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The Health-Economic growth nexus: A lower and middle-income Sub-Saharan economies comparison

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DECLARATION

I, the undersigned, hereby declare that this dissertation, save for supervisory guidance received, is the product of my own work and effort. I have, to the best of my knowledge and belief, acknowledged all the resources of information in line with normal academic conventions. I further certify that the dissertation is original, and has not been submitted before at this or any other university for the purpose of obtaining a degree.

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ABSTRACT

The relationship between health and economic growth has been examined extensively during the past 30 years in developed and European countries. However, there are few studies that have investigated this relationship in Sub-Saharan Africa countries. The study investigated the relationship between health and economic growth by comparing low and middle-income Sub-Saharan Africa countries from 2000-2016. The study employed data from World Bank Indicators (WDI) in the World Bank database. This study is unique amongst existing studies in two respects. Firstly, it investigates the relationship between health and economic growth by comparing lower-income with middle-income Sub-Saharan Africa countries, since these countries have not received enough scholarly attention. Secondly, the study introduces Principal Component Analysis (PCA) with an aim to create a health index, since no such measure variable exists for health.

The study employed two Panel Vector Autoregressive models (PVAR) to investigate the relationship between health and economic growth. A Panel Vector Autoregressive model is an appropriate model for large panel data sets (Munyengwa, 2012). The results of the study support the Endogenous Growth Theory, which emphasises the crucial role that is played by health as a determinant or engine of economic growth through human capital effect. An improvement in health by 10% raises the economic growth rate by 2% in the short run. The study found a strong positive, statistically significant influence of health on economic growth in lower-income Sub-Saharan Africa countries. The study also found a positive, but statically insignificant impact of health on economic growth in middle-income Sub-Saharan Africa countries. These findings are very important to policymakers in the respective countries.

Keywords: Health-Economic growth nexus, World Development Indicators, Principal Component Analysis, Panel Vector Autoregressive, Economic Growth and Sub-Saharan Africa Countries.

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LISTS OF ACRONYMS AND ABBREVIATIONS

ADF	Augmented Dickey Fullest
AIC	Akaike Information Criteria
ARDL	Autoregressive Distributed Lag
ASM	Augmented Solow Model
BR	Birth Rate
DR	Death Rate
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
HIV	Human Immunodeficiency Virus
IM	Infant Mortality
IRF	Impulse Response Function
LE	Life Expectancy
LLC	Levin, Lin and Chu
MDG	Millennium Development Goal
OECD	Organisation for Economic Co-Operation and Development
OLS	Ordinary Least Squares
PCA	Principal Component Analysis
PVAR	Panel Vector Autoregressive Model
PP	Phillip Peron
SARB	South African Reserve Bank
SBIC	Schwarz Bayesian Information Criteria
SSA	Sub-Saharan Africa
TB	Tuberculosis

2SLS	Two Stage Least Squares
3SLS	Three Stage Least Squares
VAR	Vector Autoregressive
VECM	Vector Error Correction Model
WB	World Bank
WDI	World Development Indicator

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION AND BACKGROUND

Sub-Saharan Africa has been described in the literature as the world's most underdeveloped continent and its underdevelopment is reflected in many aspects, but the most telling indicator has been poor health inherent in most countries of this region. Studies such as Arora (2001) and Frimpong (2012) have observed high levels of income inequality and low levels of economic growth. The main cause of this underdevelopment in Sub-Saharan Africa countries is argued to be the poor health care system (Authur, 2015). Owing to this characterisation, the World Health Organization has spent more than $15 billion over the past five years in Sub-Saharan Africa in an effort to improve health and fight chronic diseases such as HIV/AIDS and Tuberculosis (Weil, 2007). In addition, a Millennium Development Goal (MDG) was also put in place by the United Nations in 2002 aimed at reducing the level of poverty and improving health in most of these countries (United Nations, 2007). Half of the Sub-Saharan Africa countries have poverty rates that are higher than 35% due to diseases like Covid 19 pandemic, Turbeculousis and HIV/AIDs.

Health is described as a crucial indicator of the standard of living, and output or labour productivity is determined by the health of individuals (Ercelik, 2018). The issue of poor health, as portrayed by life expectancy and the high rate of infant mortality in Sub-Saharan Africa regions, motivated the international organization to invest in the African public health sector, with a large part of the investment channelled towards the Sub-Saharan region. In spite of this investment most of the countries in Sub-Saharan Africa are still experiencing slow or negative economic growth per capita as measured by the Gross Domestic Product per capita (Frimpong, 2012). Although an improvement in health is a basic human right, researchers are interested in determining its effect on economic growth. Given this background, the current study seeks to examine the causality and impact of health on economic growth in Sub-Saharan countries. The number of studies that have investigated the relationship between health and economic growth in Sub-Saharan Africa country contexts are very limited. Most of the empirical studies have been examining developed countries (Tekabe, 2012; Acemoglu and Johnson; 2007; Ogundari and Awokuse, 2018).

