technological progress, all of which contribute to economic growth.

According to Acemoglu et al. (2005) institutions matter for economic growth because they shape the incentives of key economic actors in society, in particular they influence investments in physical and human capital and technology, and the organization of production. Although cultural and geographical factors may also matter for economic performance, differences in economic institutions are the major source of cross-country differences in economic growth and prosperity. For the authors institutions not only determine the aggregate economic growth potential of the economy, but also an array of economic outcomes, including the distribution of resources in the future (the distribution of wealth, of physical capital or human capital). In other words, the institutions influence not only the size of the aggregate pie, but how this pie is divided among different groups and individuals in society.

Having a well-maintained system of institutions encourages economic development components to engage in fair and productive economic activities, while discouraging rent-seeking and illegal activities. On the other hand, poor institutions can push the economy to a low-level equilibrium due to the disincentives created by unproductive economic agents [(Dash and Raja, 2009) cited by

Roy et al. (2014)]. The authors also stated that the role of government or state intervention can significantly affect economic outcomes, it is widely accepted that efficient legal institutions, protection of property rights, and a well-enforced rule of law are essential for a country economic prosperity.

Rodrik (2000) cited by Siddiqui & Ahmed (2013), emphasized the pivotal role of various non-market institutions in creating complete and contingent markets. Institutions contribute to growth and to development by reducing the risk of doing business, thus directing resources toward innovation rather than protecting property rights or earning predatory rents. Also, for the authors a poor institutions quality can restrict the economy from using efficient production techniques, which in turn would force the country to remain at the low-equilibrium trap with low per capita income for a long time, which is the case of most sub-Saharan African countries.

Therefore, is possible to see that this evolutionary institutional approach to economic growth recognizes that the level institutions are crucial in explaining the performance of firms and of the economy as a whole. The institutional framework is shaped to a significant extent at the national level, giving rise to important differences across countries.

2.2.2. Income Inequality

According to Odusola et al (2017) one of the key arguments in literature is that high levels of income inequality can lead to political instability, social unrest, and conflict, which in turn can undermine economic growth and development. For example, the study of Alesina and Rodrik (1994) cited in Mdingi & Ho (2021) have shown that countries with high levels of income inequality are more likely to experience civil wars and other forms of political violence, which can have long-lasting negative effects on economic growth.

However, there are also some studies that suggest that the relationship between income inequality and economic growth is more complex than a simple cause-and-effect relationship. For example, the study of Gupta and Singh (1984) cited in Mdingi & Ho (2021) found that there is a "Kuznets curve" relationship between income inequality and economic growth, where income inequality initially increases during the early stages of economic development, but then decreases as the economy matures.

According to the IMF (2023) cited by Amponsah et al. (2023) over the past two decades, developing countries have experienced remarkable economic growth, surpassing developed countries. This economic growth has significantly reduced poverty in many developing regions. Unfortunately, Sub-Saharan Africa has witnessed a rise in poverty and income inequality (hereafter, inequality) rates owing to stagnated or declining economic growth in several countries in the region.

The income inequality increased in many countries in sub-Saharan Africa during this period, particularly in countries that experienced high levels of economic growth, this is because of the region's dependence on natural resources which led the benefits of economic growth to be concentrated in the hands of a few individuals or groups, leading to an increase in income inequality. Additionally, the income inequality tends to be higher in urban areas than in rural areas, and that women and ethnic minorities are often disproportionately affected by income inequality (Odusola et al., 2017). Furthermore, the authors state that sub-Saharan Africa has a high prevalence of informality in the labor market, which can limit access to social protection and exacerbate income disparities, other factors that may contribute to income inequality in the region include unequal access to education, healthcare, and financial services.

2.2.3. Trade Openness

According to Sakyi et al. (2014), a well-established strand of the literature on globalization has made it clear that trade openness is fundamental to promoting economic growth in both developed and developing countries. For example, studies by Karras (2003), Rao (2009), and Chang and Mendy (2012) cited in Malefane and Odhiambo (2018) show that trade openness provide very strong support for the impact on economic growth because it encourages investment, which in turn leads to higher growth in the long run. Moreover, these authors emphasize that openness not only increases per capita income, but also helps to achieve steady-state convergence in income. In some situations, particularly in developing countries, the act of opening up to trade by reducing the restrictiveness of trade regimes has led to rapid economic growth.

According to Barry (2010) the trade openness in sub-Saharan Africa had a positive impact on most of the countries in regions, some countries in the region have experienced significant economic growth as a result of increased trade openness comparing to the others. Botswana is one of the examples of the countries that prospered with trade openness and didn't fall victim to the natural resource curse but instead managed to their own advantages. The government of Botswana followed the classical neoliberal recommendations for developing an economy, established an appropriately valued currency, political and social stability, lowered wages, subsidized and taxed financing and training, and provided good education and infrastructure. They learned from the experience of South Korea because taxes and subsidies were accompanied by requirements that international firms employ at least 400 Botswana workers, invest 25% of the project's funds, and export most of what is produced.

2.2.4. Political Stability

According to Alesina et al. (1996) economic growth and political stability are deeply interconnected. On one hand, the uncertainty associated with an unstable political environment may reduce investment and the speed of economic development. On the other hand, poor economic performance may lead to government collapse and political unrest. Fosu (1992) argues that political instability may serve to reduce the availability of factors of production. Investment in physical capital, for example, will probably be discouraged as the risk of a capital loss will tend to rise with political instability, primarily because political and economic rules governing investments are likely to change with political regimes, increasing the uncertainty in future net returns and hence lowering expected real rates of return associated with investment projects. For the author such increased risks would also raise the cost of capital, as the likelihood of loan defaults would rise, both domestic saving and imported capital would be discouraged due to such risks. Indeed, capital flight might be characteristic of politically unstable situations.

According to Francis (2006) cited by Chtouki (2021) political instability appears to contribute to the obstacles of economic growth in Sub-Saharan Africa. In fact, political insecurity is an enormous obstacle not only to human development, but also to the establishment of a viable system of administration. Even though the levels of armed conflict have relatively subsided over the last three decades, Africa remains a turbulent region where its political situation affects its economic growth. For Asongu et al (2021) political instability has been a main threat to economic growth and human developments in Sub-Saharan Africa over the past decades. Since independence from colonial powers, countries in SSA have been characterized by a plethora of political stalemates which have substantially curtailed economic growth prospects in the regions.

Some notable examples are Angola (1975 to 2002), Chad (2005 to 2010), well known issues in the Congo Democratic Republic, Liberia (1999 to 2003), Burundi (19993 to 2005), the Central African Republic (1996 to 2003, 2004 to 2007 and 2012 to present), Sierra Leone (1991 to 2002), Côte d'Ivoire (2002 to 2007 and 2010 to 2011), Somalia and Sudan with the Darfur crisis.

2.2.5. Financial Efficiency

Financial sector development is pivotal to the efficacy and efficiency of any economy since it enhances economic growth and investment. According to Jima and Makoni (2023) finance efficiency promotes innovations and entrepreneurship that enhance economic growth, the financial sector plays an important role in mobilizing the financial resources necessary for investment and thereby promoting economic growth. Patrick (1966) cited by Jima and Makoni (2023) argued that the financial system can influence economic growth in three important ways:

- First, the financial system stimulates changes in ownership through financial intermediation among the different asset holders.

- Second, financial institutions promote the transfer of funds and the efficient allocation of resources from relatively low to relatively more productive uses.

- Third, financial institutions contribute to the rise in the rate of capital accumulation if there exists a convenient environment for business transactions, saving, and investment, which incentivizes individuals and businesses to work, save, and invest.

For the authors there is more than just financial efficiency involved in the relationship between a healthy financial sector and economic growth. Financial institutions play multiple roles in facilitating economic vitality in addition to acting as intermediaries. The financial sector becomes

a pillar in advancing an economy's growth by easing the flow of funds, encouraging effective resource allocation, and fostering an environment that is conducive to capital accumulation.

According to Akinsola and Odhiambo (2017) SSA has experienced major changes in financial market policies. Many African countries had to increase their interest rates and free their exchange rates. These policies encouraged capital flows and investment, which later increased economic growth and credit in most countries, but with a high cost of financial fragility.

Fowowe (2011) asserts that most financial systems in SSA countries are still marked by inefficient resource mobilization, high-transaction costs and information asymmetry. For example, credits are disproportionately directed to specific sectors by governments at low-interest rates. These practices usually encourage financial repression and bank running. Financial liberalization policies were introduced to correct the deficiencies in financial systems in SSA countries and to enhance the financial efficiency and economic growth. Countries like Ghana, Mauritius, Botswana, Côte d'Ivoire, Nigeria, Kenya, and South Africa have implemented interest rate liberalization policies. Cameroon and Mali have also implemented gradual financial liberalization through monetary unions. Unfortunately, the implementation of financial liberalization policies in most SSA countries has led to several challenges. These challenges include, amongst others: banking crises, shallow and unstable exchange rates, a widening spread between lending and deposit rates and a drastic decline or stagnation of the domestic credit to financial depth. In addition to that challenges most sub-Saharan African countries are still not well developed and sophisticated enough to compete with the rest of the world. The stifled development of financial markets makes the financial sector vulnerable to global financial crises and can inhibit the development of the real sector.

2.2.6. Climate, Habits and Religion

The pessimistic view that continued economic growth is incompatible with environmental sustainability since the growth process requires the use of the environment both as a source of energy and raw materials and, as a sink for its wastes (solid, gas and liquid) all of which harm the environment. Although global warming is a problem that all countries must contend with, the costs and benefits of rising global temperatures tend to vary across countries and regions. Most studies indicate that poor countries, particularly those in SSA would bear the brunt of climate change (Lanzafame, 2012 cited in Alagidede et al., 2015).

According to Alagidede et al. (2015) the overwhelming reliance on agriculture and other climate-sensitive sectors for production as well as the limited capacity to respond appropriately to climate-related shocks tends to expose the African continent to the vagaries of extreme weather conditions that is why climate change has a deleterious effect on economic growth in Sub-Saharan Africa. Warmer temperatures and falling precipitation reduce the capacity to utilize irrigation to grow crops and support export-based agriculture and light industry, which has a feedback loop on growth and poverty reduction efforts. Furthermore, the authors state that many Sub-Saharan African countries' vulnerability to the effects of climate change is made worse by a lack of sophisticated technological infrastructure and financial resources. These restrictions make it difficult for these countries to implement adaptation and mitigation strategies, which makes coping with the negative effects of environmental changes even more difficult. This emphasizes the complex interplay between economic growth and environmental sustainability on a global scale and displays the vicious cycle of environmental degradation leading to economic setbacks in the context of Sub-Saharan Africa.

According to Kottak (1990) cultural habits towards work, entrepreneurship, and innovation can influence the success of economic growth within a country. Similarly, cultural practices related to land use, resource management, and social organization can affect the sustainability of development projects. The author also states that habitual practices influence economic growth through their effects on productivity, consumption, and resource allocation. In the context of sub-Saharan Africa habitual subsistence farming practices might limit the adoption of more efficient techniques, thereby constraining agricultural productivity and overall economic growth. These habits can also influence market demand and resource utilization patterns, impacting economic growth indirectly.

According to Noland (2005) religious beliefs and practices can affect economic growth through at least two channels. First, participation in religious sects can potentially convey two economic advantages to adherents: a reputational signal and extra-legal means of establishing trust and sanctioning miscreants in intragroup transactions, reducing uncertainty, and improving efficiency. Second, religious beliefs can affect individual behavior, such as work ethic, time preference, and risk aversion, which can in turn affect economic outcomes. In the context of sub-Saharan Africa, religious beliefs play a significant role in shaping societal norms, values, and behaviors as this indirectly affects economic growth by influencing factors such as education, work ethic, social cohesion, and entrepreneurial activities. For instance, certain religious beliefs in the region emphasize the role of education in the society, as this leads to higher human capital accumulation and subsequently contributing to economic growth.

CHAPTER III – EMPIRICAL EVIDENCE ON ECONOMIC GROWTH IN SUB-SAHARAN AFRICA

Researchers have become increasingly interested in studying the economic growth of Sub-Saharan African countries in recent years. To investigate this phenomenon, a variety of authors have used a variety of methodologies and empirical studies, with the common goal being to identify the main factors influencing economic growth in the Sub-Saharan African region. These studies explore a variety of variables that affect economic growth to better understand these phenomena. These empirical studies also aimed to shed light on the complex nature of economic growth in sub-Saharan Africa, even though their methods and conclusions may vary. Researchers try to identify the key factors that have shaped the region's economic growth by examining various socio-economic factors, policy frameworks, and outside influences.

The study of **Ghura & Hadjimichael (1996)** sought to investigate the determinants of per capita economic growth in Sub-Saharan Africa from 1981 to 1992. The authors used an extended version of the Mankiw, Romer, and Weil (1992) framework applied to panel data for 29 countries in the region. They also investigated the contribution of private and government investment to growth, as well as the effects of macroeconomic policies, structural reforms, changes in the terms of trade, human capital, the weather, and political freedom. The authors found that public policies that lower inflation, promote human capital development, and improve the quality of institutions can stimulate economic growth in Sub-Saharan Africa. The authors also emphasize the crucial role played by private investment in the growth process in the region.

They suggest that policymakers should focus on creating an environment that is conducive to private investment, including improving the quality of infrastructure, reducing the cost of doing business, and promoting political stability.

The study of **Bekana (2020)** sought to explore the impact of institutional quality on economic growth and innovation in 37 African countries from 1996 to 2016. The author used two approaches: linear econometric specifications suitable for panel data analysis and structural equation models to identify the direct and indirect effects of institutional development on economic performance.

The authors found that institutional quality has a significant impact on economic performance and innovation in sub-Saharan African countries. They also found that democracy is positively associated with economic growth, while autocracy has a negative impact on economic performance. The study also confirmed that political development towards democratization positively influences economic performance through two channels: directly and indirectly through its positive impact on the innovative capacity of states, that's why the authors suggest that policymakers should focus on improving institutional quality to promote economic growth and development in sub-Saharan Africa.

The study of **Ofori et al (2022)** sought to train several machine learning algorithms to identify the main drivers of economic growth in sub-Saharan Africa and to provide reliable estimates and confidence intervals for these main determinants of economic growth, taking into consideration possible endogeneity, multicollinearity, and modeling complexities. The authors found that machine learning techniques are powerful and effective in reducing model complexities associated with large-data regression problems. With that the authors also found out that there seven key variables that impact economic growth in sub-Saharan Africa, which are manufacturing (value addition), urban population, financial development, government spending, macroeconomic

management, economic globalization, and social inclusion. The authors suggest that future research could use similar techniques to identify factors key for analyzing poverty and inequality and to examine whether the growth-globalization relationship differs between landlocked and non-landlocked countries. Also, regularization techniques can be employed to determine whether durable shared growth is driven largely by environmental factors or income growth and distributions.

The study of **Batrancea et al (2021)** sought to investigate the factors that influence economic growth in 34 African nations from 2001 to 2019, focusing on imports, exports, foreign direct investment inflows and outflows, gross domestic savings, and gross capital formation. Because the author's believed that these variables can cause direct changes in the quantity and quality of goods and services produced and consumed. The authors found that variable exports had a significant effect on GDP growth rate, savings, and capital compared to imports. They suggest that national governments should collaborate with regional authorities to establish trade deals, facilitate foreign direct investment (FDI) inflows, and encourage local investors to support development projects. They also suggest policy implications for African national authorities, such as creating stable and efficient business environments to increase exports of valuable raw materials, fuel, and mining products.

The study of **Ndambiri et al (2012)** sought to identify the key determinants of per-capita real GDP growth in Sub-Saharan Africa from 1982 to 2000, over a sample of 19 countries and suggest policy framework to promote sustainable economic growth. According to the authors findings it shows that physical capital formation, a vibrant export sector and human capital formation significantly contribute to the economic growth among sub- Saharan countries. However, government expenditure, nominal discount rate and foreign aid significantly lead to negative economic growth.

The authors suggest that relevant policies be formulated to promote those sectors that enhance economic growth in the region.

The study of **Ghazanchyan & Stotsky (2013)** sought to examine the drivers of growth in Sub-Saharan Africa from 1999 to 2011, using aggregate data from 42 African countries. It correlates growth experience to key determinants of growth, such as private and public investment, government consumption, exchange regime and real exchange rate, and current account liberalization, using econometric methodologies. The authors found that higher private and public investments boost economic growth, while government consumption is a drag and more flexible exchange regimes are beneficial. The authors recommend that African countries should invest in capital and put in place a framework to ensure high-quality investment, while government spending should be directed to critical priorities.

The study of **Chomen (2022)** sought to explore the correlation between institutions and economic growth in Sub-Saharan Africa from 2002 to 2014 using the system generalized method of moments (GMM) to fit dynamic models for 43 countries. The author's findings suggest that institutions are not essential for economic growth in sub-Saharan African countries and suggests further work to recognize their role. Key topics for future work include considering the threshold for an institution's quality and including indicators from both formal and informal institutions.

The study of **Estache et al (2005)** sought to provide a systematic assessment of the impact of infrastructure sub-sectors on Africa's growth from 1976 to 2001, using an augmented Solow growth model to compare the importance of these subsectors and their interactions with other sectoral expenditures. The findings show that the model estimated tells a useful story for sub-Saharan African as a whole but fails to provide a sense of the diversity of country specific needs.

The authors state that a more subtle Bottom-up approaches based on more disaggregated country specific assessments are needed to generate more precise and specific information on where governments should spend their scarce resources.

The study of **Kodongo & Ojah (2016)** sought to examine the relationship between public infrastructure and economic growth in 45 Sub-Saharan African countries from 2000 to 2011, using the generalized method of moments (GMM) to estimate a model of economic growth. According to authors results, infrastructure spending and increasing access to infrastructure are key drivers of economic growth in Sub-Saharan Africa, particularly for less developed economies. Access to infrastructure also has indirect effects on trade competitiveness and infrastructure quality, as well as cross-border capital flows and export diversification.

The study of **Amponsah et al (2023)** sought to examine the interrelationships between poverty, income inequality, and inclusive growth in Sub-Saharan Africa. The method used in this study was the Panel Generalized Impulse Response Function (PGIRF) model, which is estimated using the two-step system Generalized Method of Moments (GMM) estimator. The authors main findings were that inclusive growth is essential for reducing poverty and income inequality in Sub-Saharan Africa. They suggest that economic crises have a significant impact on poverty and inequality in the region, and inclusive growth policies can help mitigate these effects. They also recommend that policymakers focus on promoting inclusive growth by investing in education, health, and infrastructure, and by implementing policies that support small and medium-sized enterprises.

The study of **Ifedora et al (2022)** sought to investigate the relationship between financial inclusion and economic growth in sub-Saharan Africa, and to identify the specific dimensions of financial inclusion that have the greatest impact on economic growth.

The method used in this study was the dynamic panel data analysis, which allows for the examination of the relationship between financial inclusion and economic growth over time, while controlling for other factors that may affect economic growth. The authors main findings were that financial inclusion has a positive relationship with economic growth in sub-Saharan Africa, meaning that when one grows the other grows simultaneously. Also, the author's found out that the availability and penetration dimensions of financial inclusion had a positive and significant impact on economic growth in sub-Saharan Africa. The authors suggest that policymakers should focus on improving access to financial services in order to promote economic growth in the region. Additionally, the authors emphasize the importance of digital financial services in promoting financial inclusion, particularly in the context of the COVID-19 pandemic.

The study of **Glewe et al (2014)** sought to review recent studies that estimate the impact of education on economic growth, with a special focus on Sub-Saharan Africa. The authors also examine the quality of education in Sub-Saharan Africa and extend estimates from influential studies to show the lower impact of education on economic growth in this region. The method used in this study was a literature review of empirical studies on economic growth, with a focus on education and/or Sub-Saharan Africa. The authors main findings were that the impact of education on economic growth is lower in Sub-Saharan Africa than in other developing regions, due to the poor quality of education in the region. The authors also emphasize the challenges faced by cross-country regressions in estimating the impact of education on economic growth, and their suggestion is that future research should focus on improving the quality of education in Sub-Saharan Africa.

The study of **Bedemo (2022)** sought to analyze the role of governance quality in influencing the economic growth of 22 selected Sub-Saharan African Countries. The method used in this study was panel dynamic Generalized Method of Moments (GMM) to analyze the data obtained from the World Bank database over the period from 2002 to 2020. The author main findings were that the composite governance index has a positive significant effect on the economic growth of the countries, where a unit improvement in the aggregate governance index leads to a 3.05% increase in GDP. The disaggregated result has shown that corruption control and government effectiveness have a negative significant effect on growth performance, whereas the rule of law and regulatory quality showed a positive significant effect. Political stability and voice and accountability have an insignificant effect on economic growth. The author suggests that a strong commitment to the implementation of policy and reform measures on all governance factors. This may add to the need to devise participatory corruption control mechanisms to closely look at the proper implementation of policies and reforms that constitute the government effectiveness factors, and properly implement the rule of law at all levels of the government with a strong commitment to realizing it so that citizens at all levels can have full confidence in and abide by the rules of society.

The study of **Omoteso & Mobolaji (2014)** sought to investigate the impact of governance indices (especially control of corruption) on economic growth in some selected Sub-Sahara African (SSA) countries from 2002 to 2009 with a view to making policy recommendations. Specifically, the study attempts to assess whether either governance reforms (especially those relating to control of corruption) or simultaneous policy reforms could have any impact on the growth of the sample SSA countries. The method used in this study was the panel data framework, the fixed effect, the random effect and the maximum likelihood estimation techniques for the analyses.

The authors main findings were that political stability and regulatory quality indicators have growth-enhancing features, as they impact on economic growth in the region significantly, while government effectiveness impacts negatively on economic growth in the region. Despite several anti-corruption policies in the region, the impact of corruption control on economic growth is not very obvious. The authors also found that simultaneous implementation of the voice and accountability and the rule of law indicators has a more positive impact on economic growth in the region. Both policies are complementary, and, hence, can be pursued simultaneously. The authors suggests that reform efforts that aim at enhancing accountability, regulatory quality, political stability and the rule of law have more growth-enhancing features and, thus, should be given more priority over reform efforts that singly address the issue of control of corruption due to the endemic, systemic and ubiquitous nature of corruption in the region.

The study of **Hyacinth et al (2023)** sought to investigate the evidence of the financial development and economic growth nexus in sub-Saharan Africa from 1995 to 2022. The method used in this study was the two-stage estimated generalized least squares and robust least squares methods for the analysis. Two indices were constructed to measure financial development: one for the banking sector indicators and another for the market-based indicators. The authors main findings were that the banking sector index significantly impacts the gross domestic product (GDP) per capita positively. The market sector index has a negatively significant effect on the GDP per capita. Government expenditure has a positive impact on the GDP per capita. The authors suggest that policymakers in sub-Saharan Africa should improve and implement finance–growth inclusive strategies that promote financial reforms and development to efficiently impact all population sectors.

Also, they should take stringent measures to ensure that the banking sector's development is sustainable to lead economic growth. For the authors sub-Saharan African governments should strategize and promote capital market development using favorable listing rules for companies in the stock markets. Global stock market integration should be encouraged to diversify risks, increase public awareness, raise investors' confidence level and reduce stock market impediments like high taxes and regulatory barriers.

The study of **Donou-Adonsou (2019)** sought to examine whether access to education influences the relationship between technological progress[8] and economic growth in Sub-Saharan Africa, using a panel data of 45 Sub-Saharan African countries from 1993 to 2015. The method used in this study was the fixed-effects, two-step feasible efficient generalized method of moments estimator. The author main findings were that in countries with better access to education, the Internet contributes to economic growth, while mobile phones do not seem to do so. The author suggest that sub-Saharan African countries can derive growth effects by improving their educational systems, which would in turn foster the positive impact of technology on economic growth. The author also suggests that policymakers should focus on improving access to the Internet in countries with better educational systems, as this has a positive impact on economic growth.

The study of **Iyoha (1999)** sought to investigate the impact of external debt on economic growth in sub-Saharan African countries from 1970 to 1994 using a small macro-econometric model. The method used in this study was a simultaneous equations model that consisted of two stochastic equations (for output and investment demand) and four identities. The four identities in the dynamic simulation were for debt accumulation, the debt/GNP ratio, the debt-service ratio and the

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[8] Technological progress is measured by telecommunications infrastructure, namely the Internet and mobile phones.

lagged value of per capita investment. The author main findings were that external debt has a negative impact on investment and economic growth in sub-Saharan African countries, and the factors contribute to the high levels of external debt are decline in the terms of trade, uncontrolled auctions in export earnings, higher interest rates, re-alignment of exchange rates, and rescheduling and refinancing of SSA's external debt, which only served to increase the debt stock. The author suggests that debt reduction packages of 5%, 10%, 20%, and 50% could significantly increase investment and growth performance in these countries. For example, he created a hypothesized test that if would happen a 20% debt stock reduction, it would on average, have increased investment by 18% and increased GDP growth by 1% during the 1987-1994 period. The author also debt forgiveness could provide a much-needed stimulus to investment recovery and economic growth in sub-Saharan Africa. That's why the author also recommends that policymakers focus on increasing investment and improving the efficiency of public spending to promote growth as he emphasizes the importance of good governance and sound macroeconomic policies in promoting growth and reducing debt.

The study of **<u>Bloom et al (2014)</u>** sought to challenge the belief that tertiary education has little role in promoting economic growth and reducing poverty in Sub-Saharan Africa. The method used in this study was a literature review on earlier studies and reports on the impacts of tertiary education on economic growth and poverty reduction, a conceptual framework for the relationship of tertiary education to economic growth, and a panel data model using an aggregate production function to look at the strength of these links. The authors main findings were that there is evidence to support the existence of links between higher education and economic growth, and that donor institutions should better support tertiary education in Sub-Saharan Africa to promote economic growth and reduce poverty in the region.

The authors suggest that that donor institutions should increase funding for tertiary education in Sub-Saharan Africa and that African governments should prioritize higher education in their development strategies, and that research on this matter should seek to determine the best mix of primary, secondary, and higher education according to the circumstances of different countries in the region.

The study of **Ogundari & Awokuse (2018)** sought to revisit the relationship between human capital and economic growth in the SSA region and considers two alternative measures of human capital: health and education. The method used in this study was a dynamic model based on the system generalized method of moments (SGMM) and analyzed a balanced panel data covering 35 countries from 1980 to 2008. The authors main findings were that the two measures of human capital have positive effects on economic growth, although the contribution of health is relatively larger than the impact of education. The authors also emphasize the importance of both measures of human capital and align with the argument in the literature that neither education nor health is a perfect substitute for the other as a measure of human capital. The authors suggest that the findings call for improvement in the quality of education and health in the region and that policymakers in Sub-Saharan Africa may consider investing in both measures to promote economic growth in the region. They also recommend that joint inclusion of both measures of human capital in growth regression models should be preferred in order to minimize the omitted variable bias. Additionally, future studies should address the issue of limited data availability and consider other proxies for health and education when possible.

The study of **Zahonogo (2017)** sought to investigate how trade openness affects economic growth in developing countries, with a focus on sub-Saharan Africa (SSA). The method used in this study was a dynamic growth model with data from 42 SSA countries from 1980 to 2012.

The author employed the Pooled Mean Group estimation technique, which for him was appropriate for drawing conclusions from dynamic heterogeneous panels by considering long-run equilibrium relations. The author main findings were that the trade threshold exists below which greater trade openness has beneficial effects on economic growth and above which the trade effect on growth declines. His findings also indicate an inverted U-curve (Laffer Curve of Trade) response, robust to changes in trade openness measures and to alternative model specifications, suggesting the non-fragility of the linkage between economic growth and trade openness for sub-Saharan countries. Also, the author's findings support the view that the relation between trade openness and economic growth is not linear for SSA. Accordingly, SSA countries must have more effective trade openness, particularly by productively controlling import levels, in order to boost their economic growth through international trade.

The study of **Tahari et al (2004)** sought to identify the sources of economic growth in sub-Saharan Africa from 1960 to 2002 and to provide policy recommendations for promoting sustained growth in the region. The method used in this study was the growth accounting analysis, regression analysis, and a literature survey of selected studies. The authors main findings were that the primary drivers of economic growth in sub-Saharan Africa are physical and human capital accumulation, while total factor productivity growth has been relatively low. The authors suggest that policy reforms should focus on improving human capital, physical infrastructure, macroeconomic stability, and the rule of law. They also recommend reducing trade restrictions and promoting regional integration to enhance trade and investment in the region.

The study of **Levy (1988)** sought to provide some quantitative evidence on the relationship between savings, foreign aid, investment, and growth in the low-income countries of Sub-Saharan Africa from 1968 to 1982. The method used in this study was the theoretical and empirical

framework which takes two forms: first, each equation is estimated with average values over a period, and the correlations and regressions between these averages are tested. Second, the alternative approach of examining each of the annual observations in a pooled cross-section of time series is used. The author main findings were that foreign aid is positively and significantly correlated with investment and economic growth in sub-Saharan Africa and fixed capital formation contributed to the rate of growth. The author suggests that foreign aid should be allocated to support investment and fixed capital formation in Sub-Saharan Africa, and that efforts should be made to improve the quality of macroeconomic data in the region. The author also recommends further research to explore the causal relationship between aid and growth, and to investigate the impact of aid on poverty reduction and income distribution.

The study of **Jena & Sethi (2019)** sought to empirically examine the effectiveness of foreign aid in improving economic growth prospects in the sub-Saharan Africa (SSA) region from 1993 to 2017. The method used in this study was various econometrics tools such as Pedroni and Kao's cointegration test, Johansen-Fisher Panel cointegration test, and the Granger-causality test in order to ascertain the long-run and short-run dynamics among the variables under consideration. The authors main findings were that long-run and short-run relationships exist among foreign aid, economic growth, investment, financial deepening, price stability and trade openness of the SSA economies. The authors also found out a unidirectional causality running from foreign aid to economic growth. The authors recommend that the policymakers in these countries must be well-advised to implement suitable policy measures to build on the growth momentum created by foreign aid inflows.

CHAPTER IV – METHODOLOGY

4.1. MULTIPLE LINEAR REGRESSION

According to GUJARATI (2006), econometric models are formed by variables, equations, coefficients, and random perturbations (called error term), the most famous technique for estimating an econometric model, based on certain statistical concepts, the coefficients and consequently the equations of these models, is the technique of linear regression. When it's desired to know the equation of a random variable that is related to several random variables, a particular case of linear regression is used, the multiple linear regression.

According to Matos (2000) the multiple linear regression model is the one that contains more than one explanatory variable, and the general formula of this model is:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \mu_i$$

Where:

Y – it's the explained or dependent variable, the behavior of which one wishes to know/study.

β_0 – it's the linear coefficient of the model, whose value will be estimated using the multiple linear regression technique.

From β_1 to β_k – these are the angular coefficients of the model, whose values will be estimated using the multiple linear regression technique.

X – is the explanatory or independent variables.

μ – they are the random perturbations (called error term).

i – 1, 2, ..., n (n = size of the sample from which the calculations are made).

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4.2. MODEL SELCTION METHODS

To identify a subset of relevant predictors in econometric and statistic models, usually most researchers use the model selection criteria which refers to a set of explanatory tools for improving regression models. According to Bhatti & Al-Shanfari (2017) each model selection tool involves selecting a subset of possible predictor variables that still account well for the variation in the regression model's observation variable, these tools are often helpful for problems in which one wants the simplest possible explanation for variation in the observation variable or wants to maximize the chance of obtaining good parameter values for the regression model.

The goal of model selection is to find the model that best fits the data and provides the most accurate and reliable results, meaning that the evaluation of how accurately the model's predictions match the data involves measuring the difference between predicted and actual observations using the mean square error (MSE). The smaller the MSE, the greater the accuracy of the model.

4.2.1. Stepwise Selection

According to Wooldridge (2012) stepwise regression is a technique for choosing variables to include in a multiple regression model. Stepwise methods perform variable selection among a restricted set of models. Stepwise selection is the step-by-step iterative construction of a regression model that involves the selection of independent variables to be used in a final model. It involves adding or removing potential explanatory variables in succession and testing for statistical significance after each iteration. This not only guarantees the validity and importance of the chosen variables but also reduces additional error introduced by the redundant variables.

The stepwise selection is based on 3 statistics methods:

➤ **Adjusted R-squared:** $R^2 = 1 - \dfrac{RSS/(n-d-1)}{TSS/(n-1)}$

➤ **Mallow's Cp:** $C_p = \dfrac{1}{n}(RSS + 2\hat{\sigma}^2)$

➤ **Bayesian information criterion:** $BIC = \dfrac{1}{n\hat{\sigma}^2} = [RSS + \log(n)\,d\hat{\sigma}^2]$

Where:

RSS – Residual sum of squares.

TSS – Total sum of squares.

n – number of observations.

d – number of predictors in the subset model.

$\hat{\sigma}^2$ – the estimated variance for the full (global) model.

4.2.2. Regression or Decision Trees

James et al. (2021), defines that decision trees are sets of splitting rules, they are based on segmenting (splitting) the predictor space into separate regions. The predicted output/class is the mean/mode of the training outcomes in the region to which they belong. Trees are quite easy to analyze and explain, but the downside is that they can be less accurate because they suffer from high variance, meaning that they produce very different results if fit on different training samples. The formula for regression tree can be expressed as:

$$f(x) = \sum_{m=1}^{M} C_m\, I(x \in R_m)$$

Where:

f(x) – is the predicted response for a new observation with predictor values x.

C_m – is the mean response for observations in region R_m.

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M – are the regions from which the calculations are made $(R_1, R_2, ..., R_m)$.

I – is the indicator function that returns 1 if the observation belongs to region R_m and 0 otherwise.

According to Hastie (2013) a regression tree is built through a process known as binary recursive partitioning, which is an iterative process that splits the data into partitions or branches, and then continues splitting each partition into smaller groups as the method moves up each branch, in order reduce the risk of overfitting by verifying the predictive utility of all nodes of a regression tree a particular case of regression trees is used which is **Pruning** meaning the reduction the size of decision trees by removing parts of the tree that are redundant and do not provide power to classify instances, making the regression trees model more accurate and have a better interpretation. The formula for pruning can be expressed as:

$$CCM_\alpha = \underbrace{\sum_{m=1}^{|T|} \sum_{i\epsilon R_m} (yi - \hat{y}R_m)^2}_{SSE} + \alpha|T|$$

Where:

CCM – represents the tradeoff between the goodness of fit of the tree and its complexity.

SSE – is the sum of squared errors of the tree T on the training set.

$|T|$ – is number of terminal nodes of the tree T.

R_m – is the region corresponding to the m-th terminal node.

α – is a nonnegative tuning parameter.

4.2.3. Bagging and Random Forest

James et al. (2021), describes Bagging as an ensemble algorithm that fits multiple models on different subsets of a training dataset, then combines the predictions from all models. Bagging does help reduce variance from models that are might be very accurate, but only on the data they were trained on. This is also known as overfitting and Bagging gets around this by creating its own variance amongst the data by sampling and replacing data while it tests multiple hypothesis(models). In turn, this reduces the noise by utilizing multiple samples that would most likely be made up of data with various attributes (median, average, etc.) Bagging solves the inaccuracy problem of regression trees, but at the expense of interpretation. It doesn't have the tree structure anymore, but only values. The formula for bagging can be expressed as:

$$\hat{f}bag = \frac{1}{B} \sum_{b=1}^{B} \hat{f}b^*$$

Where:

$\hat{f}bag -$ represents the predicted response variable value for a new input, after the bagging algorithm has combined the predictions of all the trained models.

B – represents the number of bootstrap samples created from the original training dataset.

$\hat{f}b^* -$ is the prediction of the b-th model on the input example *

According to James et al. (2021), random Forest is an extension of bagging that also randomly selects subsets of features used in each data sample. Both bagging and random forests have proven effective on a wide range of different predictive modeling problems. Like bagging, random forest involves selecting bootstrap samples from the training dataset and fitting a decision tree on each.

For the authors, bagging and random forest are two popular ensemble learning techniques for building decision tree models but the key difference between them lies in how they select features for each tree. Bagging trains each decision tree on a random bootstrap sample of the training data, while in random forest, a smaller, randomly selected subset of features is used for each bootstrap sample. This approach reduces the correlation between the trees, making them more independent and less prone to overfitting. By combining the predictions of multiple de-correlated trees, the ensemble can achieve higher accuracy and lower variance than a single decision tree.

4.3. STUDY DESIGN / TYPE OF RESEARCH

To achieve the objectives of the thesis, this study presented a quantitative and descriptive study, because it aimed to establish or see the relationships between the factors (variables) which are important on determining the economic growth in sub-Saharan African countries.

As for the procedures, the following research presented Bibliographic research because it was carried a literature review on Economic Growth on what certain authors say in relation to this theory, particularly in developing countries. Also, Documentary research was carried out to collect data on Economic Growth factors (already analyzed for other purposes) to achieve the objectives of the research.

4.4. DATA SOURCE / COLLECTION

The research used panel data for the period 1990 – 2021 and for the analysis were selected 48 countries (they represent the sample on a total of 137 countries, which represent the group of developing countries in the world according to the World Bank) which are included in the sub-Saharan African region[9] respectively: Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo Democratic Republic, Congo Republic, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Tanzania, Togo, Uganda, Zambia and Zimbabwe. The researcher collected the data on the mentioned countries from the World Bank data set: **World Development Indicators (WDI) and Worldwide Governance Indicators (WGI).**

In terms of type of data, the research collected quantitative data because it aimed to collect concrete facts: numbers that are structured and statistically. These numbers served as the foundation for reaching research conclusions, which aimed to identify the key factors that contributed to Sub-Saharan Africa's economic growth.

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[9] These countries were selected according to the list of classification of countries by the World Bank. Sub-Saharan Africa | Data (worldbank.org)

4.5. DATA ANALYSIS

To achieve the study's goals, this sub-section aims to create an econometric model based on Romer's model of endogenous growth theory with additional external variables (Institutional quality, Total labor force, Gini index, Foreign direct investment and Population growth rate) that can be considered important key factors that affect the economic growth of sub-Saharan African countries. The selection of these external variables for the econometric model in the context of Sub-Saharan Africa is justified because they collectively address key factors influencing economic growth that are particularly significant to the area. Due to their capacity to include a wide range of significant factors influencing economic development in Sub-Saharan Africa, these variables were chosen over others. Also, by including these variables in the model, it offers a comprehensive framework for understanding the dynamics of economic growth in the region.

To analyze the obtained dataset, an econometric analysis was made, and the data was treated and processed by R Studio and Microsoft Excel. According to GUJARATI (2006), there are two examination methods widely used in data processing: the Ordinary Least Squares (OLS) method and the Maximum Likelihood method. For Gujarati OLS is the best method for regression analysis because it is intuitively and in mathematical terms much simpler than the second method. And it will be the OLS that was used in the following research.

Based on the previous concepts explained at the beginning of this chapter and also in Romer's model of endogenous growth theory, for the present study the multiple linear regression model that was used, is the following:

$$GDP\ Per\ Capita_{it}\ =\ \beta_0 + \beta_1 Region_{it}\ + \beta_2 Gross\ fixed\ capital\ formation_{it} +$$

$$\beta_3 Total\ Labor\ Force_{it} + \beta_4 Techonological\ progress_{it} + \beta_5 Institutional\ quality_{it} +$$

$$\beta_6 Gini\ index_{it} + \beta_7 FDI_{it} + \beta_8 Education_{it} + \beta_9 Population\ growth\ rate\ _{it} + \ \mu_{it}$$

Where:

β (The Betas) – These are parameters to be estimated, they are unknown but fixed parameters, called regression coefficients.

β_0 – it's the Intercept that represents the value of the dependent variable when all independent variables are equal to 0.

From β_1 *to* β_8 – they are the angular coefficients that are the slope parameters.

μ – it's the stochastic error, that is, it's all those variables that are omitted in the model, but which collectively affect the dependent variable.

i – it's the subscript of the panel data that represents the countries.

t – it's the subscript of the panel data that represents the years of study.

Dependent variable:

- **GDP Per Capita** – Economic growth is measured as the annual percent change of gross domestic product (GDP). Data for GDP is available for most countries, but only considering size of GDP can deviate the analysis from its goal. Population growth also increases labor force, so higher economic growth may not mean a higher standard of living. Therefore, this study considers GDP per capita in place of economic growth because GDP per capita mostly is an indicator of a more efficient economy. To avoid any possible distortion, the per-capita GDP of each country is calculated in purchasing power parity-adjusted (PPP) constant 2017 U.S. dollars (i.e., 2017 constant international dollars).

Independent variables:

- **Region** – It's a qualitative variable that indicates the region to which the group of countries belongs. It is measured by a dummy variable [10] that indicates all developing countries that are part of the sub-Saharan Africa region as 1 and all developing countries that are not part of it as 0.

- **Gross fixed capital formation** – Also known as gross domestic investment, is the addition to fixed assets such as plants, machinery, roads, and equipment purchases, and according to the World Bank[11] it can used to measure the size of factor capital. The data of this variable is related to percentages of GDP because it will help to understand the importance of investment in driving economic growth within the region's economy.

- **Total labor force** – The World Bank classifies the labor force as a group of people with ages of 15 and older who supply labor to produce goods and services during a specified period. It includes current and unemployed workers, as well as first-time jobseekers. The data of this variable is related to percentages of population because it will help to understand the level of workforce participation in the economy and it will provide insights into the employment potential, labor market dynamics, and utilization of the working-age population. A study from Kargi (2014) cited in Abdullah (2022) found a positive relationship between labor force participation and economic growth. However, the concept of labor force participation can reveal paradoxes, such as "jobless growth" and "unskilled growth," which may explain the advancing population. Despite these paradoxes, for the

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[10] Dummy variable is qualitative or discrete variable that represent categorical data and can take the values as 0 or 1 to indicate the absence or presence of a specified attribute respectively.

[11] World Development Indicators | Databank (worldbank.org)

author labor participation has an effective contribution to economic growth. That's why this variable is included on the econometric model of this thesis.

- **Technological progress –** Represent how well the country is adopting new technologies, since there are no ready-made variables for measuring an economy's technological progress, several proxy variables were adopted by various authors to replace the variable with one that is similar. A study made by Das & Nanga (2022) used the variable **"Individuals using the Internet (% of population)"** to measure the technological progress in an economy because the authors believed that this variable could help capture the extent of internet access and usage, which is vital for innovation, information sharing, and digital transformation, and it is this same variable that will be used in the case of this study to evaluate the technological progress, also the author of this thesis decided to use this variable because it was the only one with available data for the period of study (1990 – 2021) for the most countries in the analysis.

- **Institutional quality –** Similar to technological change, there are no direct variables available to measure the quality of institutions of an economy. The World Bank dataset **"*World Governance Indicator (WGI)*[12]"** has six aggregated indicators related to institutional quality, including government effectiveness (GE), control of corruption (CC), regulatory quality (RQ), political stability (PS), rule of law (RL), and voice & accountability (VA). In measuring the quality of the institution of a country, some earlier studies used [such as Knack & Keefer (1995) and Al-Marhubi (2005) cited by Abdullah (2022)], the average of these six indicators and it will be this method that will be used in the current study to measure the quality of institutions. The values of all these indicators

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[12] Worldwide Governance Indicators | Databank (worldbank.org)

range between -2.5 to +2.5, meaning that the higher value of the calculated index indicates better institutional quality, while the lower value indicates the opposite.

- **Gini index** – Measures the extent to which the distribution of income (or consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. A Lorenz curve[13] plots the cumulative percentages of total income received against the cumulative number of recipients, starting with the poorest individual or household. The Gini index measures the area between the Lorenz curve and a hypothetical line of absolute equality, expressed as a percentage of the maximum area under the line, thus the Gini index has a range from 0 to 1 on which 0 represents perfect equality, while an index of 1 implies perfect inequality.

- **Foreign direct investment (FDI)** – It measures the net inflows of cross-border investment in which an investor resident in one economy establishes a lasting interest in and a significant degree of influence over an enterprise resident in another economy. According to Lensink & Morrissey (2006) cited by Ndambiri et al (2012), FDI has been a key factor in internationalizing economic activity and promoting technology transfer and economic growth, empirical literature has consistently found a positive link between FDI and growth. Same as **Gross fixed capital formation,** the data of this variable (FDI) is also related to percentages of GDP because it will help to understand the level of international integration of the sub-Saharan African region into the global economy, and also the relative importance of FDI in the economy its potential impact on economic growth.

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[13] The Lorenz Curve is a tool used to represent income distributions; it tells which proportion of total income is in the hands of a given percentage of population. Munich Personal RePEc Archive (MPRA) - EasyPol

- **Education (School enrollment rates tertiary education)** – It measures the percentage of people enrolled in tertiary education (colleges, universities, etc.), regardless of age, and is referred to as the school's enrollment ratio. Gymiah-Brempong et al. (2006), cited by Bloom et al (2014), found that a 1% increase in the average years of higher education would increase the growth rate of per capita income by 0.09 percentage points per year, which is three times as large as the growth impact of physical capital investment. The authors made this discovery in a study of higher education and economic growth in Africa. Since it helps people catch up with technology and can lead to more rapid growth, tertiary education is a key factor in this thesis's promotion of economic growth.

- **Population growth rate** – It measures the annual average rate of change of population size, for a given country, territory, or geographic area, during a specified period. Also represents the annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage. Population is based on the fact definition of population, which counts all residents regardless of legal status or citizenship.

To find the more accurate and precise model prediction (model with the lowest mean squared error **"MSE"[14]**) to explain the economic growth in sub-Saharan Africa, the author assumed an econometric and statistical analyzes applying the following methods:

➢ **Stepwise Selection:** Adjusted R^2, Mallow's Cp and BIC.

➢ **Regression Trees:** Pruning.

➢ **Bagging and Random Forest.**

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[14] Mean squared error (MSE) is defined as the measurement of the amount of errors in statistical and econometric models and it assesses the average squared difference between the observed and predicted value.

CHAPTER V – PRESENTATION AND INTERPRATION OF THE RESULTS

This chapter consists of the presentation and interpretation of the data obtained regarding the relevant variables for the research. For such, it considers their evolution over a period of 30 years. In this chapter, the focus is on the presentation of the collected data, providing a comprehensive overview of the relevant variables.

5.1. ECONOMIC GROWTH IN SUB-SAHARAN AFRICA (1990 – 2021)

In this section and the subsequent sub-sections, the data regarding Sub-Saharan Africa is presented alongside values relative to a reasonable benchmark (point of reference): lower middle-income countries. These comparisons offer a clearer understanding of Sub-Saharan Africa's economic performance in comparison to countries within a similar income group.
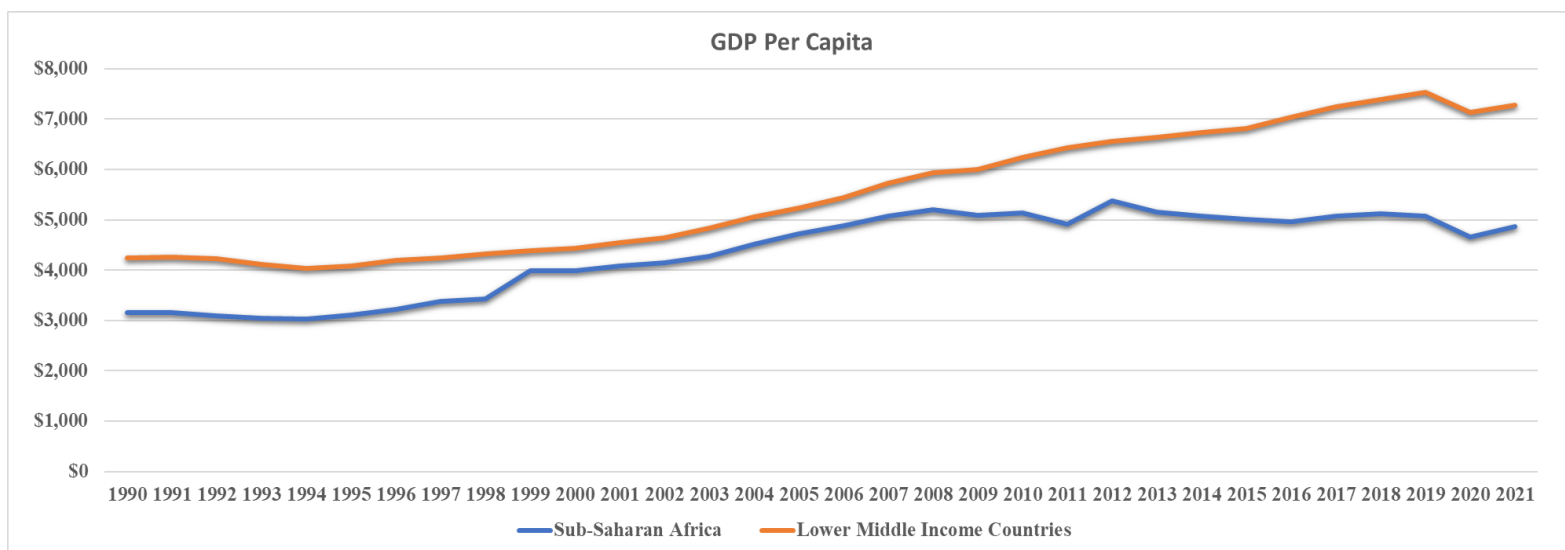
Figure 5.1: *The evolution of economic growth (1990 – 2021)*
Source: *World Development Indicators – World Bank*

According to the results in the figure 5.1, it's fair to say that, throughout the period 1990 to 2021, Sub-Saharan Africa's GDP per capita fluctuates from year to year, but overall, it shows an increase from 1990 to 2014, followed by a period of stability until 2019 and a slight decline in 2020. In 2021, there is a recovery.

From 1990 to 1994, the GDP per capita in Sub-Saharan Africa remained relatively stagnant, hovering around the $3,000 to $3,200 range. To provide context, during the same years, lower middle-income countries[15] had GDP per capita values ranging from $4,244 in 1990 to $4,032 in 1994. This period indicates the challenges and economic difficulties faced by Sub-Saharan Africa, as it had a lower GDP per capita compared to middle-income countries. The challenges and economic difficulties faced by the sub-Saharan Africa region in this period was due the fact that most of the countries were overcoming enormous challenges in development such as external shocks, weak institutions, governance issues, limited diversification, and reconstruction after the civil war. According to Cata (1999), from the mid-1990s to the early 2010s, the GDP per capita in Sub-Saharan Africa experienced a notable growth phase, moving from $3,000 to $5,000. This growth was similar to that of lower middle-income countries, which also experienced consistent economic growth during this period, as their GDP per capita grew from 4,000$ to 6,000$. The GDP per capita experienced a notable growth phase due to the fact that many sub-Saharan African countries focused on important economic and structural reforms: price controls have been abolished or liberalized, some inefficient public sector monopolies have been dismantled and many state enterprises privatized, nontariff barriers have been eliminated and import duties were lowered, exchange rates have been freed and unified also direct controls on bank credit have been

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[15] Lower middle income | Data (worldbank.org). This include all countries that are part from this group, excluding some sub-Saharan African countries which are included the group.

eliminated and market-determined interest rates established. These reforms aimed at reducing poverty and promoting economic development, that is why it's possible to see an increase on the GDP per capita from 3000$ to 5000$. In 2011, Sub-Saharan Africa's GDP per capita decreased to $4,096, while middle-income countries maintained a higher per capita income of 6,425. This decline in Sub-Saharan Africa can be attributed to global economic uncertainties and the aftermath of the global financial crisis of 2008. Lower middle-income countries, with more diversified economies, were relatively less affected during this period. The crisis led to decreased demand for commodities, and since many Sub-Saharan Africa countries heavily depend on commodity exports for revenue, the countries were hit by fluctuations in commodity prices, with some experiencing declines. Lower commodity prices negatively affected the export earnings and government revenues, which in turn decreased the economic growth. From 2012 to 2019, sub-Saharan Africa's GDP per capita showed an increase and then stabilization, fluctuating within a narrow range. This was a period of recovery for the sub-Saharan Africa region, although it lagged behind middle-income countries in terms of per capita income, the growth indicated positive economic trends and development efforts. The recovery in sub-Saharan Africa was due to the increase in commodity prices, better macroeconomic management, infrastructure development, regional integration and trade initiatives, and the demographic dividend of a young and growing population. These factors combined to create a conducive environment for sustained growth. Infrastructure development efforts improved connectivity, reduced production costs, and attracted private sector investments. Regional integration and trade initiatives, such as the African Continental Free Trade Area (AfCFTA), reduced trade barriers and fostered greater intra-regional trade.

In 2020, the GDP per-capita of Sub-Saharan Africa's and lower middle-income countries declined, although lower middle-income countries with more established economic systems, maintained a higher per capita income of 7,125$. This decline was attributed to the COVID-19 pandemic, which had a significant impact on economies worldwide. Lower middle-income countries also faced challenges but generally fared better in terms of per capita income. In 2021, there is a slight increase in Sub-Saharan Africa's GDP per capita, but it's not very significant. This reflects the ongoing challenges faced by the region due to the pandemic, and lower middle-income countries continue to maintain a higher per capita income compared to the sub-Saharan Africa.

5.1.1. The role of Investments

The Gross Fixed Capital Formation (GFCF) is a measure of investment in fixed assets, such as machinery, buildings, and infrastructure, relative to the size of the economy, it indicates the level of investment in productive assets that contribute to economic growth and development. The Foreign Direct Investment (FDI) refers to investment made by foreign entities into the economy of a country. The results of both investments are expressed as percentages of GDP, indicating the proportion of GFCF and FDI in relation to the total GDP. This allows a better evaluation of the extent on how much both types of investments contribute to economic growth.

a) Gross Fixed Capital Formation
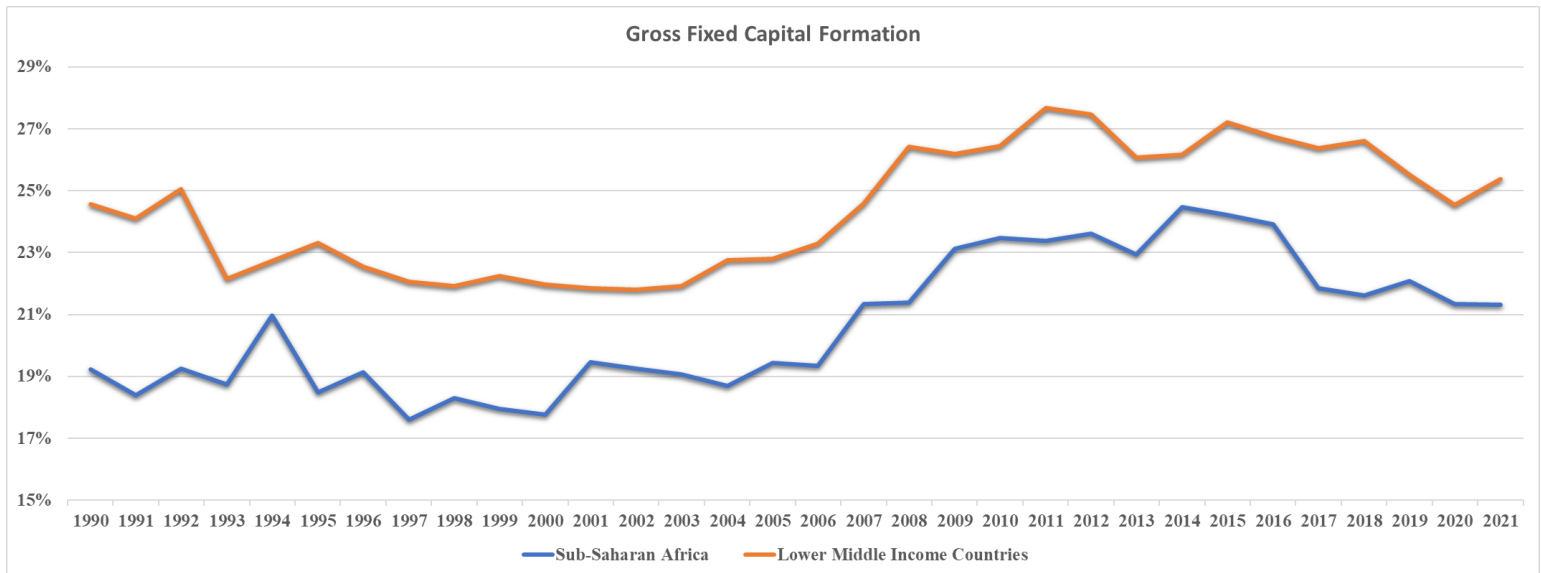
Figure 5.2: *The impact of gross fixed capital formation on economic growth (1990 – 2021)*
Source: *World Development Indicators – World Bank*

Considering the results in figure 5.2, it is reasonable to say that from 1990 to 2021 the contribution of gross fixed capital formation to economic growth in sub-Saharan Africa has changed over time, although there is no obvious linear trend, some patterns can be seen. The lower middle-income countries show a similar pattern even though their GFCF contribution to economic growth is higher than sub-Saharan Africa, as this means that lower middle-income countries allocated a larger share of their fixed capital formation to economic growth compared to sub-Saharan Africa. The percentage was largely stable in the early years (1990s) for both lower middle-income countries and sub-Saharan Africa, with some minor variations. There was an upward trend from the middle of the 1990s to the beginning of the 2000s. After that, there were only minor fluctuations in the percentage.

Meaning that from 1990 to 1999 in sub-Saharan Africa, the percentage fluctuated between 17.61% and 20.97%, while in lower middle-income countries the percentage fluctuated between 21.92% and 25.05%, as these results indicate some volatility in the contribution of GFCF to the total GDP. From 2000 to 2007 in sub-Saharan Africa, the values remained relatively stable, ranging from 17.77% to 21.39%, while lower middle-income countries the values experienced some growth from 21.86% to 24.58% due to the substantial increase in investments on infrastructure, machinery, and other fixed assets as a proportion of their GDP, the example of this is India's commitment to infrastructure development played a pivotal role in the growth of its GFCF contribution. Investments were made in areas such as transportation, energy, telecommunications, and urban development. During this period, these investments played a pivotal role in India's economic growth, contributing to GDP growth rates that consistently exceeded 8%.

However, there was a notable increase from 2008 to 2014 in sub-Saharan Africa, reaching a peak of 24.48% in 2014 which is the higher value for the period of the analysis and according to IMF (2013) this increase can be attributed to various factors such as:

- **Robust import demand:** Most of the sub-Saharan African countries (Burkina Faso, Guinea, and Mozambique among others) experienced strong import demand, leading to widening current account deficits. This increased import activity contributed to higher levels of GFCF.

- **Rising exports:** Some countries like Sierra Leone and others, witnessed a significant increase in export levels, particularly due to the commencement of new resource projects. Higher export earnings stimulated more investment in fixed assets and contributed to the rise in GFCF.

- **Declining grant aid:** While grant aid remained relatively stable in nominal terms, its share of GDP gradually declined since the global financial crisis in 2008. This decline in aid dependency prompted SSA countries to rely more on domestic and private sector investment, resulting in the increase of GFCF.

Afterwards, the percentages for both sub-Saharan Africa compared to the lower middle-income countries declined gradually, with some minor fluctuations, as they reached 21.32% in the case of sub-Saharan Africa and 25.37% for lower middle-income countries in 2021.

b) Foreign Direct Investment
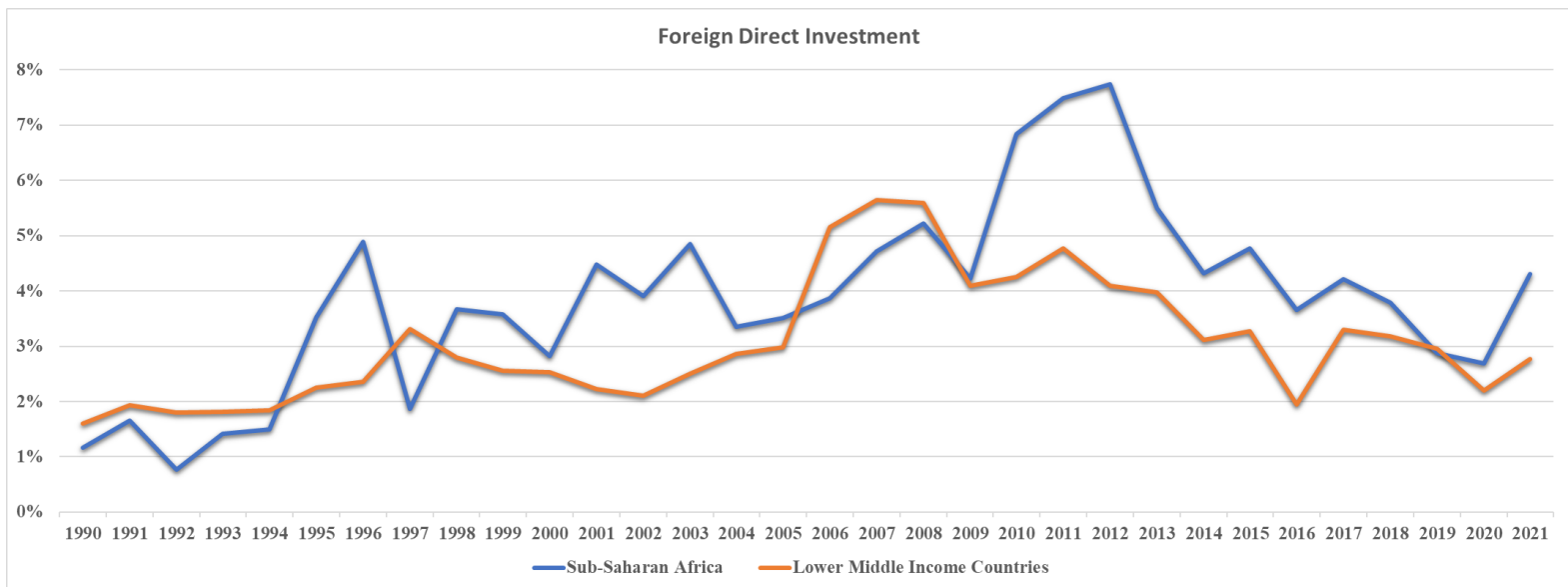
Figure 5.3: *The impact of foreign direct investment on economic growth (1990 – 2021)*
Source: *World Development Indicators – World Bank*

Given the results presented in figure 5.3 it's proper to say that between 1990 and 2021, the contribution of foreign direct investment on economic growth are comparatively low compared to gross fixed capital formation but there is a similarity as the results shows fluctuations and also there is no consistent linear trend. Also is possible to see that in most of the years of the analysis the foreign direct investment is higher in sub-Saharan Africa compared to lower middle-income countries as this means the foreign investors invest more in sub-Saharan Africa due to market potential and the abundant natural resources that the region has to offer.

In the early years (1990s), FDI as a percentage of GDP for both groups of countries was relatively low and showed some variations. From the late 1990s to the early 2000s, there was a general increasing trend, with sub-Saharan Africa reaching its peak in 2012. However, the percentage declined after 2012, with some fluctuations in recent years. As this means that for sub-Saharan Africa, from 1990 to 1995, the percentage fluctuated between 0.77% and 3.52%, while in lower middle-income countries the percentage fluctuated between 1.60% and 2.25% respectively as these results indicates some variability in the contribution of FDI to the total GDP. Starting from 1996, there was a substantial increase in FDI, for both sub-Saharan Africa and lower middle income countries, with sub-Saharan surpassing lower middle income countries and reaching its peak in 2012 with 7.74%, which is the higher value for the period of the analysis and according to Ezeoha & Cattaneo (2012) this increase was due to the reforms and improved economic conditions as many countries in Sub-Saharan Africa implemented substantial economic and financial system reforms since the mid-90s, these reforms included fiscal and monetary policies, reduction of macroeconomic imbalances, removal of price controls, establishment of market-determined interest rates, exchange rate liberalization, and restructuring of public sector enterprises.

These improvements in the economic and institutional environment made the region more attractive to foreign investors. Nevertheless, starting from 2012, the FDI percentages experienced a declining trend in both groups of countries, punctuated by occasional fluctuations. By 2021, sub-Saharan Africa recorded a percentage of 4.30%, while lower middle-income countries registered a lower percentage of 2.77%.

In general, it can be realized that both Gross Fixed Capital Formation (GFCF) and Foreign Direct Investment (FDI) have played pivotal roles in promoting economic growth. Lower middle-income countries, such as those in Asia and Latin America, have often exhibited higher contributions to Gross Fixed Capital Formation (GFCF). On the other hand, Sub-Saharan Africa, a diverse region encompassing numerous nations with varying levels of development, has frequently shown higher contributions in terms of Foreign Direct Investment (FDI).

However, GFCF has made a larger overall contribution compared to FDI. Analyzing the period from 1990 to 2021, the trends for both indicators exhibited fluctuations without consistent linear patterns. These fluctuations and the absence of a steady trend in GFCF and FDI percentages highlight the complex and dynamic nature of investment patterns and their correlation with economic growth. It implies that multiple factors, including domestic policies, global economic conditions, and regional dynamics, can influence investment levels and patterns over time. Moreover, the balance between Gross Fixed Capital Formation (GFCF) and Foreign Direct Investment (FDI) can vary even within regions due to the unique economic and policy landscapes of individual countries. For example, within Latin America and Asia, some nations may heavily prioritize GFCF, focusing on infrastructure projects, while within sub-Saharan Africa certain countries attracts significant FDI flows into emerging industries like renewable energy or technology startups.

5.1.2. The role of Education

School enrollment - tertiary education
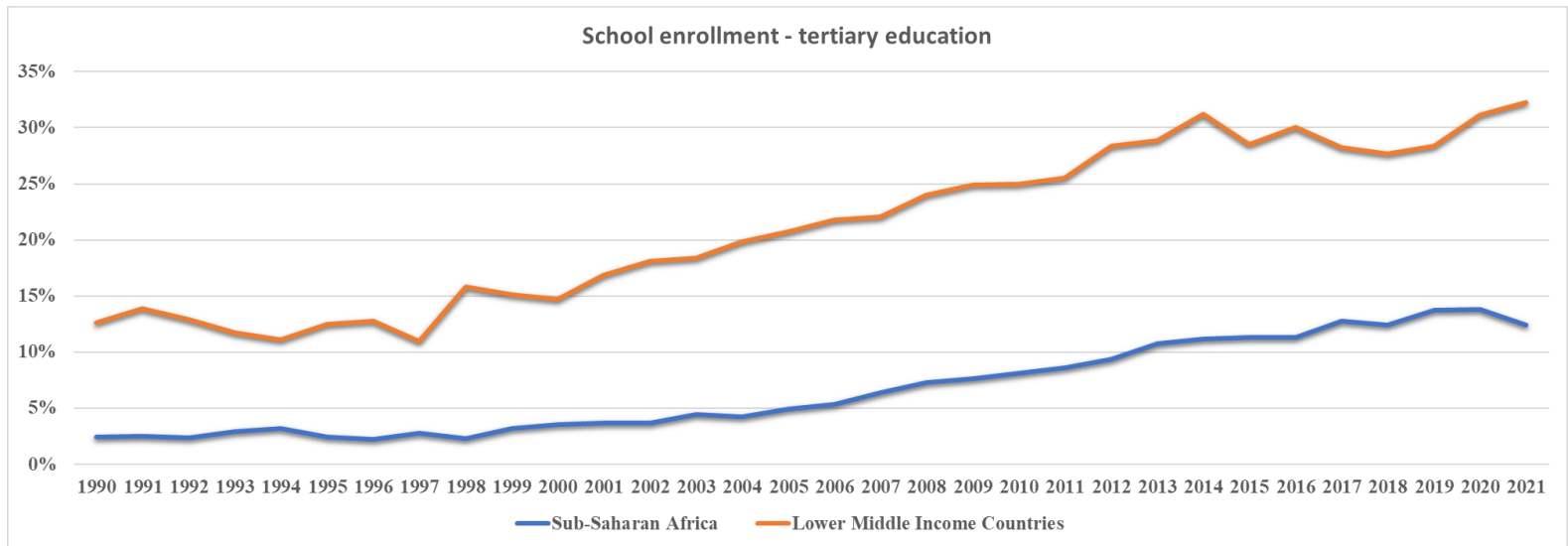
Figure 5.4: *The evolution of enrollment rates on tertiary education (1990 – 2021)*
Source: *World Development Indicators – World Bank*

Considering the results in figure 5.4, it is reasonable to say that from 1990 to 2021 the school enrollment rates on tertiary education have shown an overall increasing trend over the years, with Lower middle-income countries showing higher enrollment rates than sub-Saharan Africa.

In the sub-Saharan African region, the rate of access to higher education has steadily increased from 1990, when it was 2.42%, to 2021, when it reached 12.45%. Similar to Lower middle-income countries, which also have seen significant growth, with the rate increasing from 12.63% in 1990 to 32.25% in 2021. These results indicate a gradual expansion of access to higher education. However, it's worth noting the disparity in educational access between sub-Saharan Africa and Lower middle-income countries due to a combination of factors, including differences in economic development, infrastructure, government investments in education, and regional challenges like poverty and conflict. These elements collectively influence the ability of countries to expand tertiary education opportunities and encourage student enrollment in higher education institutions.

In sub-Saharan from 1990 to 2000, the enrollment rate remained relatively low, ranging from 2.42% to 3.67% compared to Low middle-income countries which were ranging from 11.08% to 15.82%. This low enrollment rates in sub-Saharan Africa were characterized by limited access to tertiary education and challenges in expanding educational opportunities since the countries were implementing government reforms to diminish the negatives effects of the colonialism followed by a civil war era, many countries at that time were still facing huge economic and political challenges.

Starting from the early 2000s, there was a noticeable upward trend in the enrollment rates in sub-Saharan Africa. The percentages increased from 3.67% in 2001 to 13.80% in 2020, which is considered the peak for the period of the analysis. This period reflects significant progress in improving access to tertiary education and according to Amin & Ntembe (2020) this is increase was due to the following factors:

> - **Demographic factors:** Sub-Saharan Africa has a youthful population, with approximately 70 percent of the population under 30 years old. This large cohort entering the age of higher education has contributed to increased enrollment rates.

- **Growth in primary and secondary education:** The expansion and improvement of primary and secondary education systems in the region has provided a strong foundation for students to progress to tertiary education. The high growth rate in these education sectors has acted as a key input for higher education enrollment.

- **Rise in public demand:** Factors such as income growth, economic development, and increasing global competitiveness have led to a rise in public demand for higher education. As individuals aspire to secure better job opportunities and improve their socio-economic status, pursuing tertiary education becomes increasingly important.

- **Stable political institutions:** Progress in establishing stable and healthy political institutions has played a role in creating an environment conducive to higher education enrollment. Political stability promotes confidence and investment in education, attracting more students to pursue tertiary studies.

- **Private demand and job opportunities:** The expansion of private sector employment opportunities and the recognition of the value of higher education in securing well-paying jobs have increased private demand for tertiary education. As individuals seek to enhance their employability and career prospects, enrollment in higher education has witnessed growth.

- **Improved social justice:** Efforts to improve social justice, access, and equity in education have contributed to increased enrollment in tertiary education. Governments and organizations have implemented policies and programs to ensure that education opportunities are available to a broader segment of the population, including historically marginalized groups.

From 2020 to 2021, there was a slight decrease from 13.80% to 12.45%, as this decline indicates that there were challenges or disruptions in educational systems, such as school closures, limited access to digital learning resources, and economic hardships faced by many families. As a result, students in the region faced barriers to pursuing higher education, leading to a drop in enrollment rates during this period. These challenges were due to the COVID-19 pandemic.

5.1.3. The role of Institutions
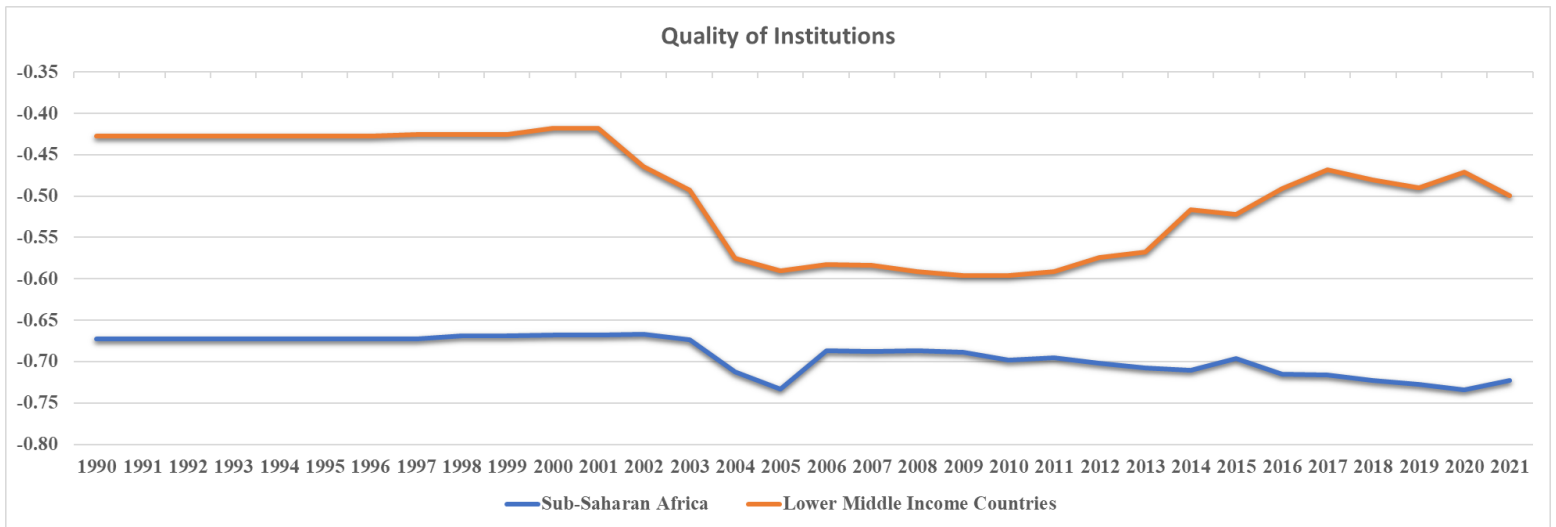
Figure 5.5: *The evolution of quality of institutions index (1990 – 2021)*
Source: *World Governance Indicators – World Bank*

The Quality of Institutions Index is a measurement that assesses the strength and effectiveness of institutions within a country. It is often used as an indicator of the overall governance and regulatory environment within a nation. The World Bank measured this index with a range between -2.5 to +2.5, this implies that a higher score (2.5) on the index represents a superior level of institutional quality, whereas a lower score (-2.5) suggests a lower level of institutional quality.

Based on the results in figure 5.5, it is reasonable to say that from 1990 to 2021 the quality of institutions index in sub-Saharan Africa remained relatively stable throughout the period. However, when the index is compared to that one of the Lower-middle-income countries, it becomes evident that sub-Saharan Africa's institutional quality index remained consistently low throughout this period. This means that the region's institutions have not shown significant improvement and continue to underperform when compared to their counterparts in lower-middle-income countries.

Also, the figure 5.5 shows a common challenge faced by many developing countries concerning the quality of their institutions and their ability to effectively allocate economic resources for productive purposes. This problem is not unique to a specific region but rather a widespread issue observed in various developing countries as it highlights the crucial role that institutions play in shaping a country economic growth because institutions are made up of a diverse range of components, including governance structures, public administration, and legal and regulatory frameworks. When these institutions are unreliable, dishonest, or ineffective, they prevent a country from using its resources wisely and realizing its full economic potential. Resources may be misallocated in such situations, resulting in inefficiencies, rent-seeking actions, and the maintenance of economic inequality. Thus, innovation is blocked foreign investment is discouraged, and overall economic progress is hindered. Furthermore, these weak institutions undermine the rule of law and decrease public confidence in the government, inhibiting both domestic and foreign stakeholders from engaging in economic activity.

The index score in sub-Saharan Africa ranges from -0.67 to -0.73, indicating a consistently low level of institutional quality in the region and faces ongoing challenges in establishing and maintaining strong institutions. From 1990 to 2003, the index remains consistently at -0.67. This indicates a period of relative stability in institutional quality, albeit at a low level. During this time, sub-Saharan African countries faced challenges in improving their institutions but struggled to make significant progress. Starting from 2004 the decline starts in which reached a low point of -0.73 in 2005, after that followed by a small recovery to -0.70 in 2010 and again reaching a lower point of -0.73 in 2020 the same as 2005. Some argue that sub-Saharan Africa's weak institutions resulted from too little political competition (or lack of interstate conflicts).

Herbst (2000) cited by Siba (2007) suggests that the structural conditions for state formation and institution building in Europe were absent in Africa. Unlike in Europe, land was not scarce in Africa. After independence, colonial boundaries were made to largely determine the form of the newly formed nations by the international state system and United Nations, hence preventing border disputes once again. As a result, Herbst argues that African states did not develop institutions that could effectively guard their territories.

The lack of development of sub-Saharan African state institutions helps explain many aspects of modern Africa. Since states never had to fight to survive, they never had to build effective fiscal institutions. States never had to make political concessions to their citizens, hence the lack of functioning domestic political institutions in Africa. Post-independence factors also have contributions to institutional failures of countries in the region. Foreign aid dependence undermines institutional quality by making it difficult for societies to have strong rule law, encouraging corruption, and alleviating pressures to reform inefficient bureaucracy and public service delivery (Siba, 2007).

In general, the figure 5.5 indicates a limited improvement in institutional quality in sub-Saharan Africa over the years compared to Lower middle-income countries. The progress in quality of institutions in sub-Saharan Africa has been slow despite numerous initiatives and efforts to improve governance frameworks, as the area still faces ongoing difficulties. The policies adopted by post-independence rulers and a combination of historical elements can be attributed to these difficulties. The public's trust has been undermined by corruption, which makes it difficult to have effective governance. Additionally, the lack of accountability caused by the region's weak legal frameworks promotes inefficiency and undermines the rule of law. The lack of transparency continues to be a major problem because it prevents fair and effective institutions from operating.

5.2. DESCRIPTIVE STATISTICS

The author explores descriptive statistics in this section, which is a crucial part of data analysis for this study. Three essential elements—outliers, summary statistics and distribution—are examined in order to give a clear vision of the collected dataset.

5.2.1. Outliers

According to Larson & Farber (2011), an outlier is an observation that is numerically distant from the rest of the data, it can be an unusually high or low value that stands out from the rest. They have the potential to distort statistical analysis and affect the accuracy of our model.

To ensure the robustness of our model and prevent these outliers from unduly influencing our results, the author has made the decision to remove them from our dataset.
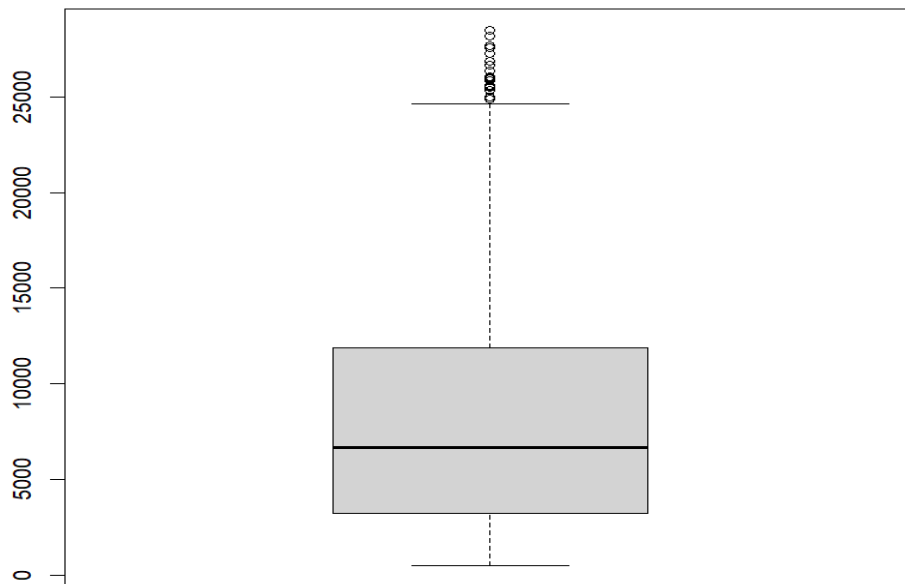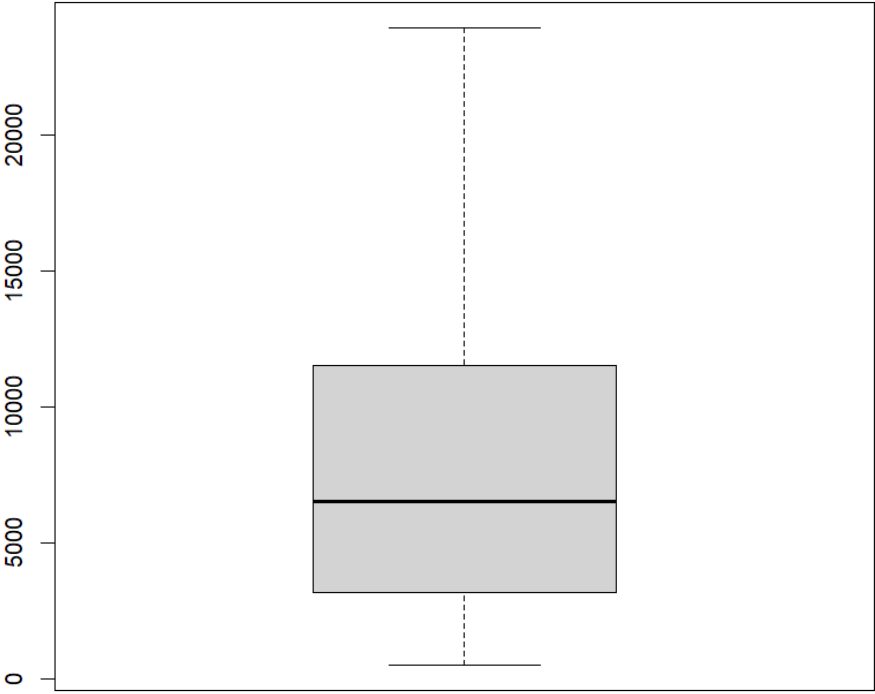

Figure 5.6: *Boxplot with outliers*
Source: *R-studio, developed by the author.*

According to figure 5.6, it becomes evident that GDP per capita values above 24,100$ stand out as outliers, as they are significantly distant from the rest of the dataset. These outliers may represent countries with exceptionally high-income levels that deviate from the typical distribution observed in the data.

Considering these findings, the author has made the decision to remove these observations from the dataset. By excluding these outliers, the author aims to ensure that the subsequent analysis and interpretation of the data are not unduly influenced by these extreme values. This step allows for a more accurate representation of the majority of countries and facilitates the identification of trends and patterns that are applicable to the broader dataset. By removing these outliers, the author enhances the reliability and validity of the analysis, enabling more meaningful insights from the remaining data.

Figure 5.7: Boxplot without outliers
Source: R-studio, developed by the author.

To address the presence of outliers in the dataset, the author opted for a solution by creating a subset consisting of 1567 observations. This subset is 33 observations smaller than the original dataset, which initially comprised 1600 observations. The author systematically removed all observations where the GDP per capita exceeded 24,100$. As a result of this data cleansing process observed in figure 5.7, the subset under analysis now exhibits a notable absence of outliers.

By removing these extreme values, the author has effectively eliminated any observations that deviated significantly from the majority of the data. Consequently, the dataset is now composed of values that are more representative of the overall distribution.

5.2.2. Summary Statistics

Variables	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
GDP per capita	502	3187	6524	7915	11538	23934
Region	0	0	0	0.34	1	1
GFCF	1.10	18.12	22.21	23.35	27.05	93.55
Total labor force	19.05	35.46	40.76	40.31	45.63	59.57
Technological progress	0	0.70	8	19.11	33.17	88.13
Institutional quality	-1.66	-0.74	-0.39	-0.41	-0.11	0.88
Gini index	24	35.01	39.68	40.87	45.70	64.70
FDI	-37.17	0.95	2.24	3.0	4.25	43.91
Education	0.33	7.49	18.42	24.07	36.85	99.17
Population growth rate	-3.21	0.96	1.63	1.59	2.55	6.76

Table 5.1: *Summary statistics*
Source: *R-studio, developed by the author.*

This summary statistics provide an overview of the distribution and average values of various economic and social indicators in the dataset, allowing for comparisons and analysis of different countries' characteristics Therefore, here are some statistics interpretations and meaning of the variables:

- **GDP Per Capita:** The minimum GDP per capita in the dataset is $502 which corresponds to Mozambique in 1996, while the maximum is $23,934 which corresponds to Argentina in 2015. The average GDP per capita is $7,915 which indicates a significant disparity in economic development among the developing countries.

- **Region:** This variable represents a categorical dummy variable that takes on values of 0 or 1. It is used to indicate whether a country is a member of a specific region or not in the dataset. In this case, it represents the sub-Saharan Africa region. The mean value of 0.34 indicates that, on average, approximately 34% of all developing countries in the dataset belong to the sub-Saharan Africa region.

- **Gross Fixed Capital Formation (GFCF):** The minimum value is 1.10% which corresponds to Sierra Leone in 2000, and the maximum is 93.55% which corresponds to Mauritania in 1994. The average capital formation is 23.35%, this indicates disparities in the extent to which investment affects economic growth among the countries in the dataset. In other words, investments (capital formation) have a greater impact on economic growth in some countries compared to others.

- **Total Labor force:** The minimum labor force value is 19.05% which corresponds to West Bank and Gaza in 2002, and the maximum is 59.57% which corresponds to Thailand in 2012. The average labor force size is 40,31%, this indicates the disparities in the availability of labor resources and the potential for economic output. Since this variable is

linked to the population, it implies that, on average, approximately 40% of the population of all developing countries together belongs to the working-age population.

- **Technological Progress:** The range of values for this variable varies from a minimum of 0%, which corresponds to most developing countries in the early 90s to 2000, to a maximum of 88.13%, represented by Morocco in 2021. On average, the level of technological progress is 19.11%. This indicates that some countries have experienced significant growth and demonstrated high levels of internet usage, enabling them to provide their population with improved and quality services in technology and communication. However, it is important to note that some countries still lag-behind in terms of technological advancement.

- **Institutional Quality:** The range of values varies from a minimum of -1.66, corresponding to Congo Democratic Republic in 2011, to a maximum of 0.88, observed in Mauritius in 2015. On average, the institutional quality is approximately 0.41. This indicates that factors such as the effectiveness of governance, rule of law, and levels of corruption continue to pose challenges for developing countries. These issues can potentially hinder economic growth, even when other indicators are favorable. It is particularly noteworthy in sub-Saharan Africa, where the level of institutions is generally low due to high levels of corruption, political instability etc...

- **Gini Index:** The range of Gini coefficients varies from a minimum of 24%, observed in Ukraine in 2014, to a maximum of 64.70%, observed in Botswana in 2002. On average, the Gini coefficient stands at 40.87%. This highlights the prevailing issue of high-income inequality in developing countries. It indicates that a significant number of countries continue to face substantial disparities in income distribution. High levels of income

inequality can have adverse effects on social cohesion, limit access to opportunities, and hinder sustainable and inclusive economic growth.

- **Foreign Direct Investment (FDI):** The range of FDI values varies from a minimum (decline) of -37.17%, observed in Mongolia in 2016, to a maximum of 43.91%, also observed in Mongolia but in 2011. On average, the FDI level is approximately 3.30%. This indicates the differences in the attractiveness of countries for foreign investment. Some countries have been successful in attracting FDI due to factors such as their resource endowments, infrastructure development, or market potential. However, other countries face challenges in attracting and retaining foreign investment due to factors such as transparent regulations, political stability, and infrastructure development. In other words, compared to other countries, certain countries experience a greater impact on economic growth because of foreign direct investment.

- **Education:** The range of enrollment rates varies from a minimum of 0.33%, observed in Tanzania in 1991, to a maximum of 99.17%, observed in Argentina in 2020. On average, the enrollment rate is 24.07%. This substantial range highlights the disparities in educational opportunities among different countries, showing how some nations have invested more in tertiary education compared to others. While the average enrollment rate shows progress, it also reveals that access to quality education remains limited for many people in the region. Various challenges, including inadequate infrastructure, teacher shortages, and gender disparities, hinder the development of education. These obstacles contribute to the ongoing need for improvement in educational systems and ensuring equitable access to quality education for all.

- **Population growth rate:** The minimum growth rate is -3.21% which corresponds to Georgia in 1997 and indicates a population decline, while the maximum is 6.76% which corresponds to Jordan in 2006. The average population growth rate is 1.59%. This indicates a moderate rate of population increase, which can have both positive and negative implications. Rapid population growth can put pressure on resources, infrastructure, and public services, potentially straining socio-economic development efforts. However, a growing population also presents opportunities for economic expansion, market growth, and human capital development when accompanied by effective policies and investments.

5.2.3. Distribution
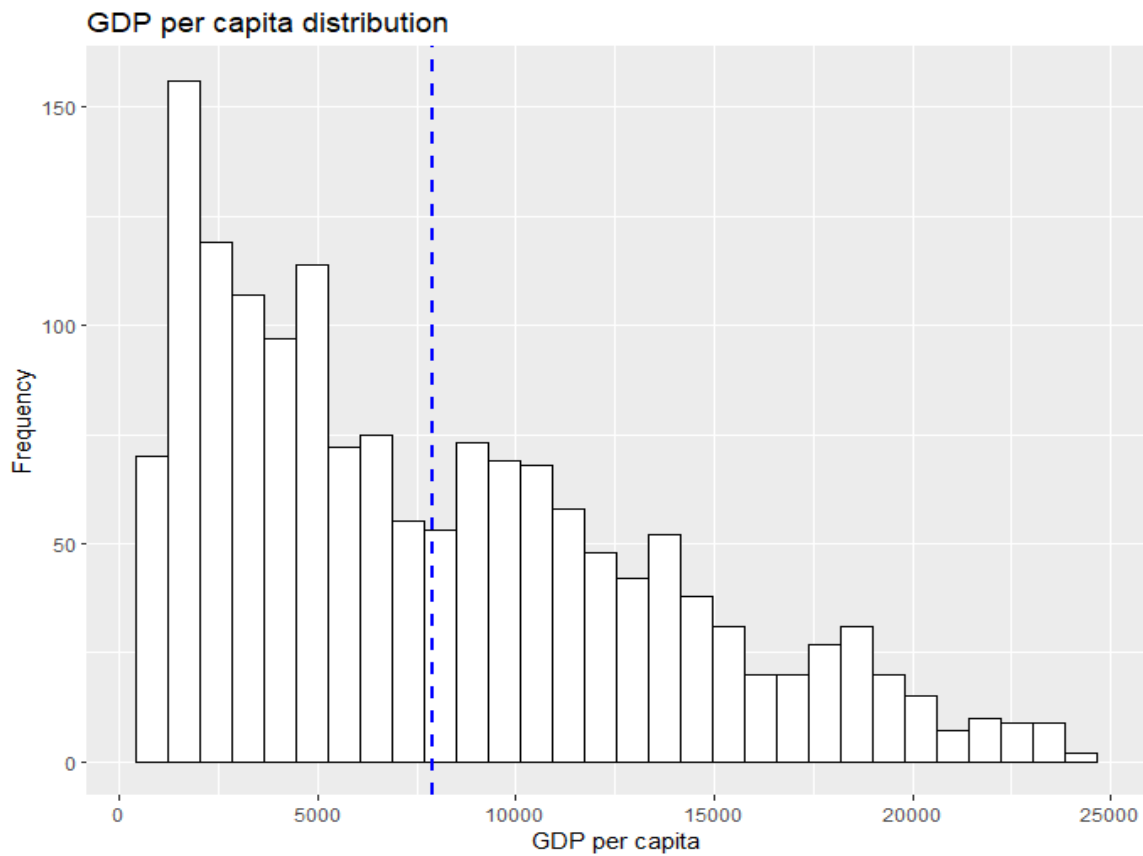
Figure 5.8: GDP per capita distribution
Source: R-studio, developed by the author

The Histogram illustrates the distribution of the dependent variable, which in this case is GDP per capita. The distribution of the response variable is visibly non-normal, displaying a right-skewed pattern. This means that most countries in the dataset have lower GDP per capita values, with a few countries having significantly higher values, resulting in a tail on the right side of the histogram. This confirms the significant disparity in economic growth among developing countries since it indicates that certain countries are experiencing more substantial growth compared to others and the factors contributing to this disparity can be multifaceted, such as variations in investment levels, institutional quality, technological progress, labor force size, or income inequality and many others.

The mean value of GDP per capita in the dataset is 7,915$ with a frequency of approximately 155, meaning that most of the countries in the analysis fall within this range. It is important to note that the mean is greater than the median in this scenario, as this occurs because extreme values found in the tail of the distribution have a greater impact on the mean than the median. These extreme values contribute to the higher mean value since the histogram gives a good overview of the dataset.

5.3. MULTIPLE LINEAR REGRESSION

Independent variables	Estimate (β)	Standard error	t-value	p-value
Intercept	-788.098	719.124	-1.082	0.279
Region	-1147.550	209.845	-5.469	0.000 ***
GFCF	18.610	10.444	1.782	0.075
Total labor force	14.228	11.041	1.289	0.198
Technological progress	39.065	4.324	9.035	0.000 ***
Institutional quality	2949.159	117.800	16.587	0.000 ***
Gini index	128.115	10.440	12.271	0.000 ***
FDI	-64.848	17.869	-3.629	0.000 ***
Education	115.907	6.299	24.751	0.000 ***
Population growth rate	-155.429	88.408	-1.758	0.079
F = 452.6 (p-value = 0.000 ***[16])				
R-squared = 0.7235				

Table 5.2: Multiple linear regression
Source: R-studio, developed by the author

The t-student test results indicate that out of the 9 independent variables, only 5 (Technology progress, Institutional quality, Gini index, FDI, and Education) are considered significant factors influencing the dependent variable (GDP per capita) because their respective p-values are smaller than 0.001. Among these 5 significant variables, it is surprising to observe that only FDI has an unexpected negative impact on GDP per capita, contradicting the expected outcome.

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[16] The *** means that the p-values are significant at the 0.001 level of significance.

Additionally, the Gini Index unexpectedly exhibits a positive impact, further deviating from the anticipated result. While the remaining variables show the expected positive impact.

It's important to note that the conclusions drawn from the F-test differ from those of the t-test. The F-test assumes the statistical significance of the estimated model because his p-value is smaller than 0.001, but this is not enough evidence to conclude that all variables are significant, as it tests the variables jointly, including both the significant and insignificant ones. This is why the F-test can occasionally lead to misleading conclusions.

Analyzing the R-squared value it's possible to see that approximately 72.35% of the variation in GDP per capita can be explained by the independent variables included in the model and the remaining 27.65% of the variation is explained by other factors that are omitted and included in the residuals of the present model.

5.3.1. Collinearity and The Variance Inflation Factor Test

According to Wooldridge (2012) collinearity refers to a situation where predictors are strongly correlated with each other, and it poses a problem because it violates the assumption of independence among variables. When variables are highly correlated, the coefficients in a regression model can become inflated, causing the OLS estimators to be inefficient and distorted. This makes it challenging to accurately assess the impact of these predictors on the dependent variable. Failing to address collinearity issues can result in reduced model accuracy, economists widely consider the Variance Inflation Factor (VIF) to be the best test for detecting collinearity in an econometric model.

Independent variables	VIF results
Region	1.784229
GFCF	1.192410
Total labor force	1.327031
Technological progress	1.759403
Institutional quality	1.316478
Gini index	1.359422
FDI	1.114496
Education	2.905562
Population growth rate	2.153015

Table 5.3: *VIF test*
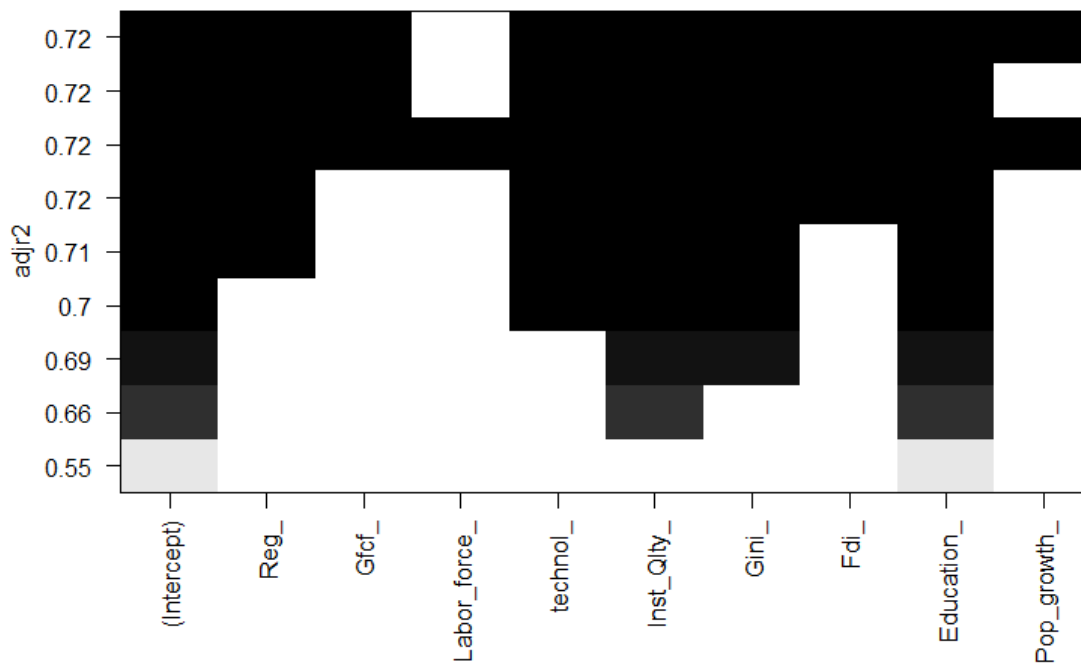**Source:** *R-studio, developed by the author.*

The VIF test results reveal that all independent variables in the model have VIF values below 10. This indicates the absence of collinearity in the model, consequently it means that the estimated parameters remain unbiased and the standard errors are not inflated. The model's independent variables are not strongly correlated with one another, as this is beneficial for accurately estimating the coefficients, as it allows to have more confidence in the individual effects of the predictors on the dependent variable. Moreover, the absence of collinearity ensures that the standard errors of the model's parameters remain reliable. As result, is possible to make accurate inferences about the statistical significance of the coefficients.

5.4. MODEL SELECTION

5.4.1. Stepwise Selection

a) Adjusted R-Squared

According to Gujarati (2006) the Adjusted R-squared is a modified version of R-squared that has been adjusted for the number of predictors in the model. The adjusted R-squared increases when the new term improves the model more than would be expected by chance. It decreases when a predictor improves the model by less than expected. Typically, the adjusted R-squared is positive, not negative. It is always lower than the R-squared.

Figure 5.9: *Adjusted R-squared*
Source: *R-studio, developed by the author.*

Figure 5.9 displays the results that show which independent variables the Adjusted R-Squared selected to maximize and improve the model's explanation. The black lines indicate the subset of predictors that gives the best result for each subset size. The white line indicates the best subset of predictors for each subset size while imposing a constraint, such as a limit on the number of predictors. The gray points indicate all other possible subsets of predictors, showing how their performance compares to the best subset (black) and the constrained best subset (white) for each subset size. Looking at the highest point on the y-axis which has the black line is the key to selecting the best subset of variables for the regression model, as this point corresponds to the best-performing subset of predictors.

Based on the previous interpretation, the best model according to the adjusted R-squared has 8 predictors out of 9 predictors from the original model and the variable excluded by the adjusted R-squared is Total Labor Force.

b) Mallow's Cp Statistics

According to Larson & Farber (2011) the main goal of Mallow's Cp is to find a model that balances the trade-off between goodness of fit (low sum of square errors) and model complexity (fewer predictors). Cp measures a model's ability to fit the data while excluding the use of irrelevant predictors. It is particularly useful in cases where the model has a large number of predictors and need to identify the most relevant ones to the model. These statistics are valuable for selecting the most appropriate regression model while avoiding overfitting (using too many predictors) or underfitting (using too few predictors). The lower values of Mallow's Cp indicate better models in terms of this balance.
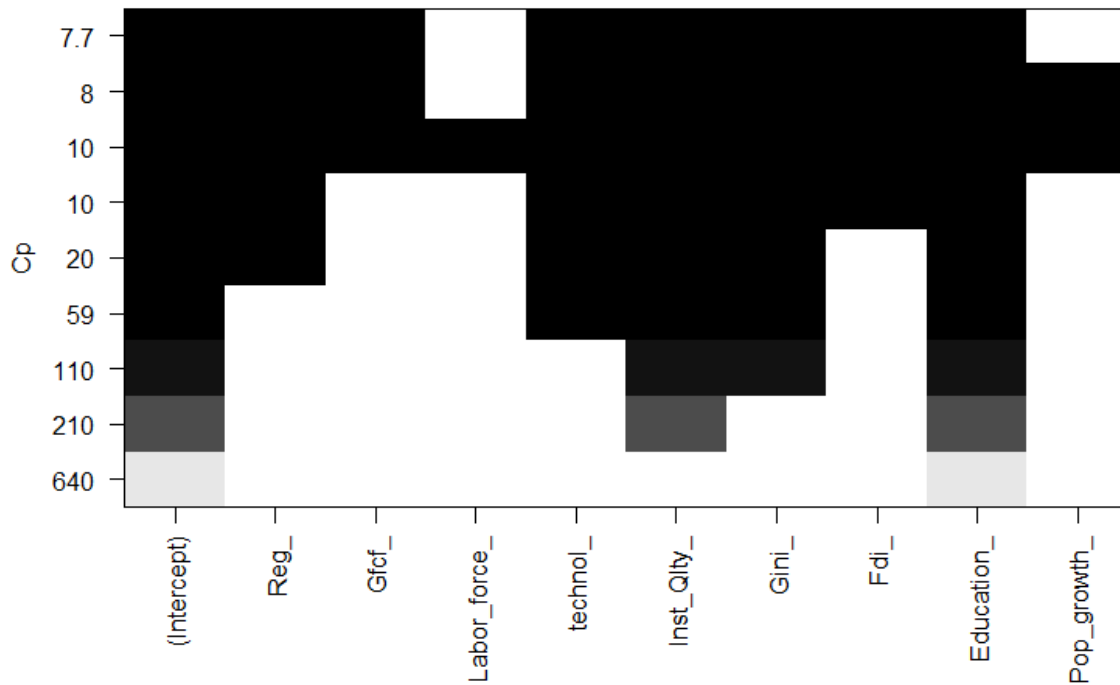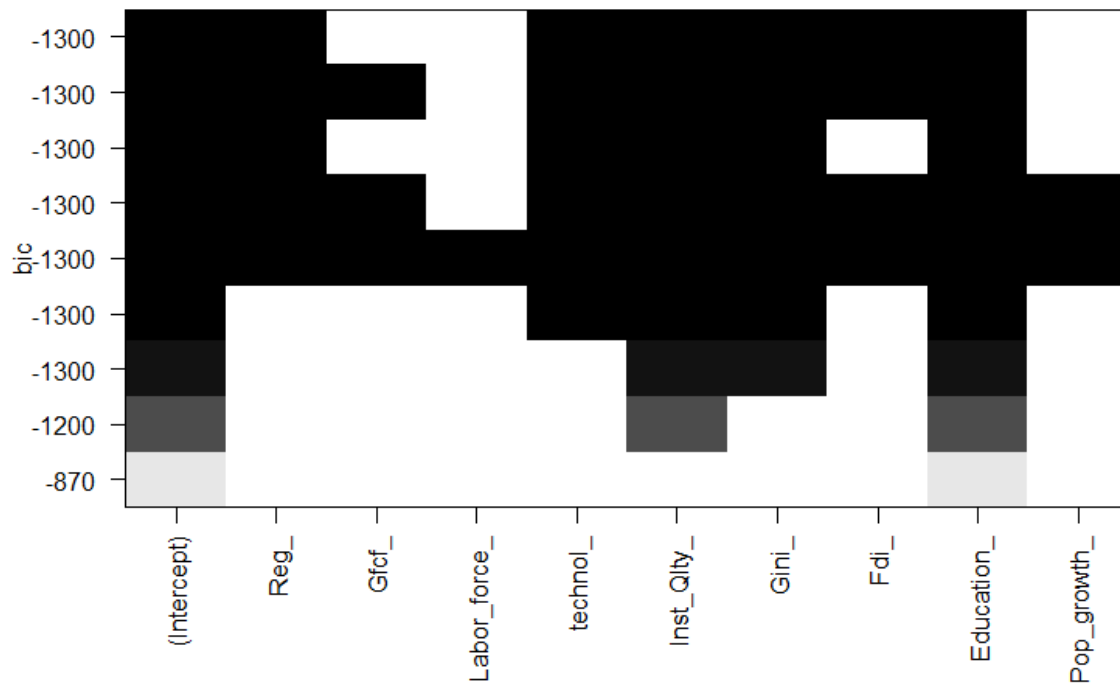
Figure 5.10: *Mallow's Cp statistics*
Source: *R-studio, developed by the author.*

Figure 5.10 displays the results that show which independent variables the Mallow's CP statistics selected to maximize and improve the model's explanation. The black lines indicate the subset of predictors that gives the best result for each subset size. The white line indicates the best subset of predictors for each subset size while imposing a constraint, such as a limit on the number of predictors. The gray points indicate all other possible subsets of predictors, showing how their performance compares to the best subset (black) and the constrained best subset (white) for each subset size. Looking at the highest point on the y-axis which has the black line is the key to selecting the best subset of variables for the regression model, as this point corresponds to the best-performing subset of predictors.

Based on the previous interpretation, the best model according to the Mallow's CP statistics has 7 predictors out of 9 predictors from the original model and the variables excluded by the CP statistics are: Total Labor Force and Population Growth rate.

c) Bayesian Information Criterion

According to Larson & Farber (2011) the Bayesian information criterion also known as BIC, or the Schwarz criterion is another method that is used in the context of stepwise selection and helps determine the appropriate trade-off between model fit and model complexity when comparing different models. The higher value of BIC indicates better-fitting models.

Figure 5.11: *Bayesian information criterion*
Source: *R-studio, developed by the author.*

Figure 5.11 displays the results that show which independent variables the Bayesian Information Criterion selected to maximize and improve the model's explanation. The black lines indicate the subset of predictors that gives the best result for each subset size. The white line indicates the best subset of predictors for each subset size while imposing a constraint, such as a limit on the number of predictors.

The gray points indicate all other possible subsets of predictors, showing how their performance compares to the best subset (black) and the constrained best subset (white) for each subset size. Looking at the highest point on the y-axis which has the black line is the key to selecting the best subset of variables for the regression model, as this point corresponds to the best-performing subset of predictors.

Based on the previous interpretation, the best model according to BIC has 6 predictors out of 9 predictors from the original model and the variables excluded by BIC are: Gross Fixed Capital Formation, Total Labor Force and Population Growth rate.

Due to inconclusive results obtained from the previous models, the author decided to employ cross-validation methods to assess the mean squared errors (MSEs) and ultimately determine the optimal model to select.

d) K-fold cross-validation

K-fold cross-validation involves dividing the dataset into K groups, also known as folds. In each iteration, one of the K folds is used as the validation set, while the model is trained on the remaining K - 1 folds. The mean squared error (MSE) is then calculated using the observations within the current fold of cross-validation.

Stepwise Selection Methods	K-fold MSE results
Adjusted R Squared	8.803725%
Mallow's Cp Statistics	8.842792%
Bayesian Information Criterion	8.755506%

Table 5.4: K-fold cross-validation
Source: R-studio, developed by the author

According to K-fold cross-validation, the Bayesian Information Criterion (BIC) model with 6 predictors is considered the best model due to its lowest mean squared error (MSE), indicating higher accuracy and precision. However, an issue with traditional cross-validation arises when running the code multiple times, as the results may vary due to the changing sampling seed for K-fold cross-validation. To mitigate this problem, the author employed the Leave-One-Out Cross-Validation (LOOCV) method.

e) **Leave one out cross-validation**

LOOCV addresses the variability concern by iteratively training the model using all but one data point as the training set and using the omitted point as the validation set. This process is repeated for each data point in the dataset, resulting in a more robust estimation of model performance. By using LOOCV, the author ensures that the model evaluation is not significantly affected by the random seed used in the sampling process, offering more reliable and consistent results.

Stepwise Selection Methods	LOOCV MSE results
Adjusted R Squared	8.789198%
Mallow's Cp Statistics	8.785423%
Bayesian Information Criterion	8.812993%

*Table 5.5:* *Leave one out cross-validation*
Source: *R-studio, developed by the author*

According to the Leave-One-Out Cross-Validation (LOOCV) results, the CP statistics model with 7 predictors is considered the best model for predicting economic growth in sub-Saharan Africa. This model has demonstrated superior performance compared to other models, including the one previously identified as the best model through traditional cross-validation. The decision to select the CP statistics model over the BIC model is motivated by its lower mean squared error (MSE),

indicating higher accuracy and precision in predicting economic growth. Notably, the inclusion of gross fixed capital formation (national investments) as a predictor in the CP statistics model is a key factor contributing to its superior performance.

Considering the LOOCV results and taking into account the significant impact of gross fixed capital formation on economic growth in sub-Saharan Africa, as highlighted in the beginning of chapter 5, it is recommended to prioritize the CP statistics model with 7 predictors. This model provides the lowest error and incorporates the crucial variable of gross fixed capital formation, thereby enhancing the accuracy and reliability of economic growth predictions in the sub-Saharan Africa region.

5.4.2. Regression Trees
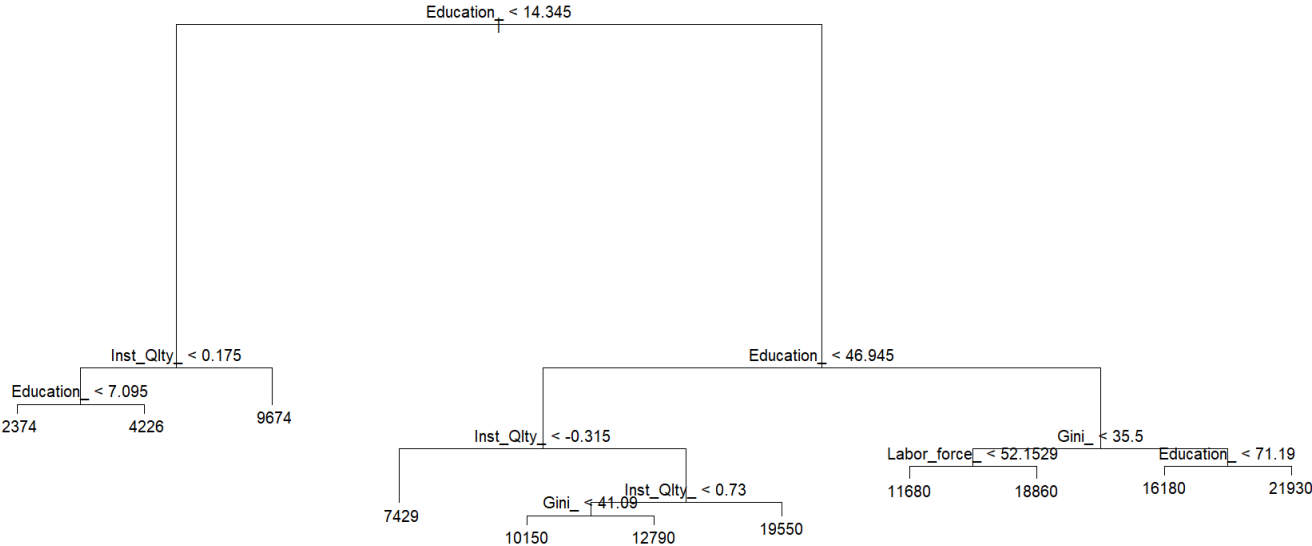

Figure 5.12: Regression trees

Source: R-studio, developed by the author.

According to the results in figure 5.12 the algorithm selects the split that minimizes the sum of the squared deviations from the mean in the two separate partitions. The results also show some characteristics of regression tree such as:

- Out of the 9 independent variables of the model only 4 were used in the tree construction respectively: Education, Institutional quality, Gini index and Total labor force.

- The tree has 11 terminal nodes.

- The most important variables determining the splits are Institutional quality and Education.

The complexity of the tree led to the decision to employ pruning. Rather than calculating every potential subtree, the utilization of Cross-Validation for Cost Complexity Pruning enabled the identification of the subtree that exhibited the lowest cross-validation error rate.

Terminal nodes ($size)	1	2	3	4	5	6	7	8	9	10	11
Error rate ($dev)	3384	2037	1774	1442	1295	1249	1237	1184	1171	1176	1125
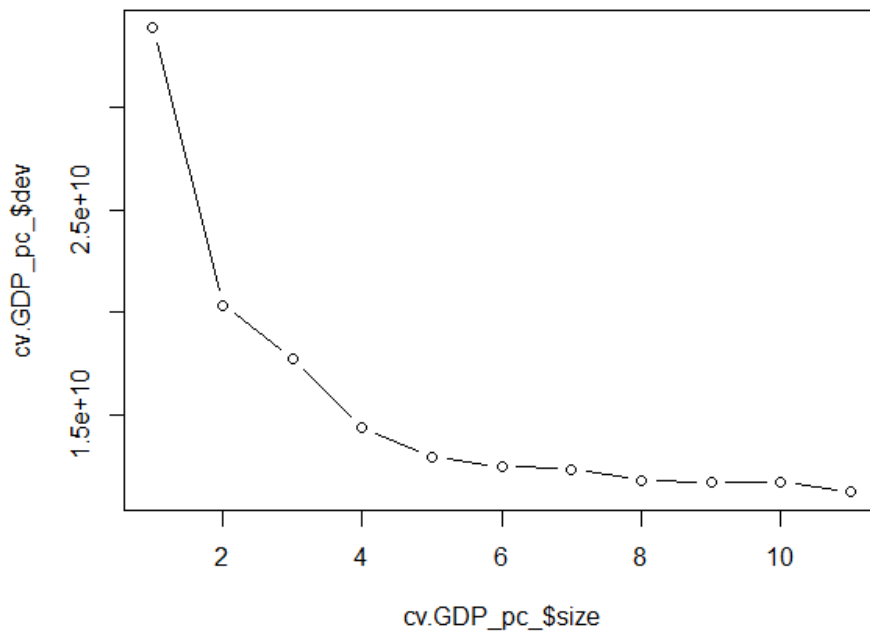
Figure 5.13: Pruning

Source: *R-studio, developed by the author.*

The chosen approach involves selecting the subtree characterized by the lowest cross-validation error rate ($dev). In this particular scenario, the decision was made to opt for the subtree comprised of 11 terminal nodes, which exhibited an error rate of 1125. The pruning process is visually represented in Figure 5.13, providing a graphical representation of the pruning activity.

The pruning results have demonstrated that the regression trees and the pruned trees exhibit remarkable similarity. Despite undergoing the pruning process, both approaches resulted in trees with 11 terminal nodes, indicating that the overall structure of the models remained largely unchanged. This consistency suggests that the initial tree construction effectively captured the relationships between the predictors and the target variable which in this case is the economic growth (GDP per capita). The persistence of these predictors across both the regression trees and the pruned trees highlights their robust impact on the model's performance. These findings show the importance of factors such as education, institutional quality, income inequality, and labor force when seeking to understand, explaining the economic growth in sub-Saharan Africa.

Furthermore, their consistent appearance in both the regression trees and the pruned trees provides evidence of their multifaceted influence on economic growth in sub-Saharan Africa. This implies that while each of these factors is important in and of itself, their combined influence may result in complex and interrelated dynamics which drive economic growth in the region.

5.4.3. Bagging and Random Forest

a) Bagging

Independent variables	%Inc. MSE
Education	138.80482
Institutional quality	107.53030
Gini index	74.57867
Total labor force	50.30702
Population growth rate	35.65123
Technological progress	31.04138
GFCF	28.04126
FDI	24.84062
Region	14.23431
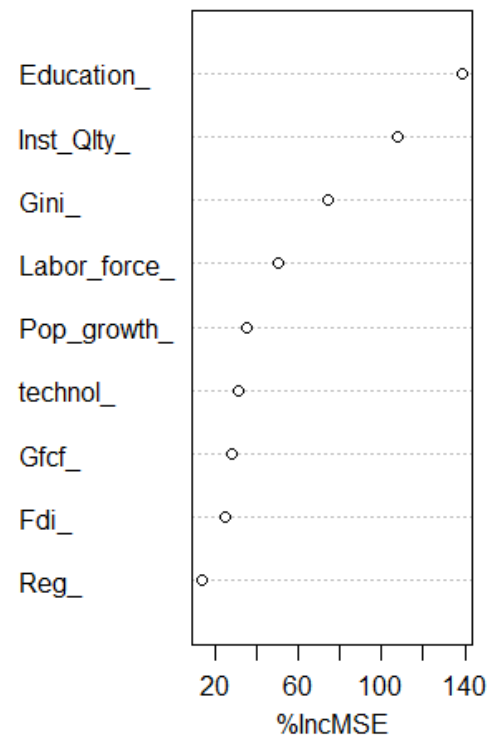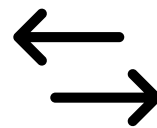
Figure 5.14: *Bagging*
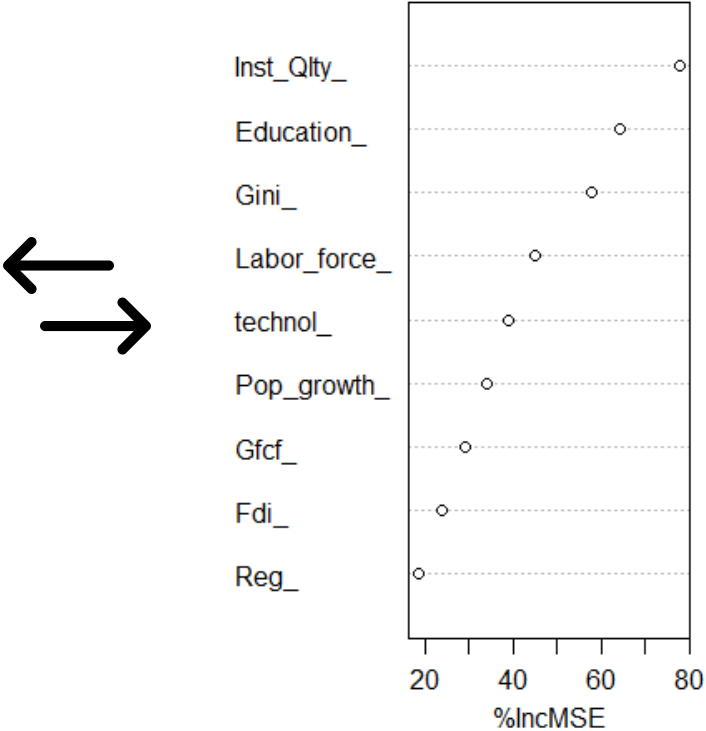***Source:*** *R-studio, developed by the author.*

The percentage increase in mean squared error (MSE) provides an indication of the extent to which the MSE would rise in the absence of a specific predictor variable. It quantifies the impact of excluding a particular predictor on the accuracy of the model.

According to bagging results, the model's accuracy is greatly impacted by four key variables: Education, Institutional Quality, Gini Index, and Labor Force. These variables carry substantial weight in the mean squared error calculation, which is a critical determinant of the model's precision. This means that any attempt to remove these variables would inevitably result in an increase in mean squared error, ultimately leading to reduced accuracy of the model.

It is confirmed by the results that these four variables are among the most important predictors for economic growth (GDP per capita), coming to the same conclusions as regression trees, this convergence across different modeling approaches underscores the robustness and importance of these predictors in understanding and predicting variations in GDP per capita.

b) Random Forest

Independent variables	%Inc. MSE
Institutional quality	77.77090
Education	64.15884
Gini index	57.90105
Total labor force	45.00983
Technological progress	38.99872
Population growth rate	33.86472
GFCF	29.19309
FDI	23.68482
Region	18.70119

Figure 5.15: *Random forest*
Source: *R-studio, developed by the author.*

The findings from the random forest analysis align with the conclusions drawn from decision trees and bagging, confirming the significance of Education, Institutional quality, Gini index, and Labor force as influential predictors of GDP per capita.

Notably, both the bagging and random forest models reveal that the fourth predictor, Labor Force, exerts a particularly strong impact on GDP per capita compared to regression trees. In the case of bagging, excluding the Labor Force variable would result in a substantial 50.31% increase in mean squared error (MSE), indicating its critical role in accurately predicting GDP per capita. Similarly, in the random forest model, omitting the Labor Force predictor would lead to an approximate 45% increase in MSE, further highlighting its pronounced influence on the model's performance. These findings emphasize the vital importance of the labor force in identifying and comprehending variations in GDP per capita. The accuracy and predictive power of the models are significantly increased by including this predictor in both bagging and random forest models, highlighting the significance of this predictor in explaining the economic dynamics associated with GDP per capita.

Besides the similarities there are also differences between bagging and random forest. For bagging the most important variable is education with the highest percentages of MSE, while in random forest the most important variable is the quality of institutions, as this indicates that the two methods captured different magnitude of the impact of the variables in the model. The results of bagging show that Education plays a crucial role in socioeconomic development in Sub-Saharan Africa, impacting human capital development, workforce productivity, and social progress. Investing in educational infrastructure, curriculum enhancement, and equitable access to education resources is essential for sustainable development. On the other hand, the results of random forest show that the quality of institutions is the most influential factor in Sub-Saharan Africa's development trajectory, highlighting the importance of governance, political stability, and rule of law. High-quality institutions foster economic growth, foreign investment, and social cohesion.

CHAPTER VI – DISCUSSION OF THE RESULTS

The present chapter consists of the analysis and explanation of the results obtained in the previous chapter and its implications, according to the theories and empirical studies presented in the theoretical and referential framework. Moreover, this chapter aims to evaluate the consistency and alignment between the sets of the analyzed results, providing further insights into the predictive factors that influenced the economic growth in sub-Saharan Africa from 1990 – 2021.

Model selection methods	Stepwise selection	Regression trees	Bagging	Random forest
MSE results	8.853605%	9.218910%	3.215448%	3.012307%

Table 6.1: *Comparison of the results based on the mean square error*
Source: *R-studio, developed by the author.*

According to the results and interpretation of model selection is possible to confirm that Random Forest has best test-set performance because it shows the lowest Mean Square Error rate, which corresponds to 3.01%, which is close to the one of Bagging of 3.22%, but clearly better than those of Stepwise Selection (8.85%) and Regression Trees (9.22%). Also, is possible to see that all the techniques from model selection methods agreed that there are three main predictors that impact and explained the most the behavior of economic growth in sub-Saharan Africa from 1990 – 2021 which are:

- Education

- Institutional Quality

- Gini Index

Although, Regression trees, Bagging and Random Forest considers one additional predictor, **Labor Force**, which however isn't even considered significant by the Stepwise selection.

6.1. EDUCATION

Robert Solow in his theory of economic growth emphasized the crucial role of education in fostering economic growth. He argued that a highly educated workforce is a driving force behind sustained economic development.

This principle held a particular relevance to this study because Sub-Saharan Africa still faces unique challenges and opportunities on its path to economic growth. By recognizing education as a key driver of sustainable development, Sub-Saharan Africa made significant strides in investing in its human capital, diversifying its economy, and addressing socio-economic challenges. Education not only contributed to economic growth but also played a crucial role in promoting social inclusivity, gender equality, and improved health outcomes. The region's commitment to education has set a foundation for continued progress and prosperity in the years to come.

It is important to recognize that investing in education is a multifaceted strategy with broad implications for different facets of society. Governments, organizations, and communities in Sub-Saharan Africa must keep working together to increase access to high-quality education, guarantee educational equity for all, and promote an environment that supports lifelong learning if they are to fully realize the benefits of education. There is a need to embrace cutting-edge educational approaches and use technology to close the gaps in access and quality as the region's educational systems develop and adjust to the shifting global landscape to ensure that each person can realize their full potential and contribute to the development of region. Ongoing efforts should be made to address obstacles to education, such as poverty, conflict, and cultural norms.

6.2. INSTITUTIONAL QUALITY

Douglas North in his theory of economic growth emphasized the critical importance of Quality of Institutions in shaping economic behavior and outcomes.

According to results in this study is possible to see that Sub-Saharan African countries still encounter struggles to have a good institutions quality due to many factors such as political instability, weak rule of law, corruption, lack of accountability, and ineffective governance structures. The struggles faced by Sub-Saharan African countries in establishing good institutional quality have significant implications for their economic growth and development as this means that the effectiveness of government policies and the overall business environment can be hindered. Weak institutional quality can deter foreign investment, limit domestic business expansion, and hinder economic productivity. Additionally, it may lead to inefficient allocation of resources and hinder innovation and technological advancements.

To overcome these challenges, there is a need for comprehensive institutional reforms that address the root causes of these issues. Political stability and effective rule of law are crucial pillars that should be strengthened to promote investor confidence and ensure a fair and transparent business environment. Initiatives to tackle corruption, enhance accountability, and promote good governance practices are essential in establishing a framework that supports sustainable development. Moreover, regional and international cooperation can play a pivotal role in assisting Sub-Saharan African countries to improve their institutions' quality. Partnerships with developed nations, international organizations, and regional bodies can provide technical expertise, financial assistance, and knowledge exchange, facilitating the implementation of effective institutional reforms.

6.3. GINI INDEX

According to the results of this study is possible to see that income Inequality in sub-Saharan still represents a huge problem since the income is not distributed equally among the population. Income inequality is a pressing issue in many Sub-Saharan African countries and has far-reaching consequences on social cohesion, access to education and healthcare, and overall economic development. One of the significant contributors to income inequality in Sub-Saharan Africa is the disparity between rural and urban areas. Urban centers tend to attract more economic opportunities, investment, and better infrastructure, leading to higher income levels for those living in cities. On the other hand, rural areas often face limited access to essential services, agricultural challenges, and lower-paying job opportunities, perpetuating the income gap. Income inequality in Sub-Saharan Africa has far-reaching implications that extend beyond its economic impact. It aggravates social tensions, contributes to increased crime rates, and erodes trust in institutions and the government. In certain countries, the situation has escalated to extreme cases, triggering social unrest and political instability (War), which are undermining the efforts done towards achieving sustainable economic growth. Addressing income inequality requires a comprehensive approach that involves both economic policies and social interventions. Governments in Sub-Saharan African countries must focus on promoting inclusive growth by investing in education and skill development programs that enable individuals to participate in the formal workforce. This can help reduce the income gap by providing people with better job prospects and increased earning potential. Moreover, progressive taxation and targeted social welfare programs can play a significant role in redistributing wealth and supporting those in need. By implementing policies that ensure the wealthy contribute their fair share in taxes, governments can generate funds to invest in social programs that benefit the less privileged.

CONCLUSION

At the end of this research, it is possible to verify that economic growth in sub-Saharan Africa fluctuated between 1990 and 2021, but in general it shows an increasing trend until 2014. Thereafter, there was a period of stability until 2019. A slight decline occurred in 2020, most likely because of the COVID-19 pandemic and a partial recovery occurred in 2021. This means that the region is still growing and expanding its economic potential, albeit with occasional setbacks. However, it is essential to recognize that the sub-Saharan African region is diverse, and not all countries are experiencing the same level of economic growth. Persistent challenges such as poverty, political instability, and inadequate access to basic services remain to be addressed in most of the countries in the region. Despite the challenges, the overall trajectory of economic growth suggests that sub-Saharan Africa remains on a positive growth path, with the potential for significant economic advancements in the coming years. The region's youthful population, natural resources, and increasing focus on sustainable development provide a strong foundation for future economic expansion and prosperity.

This research has also shed light on the main factors influencing economic growth in sub-Saharan Africa during the study period using a regression analysis. The results from the model selection methods mutually agreed that there are three main factors which are: Education, Institutional Quality and Gini Index.

The significance of **Education** (measured by school enrollment rates) aligns with the well-established economic theory that emphasizes the role of human capital in economic development. A well-educated workforce enhances labor productivity and innovation, driving economic growth.

The results show how crucial education is to Sub-Saharan Africa's economic growth as the region made significant progress in investing in human capital, diversifying its economy, and tackling socioeconomic challenges as a result of realizing its importance for sustainable growth. The way that Sub-Saharan Africa approached education has seen a significant change. Governments and international organizations have acknowledged that education is a fundamental human right as well as a tactical tool for lifting countries out of poverty and fostering long-term prosperity. As a result, more work has been done to enhance the region's educational infrastructure, accessibility, and quality. One of the main forces behind this transformation has been the realization that funding education is not only a social initiative but also a necessity for the economy. The prospects for the region's economic growth have improved along with the enrollment rates. A workforce with more education is better prepared to meet the demands of a rapidly changing global economy, increasing Sub-Saharan Africa's competitiveness on the international stage. Moreover, the region has made significant progress in diversifying its economy, realizing the importance of a strong educational system in the process. Sub-Saharan Africa has reduced its historical reliance on a limited range of industries and commodities by fostering a skilled and adaptable workforce through improved education. This diversification has improved economic resilience while also fostering entrepreneurship and innovation, which has accelerated economic growth. Education has been crucial in addressing the socioeconomic issues that have historically plagued the region in addition to its economic advantages, it has been an effective tool for lowering inequality, giving marginalized communities opportunities, and promoting social cohesion. The region has seen a gradual improvement in living standards and a decline in poverty rates as educational opportunities become more equitable and widespread.

The influence of **Institutional Quality** on economic growth is consistent with the understanding that effective governance, transparent institutions, and the rule of law are critical for creating an enabling environment for businesses, investment, and economic stability. Modern economic theories claim that countries with strong institutions tend to attract more investments and foster sustainable economic growth. The results show how sub-Saharan Africa still encounters struggles to have a good institutions quality due to many factors such as political instability, weak rule of law, corruption, lack of accountability, and ineffective governance structures. Numerous countries in the region are currently experiencing unstable political situations, which is disrupting the continuity in policy and also obstructing the long-term planning. Political instability is still a huge problem in the region. The problems that sub-Saharan African countries face are made even more difficult by the weak legal system. Lack of consistency and effectiveness in enforcing legal frameworks is undermining many investors' confidence and consequently this is disrupting and preventing the region from reaching its full capacity on economic growth. Another major problem is corruption, which is not adequately addressed and is harming the public trust and discouraging both domestic and foreign investment. Furthermore, a lack of accountability within government structures is hindering the progress in addressing these issues. Effective governance structures are essential for implementing reforms and ensuring that policies aimed at improving institutional quality are carried out effectively. The region is not effective with these structures, as this just shows why the progress may be slow, and also these initiatives are obstructed by political interests. Despite these difficulties, it is important to recognize the efforts made by numerous sub-Saharan African countries in resolving these problems. Numerous governments in the region have started a number of reform initiatives to strengthen their governance structures and legal frameworks as a result of realizing the significance of institutional quality for their economic growth.

The inclusion of the **Gini Index** as a significant factor indicates that income inequality plays a pivotal role in shaping economic growth patterns. Economic theories have long stated that excessive income disparities can hinder economic progress and lead to social and political instability. A more equitable distribution of resources can stimulate domestic demand, reduce social tensions, and promote inclusive growth. The results show how income inequality in sub-Saharan still represents a huge problem since the income is not distributed equally among the population. Income inequality is a pressing issue in many Sub-Saharan African countries and has far-reaching consequences on social cohesion, access to education and healthcare, and overall economic development. Social cohesion is becoming more difficult as income disparities continue to grow, this is leading to social unrest and conflicts that is happening in the region and is making it harder for governments to maintain stability and security. Access to education and healthcare are also being significantly impacted, as individuals with lower incomes find it difficult to afford these essential services as this is creating a vicious cycle, as limited access to education and healthcare is perpetuating further inequality. Furthermore, the consequences of income inequality extend to overall economic growth. This is because a significant part of the population in the region is excluded from economic opportunities due to unequal access to resources and education, as this is compromising the full realization of the regions' potential. In addition to these challenges, income inequality is also undermining the effectiveness of public policies aimed at poverty reduction and sustainable economic growth in the region, due to this limitation in public policies is becoming increasingly difficult to achieve meaningful progress in reducing poverty rates and improving the overall well-being of the population.

The alignment of the findings of this study with well-established economic theories reinforces the importance of these factors in fostering sustainable and inclusive economic growth. Furthermore, it's possible to see how these variables are related and reinforce each other's impact on economic growth in sub-Saharan Africa. For instance, education not only enhances labor productivity and innovation but also contributes to improving institutional quality. A well-educated population is more likely to demand transparent and effective governance, leading to the development of strong institutions. Moreover, the relationship between institutional quality and the Gini Index should not be overlooked. Transparent and accountable institutions can help address income inequality by ensuring that policies and regulations are designed to benefit the broader population. When institutions are weak or corrupt, income inequality tends to worsen, perpetuating a cycle of poverty and hindering economic progress.

In conclusion, the regression analysis conducted in this thesis showed that the improvement of economic growth in sub-Saharan Africa from 1990 to 2021 is largely attributable to investments and advancements in education, but these advancements are being constrained by poor institutional quality and higher rates of income inequality as this means that only a part of the population (usually the higher ranks and elite society) benefits from economic growth, and not the entire population. These factors continue to limit the extent to which the benefits of economic growth can be shared across the entire population, leaving the majority of the region's inhabitants with limited access to the opportunities and benefits of development.

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APPENDICES

Regression Results

```
       GDP_pc_              Reg_            Capital_form_        Labor_force_          technol_
 Min.   :  502.4    Min.   :0.0000    Min.   : 1.097    Min.   :0.1905    Min.   : 0.00
 1st Qu.: 3187.0    1st Qu.:0.0000    1st Qu.:18.166    1st Qu.:0.3546    1st Qu.: 0.70
 Median : 6524.2    Median :0.0000    Median :22.209    Median :0.4076    Median : 8.00
 Mean   : 7914.9    Mean   :0.3421    Mean   :23.348    Mean   :0.4031    Mean   :19.11
 3rd Qu.:11538.4    3rd Qu.:1.0000    3rd Qu.:27.046    3rd Qu.:0.4563    3rd Qu.:33.17
 Max.   :23933.9    Max.   :1.0000    Max.   :93.547    Max.   :0.5957    Max.   :88.13
     Inst_Qlty_           Gini_              Fdi_            School_enroll_      Pop_growth_
 Min.   :-1.6600    Min.   :24.00     Min.   :-37.1726    Min.   : 0.33    Min.   :-3.210
 1st Qu.:-0.7400    1st Qu.:35.01     1st Qu.:  0.9477    1st Qu.: 7.49    1st Qu.: 0.960
 Median :-0.3900    Median :39.68     Median :  2.2438    Median :18.42    Median : 1.630
 Mean   :-0.4058    Mean   :40.87     Mean   :  3.2965    Mean   :24.07    Mean   : 1.590
 3rd Qu.:-0.1100    3rd Qu.:45.70     3rd Qu.:  4.2485    3rd Qu.:36.85    3rd Qu.: 2.545
 Max.   : 0.8800    Max.   :64.70     Max.   : 43.9121    Max.   :99.17    Max.   : 6.760

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)     -778.098    719.124  -1.082 0.279416
Reg_           -1147.550    209.845  -5.469 5.28e-08 ***
Capital_form_     18.610     10.444   1.782 0.074948 .
Labor_force_      14.228     11.041   1.289 0.197704
technol_          39.065      4.324   9.035  < 2e-16 ***
Inst_Qlty_      2949.159    177.800  16.587  < 2e-16 ***
Gini_            128.115     10.440  12.271  < 2e-16 ***
Fdi_             -64.848     17.869  -3.629 0.000294 ***
School_enroll_   155.907      6.299  24.751  < 2e-16 ***
Pop_growth_     -155.429     88.408  -1.758 0.078929 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2950 on 1557 degrees of freedom
Multiple R-squared:  0.7235,    Adjusted R-squared:  0.7219
F-statistic: 452.6 on 9 and 1557 DF,  p-value: < 2.2e-16
```

```
> #Collinearity
> car::vif(multi.mod)
        Reg_   Capital_form_    Labor_force_        technol_      Inst_Qlty_           Gini_
    1.784229        1.192410        1.327031        1.759403        1.316478        1.359422
        Fdi_   School_enroll_     Pop_growth_
    1.114496        2.905562        2.153015
```

```
[1] "8.803725%" "8.842792%" "8.755506%"    [1] "8.789198%" "8.785423%" "8.812993%"
> c(mse8.K5, mse7.K5, mse6.K5)             > c(mse8.loocv, mse7.loocv, mse6.loocv)
```

```
Regression tree:
tree(formula = GDP_pc_ ~ ., data = train)
Variables actually used in tree construction:
[1] "School_enroll_" "Inst_Qlty_"     "Gini_"          "Labor_force_"
Number of terminal nodes:  11
Residual mean deviance:  8205000 = 8.927e+09 / 1088
Distribution of residuals:
   Min. 1st Qu.  Median    Mean 3rd Qu.     Max.
-9998.0 -1565.0  -266.7     0.0  1460.0  14110.0


$size
 [1] 11 10  9  8  7  6  5  4  3  2  1

$dev
 [1] 11250404673 11757196839 11710153113 11837997397 12374617355 12487551273 12953098285
 [8] 14415258255 17740089981 20369309080 33849150827

$k
 [1]        -Inf   370447703   385447287   390046811   521664565   548940530   745609884
 [8]  1543883631  2290056536  3428211054 14584618763

$method
[1] "deviance"

attr(,"class")
[1] "prune"          "tree.sequence"



> importance(bag.GDP_pc_)                          > importance(rfor.GDP_pc_)
                 %IncMSE IncNodePurity                            %IncMSE IncNodePurity
Reg_             14.23431     212342332          Reg_             18.70119    1221782492
Capital_form_    28.04126     702329786          Capital_form_    29.19309    1002390633
Labor_force_     50.30702    1760984993          Labor_force_     45.00983    2091843841
technol_         31.04138    1972270655          technol_         38.99872    5090488709
Inst_Qlty_      107.53030    4854724001          Inst_Qlty_       77.77090    4466656183
Gini_            74.57867    2142406108          Gini_            57.90105    2356374292
Fdi_             24.84062     775095151          Fdi_             23.68482     894237090
School_enroll_  138.80482   20125728652          School_enroll_   64.15884   12905613351
Pop_growth_      35.65123    1024148966          Pop_growth_      33.86472    3270948040


[1] "8.853605%" "9.218910%" "3.215448%" "3.012307%"
> c(test.mse.lm, test.mse.tree, test.mse.bag, test.mse.rf)
```
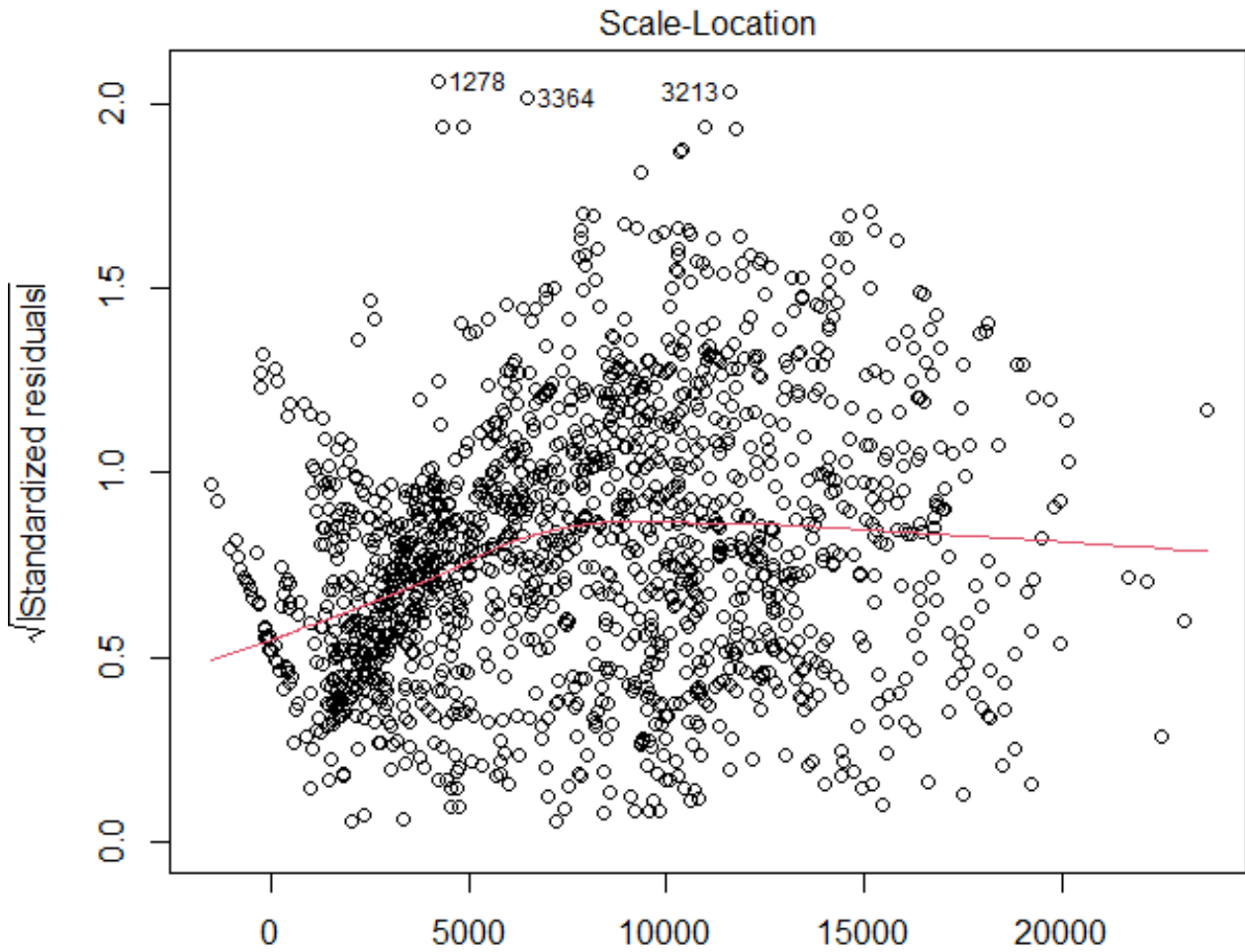
Normal Q-Q

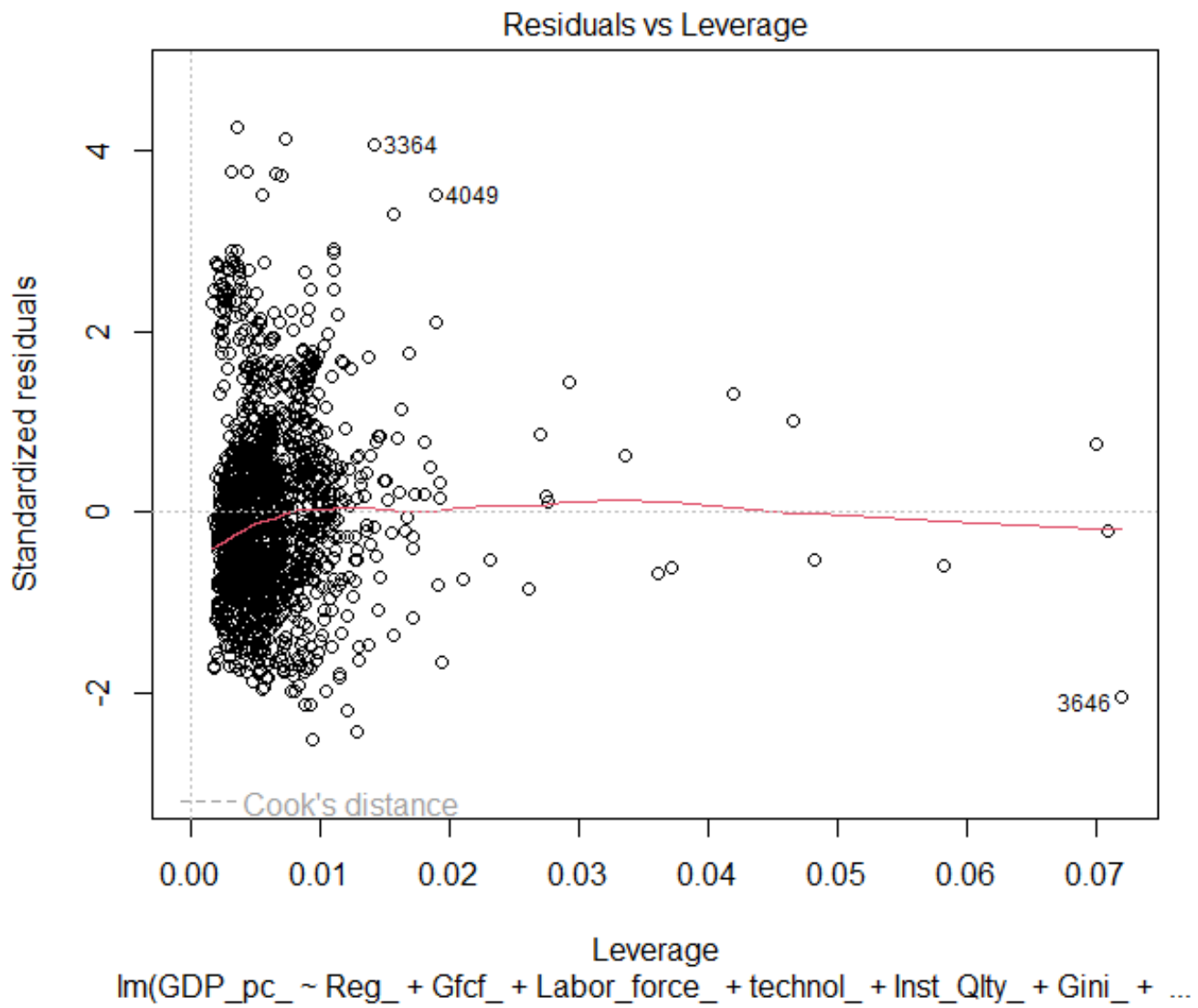Standardized residuals

Theoretical Quantiles
lm(GDP_pc_ ~ Reg_ + Gfcf_ + Labor_force_ + technol_ + Inst_Qlty_ + Gini_ + ...

Scale-Location

lm(GDP_pc_ ~ Reg_ + Gfcf_ + Labor_force_ + technol_ + Inst_Qlty_ + Gini_ + ...

Residuals vs Leverage

Leverage
lm(GDP_pc_ ~ Reg_ + Gfcf_ + Labor_force_ + technol_ + Inst_Qlty_ + Gini_ + ...

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