By taking the focus in previous studies into consideration, this study will fill the gap and contribute to the empirical literature on the causality between economic growth and health status in Sub-Saharan Africa countries. The study has a sample size of 136 for lower-income countries and 119 for middle-income Sub-Saharan Africa countries to estimate the influence of health on the economic growth of seven middle-income and eight lower-income countries, over a period of 16 years from 2000-2016. The study is guided and limited by the availability of data from 2000-2016. The study will follow the neoclassical growth theory in which capital accumulation is a fundamental determinant of economic growth. Measures of life expectancy at birth, birth rate and the prevalence of HIV/AIDs in both lower-income and middle-income Sub-Saharan Africa countries are used in the construction of an overall index proxying health. The study has three objectives. The first objective is to analyse the influence of health on economic growth in both low-income and middle-income Sub-Saharan Africa countries. Secondly, the direction of causality between economic growth and health will be determined; and lastly the effect of health shocks on growth in lower-income and middle-income Sub-Saharan Africa countries will be established. This study contributes to the existing literature by firstly investigating the relationship between health and economic growth, by employing the Panel Vector Autoregressive (PVAR) method and drawing a comparison between middle and lower-income Sub-Saharan Africa regions. Amongst the previous studies that employed PVAR to estimate the impulse responses of economic growth stemming from health dynamics, most of these studies were limited to developed countries.

The use of the PVAR model is based on several considerations. Firstly, it is a model that is able to treat all the variables endogenously and also interdependently in a static manner (Ramey and Shapiro, 1998). This is crucial since health is likely to be endogenous in the growth specification. Secondly, the PVAR model is characterised as a model that is able to mix the characteristics of a Vector Autoregressive (VAR) model with panel data. This makes it able to control for unobserved country-heterogeneity. In addition, the PVAR model accounts for cross-sectional dynamic heterogeneity (Canova and Cinderella, 2013).

The second contribution of the study to existing literature is that, while previous studies employed different indicators to measure population health, this study applies Principal Component Analysis (PCA) to create an index of health. According to Karamizadeh *et al.* (2013), Principal Component Analysis is employed when the variable includes many factors. There are many health indicators, with different impacts on the economy. Poor health has a negative effect on labour productivity, since workers may be absent from work regularly, or unable to complete a full day's work, which would then negatively affect economic growth. It is also argued that health affects economic growth by affecting labour supply. Poor health increases infant and early adult mortality rates, thus reducing labour supply. A decrease in labour supply will have a negative effect on economic growth.

Several authors have established positive interrelationships between labour productivity, health and economic growth empirically (Djafar, 2011; Cervellati and Sunde, 2011; Rengin, 2012; Boussalem and Taiba 2014; Kurt, 2015; Boachie, 2015 and Ercelik, 2018). The study of Halici-Tuluce *et al.* (2016), in particular, investigated the relationship between health expenditure and economic growth in high-income and lower-income African countries. From their results, a positive relationship between private health spending and economic growth and a negative relationship between public health spending and economic growth was confirmed.

1.2 THE PROBLEM STATEMENT OR RESEARCH PROBLEM

There is extensive literature on health and economic growth (see for example Hansen and Lønstrup, 2015., Oni, 2014; Novignon and Lawanson,2017; Zaidi and Saidi, 2018; Dincer and Yuksel, 2019., Kar and Taban, 2003; Malik, 2006; Yumusak and Yildirim, 2009; Hansen and Lønstrup, 2015). Despite the extensiveness of this literature, there are still several outstanding and contentious issues that, if addressed differently and appropriately, might shed more light on how health affects economic growth. Firstly, there is no agreement on how health can best be measured. The current approach in the literature uses different indicators of health, which are usually life expectancy, mortality rates and health expenditure. This practice has at least two limitations. These indicators are often correlated, making it difficult to partial out the effect of each health indicator on economic growth, and it is difficult to reach a solid conclusion about health and economic growth in cases where two different indicators appear in the same model with different signs.

Secondly, there is a possibility that the way health affects growth depends on the income status of a country, and failure to consider this may bias the effect of health. There are few cross-country panel studies on Sub-Saharan Africa available that mostly address the issue of time-invariant unobserved heterogeneity across countries, while failing to adequately deal with time-varying heterogeneity such as the country's income status. It may be inappropriate, for example, to control for time-invariant heterogeneity and assume that the effect of health on economic growth in Sub-Saharan Africa is homogenous across all the income groups in the region. Given the above limitations in the existing literature, this study will address the limitations through the calculation and introduction of a health index. This index has the advantage of addressing the problem of potential multicollinearity, while at the same time presenting a composite health variable that is comparable across countries. To deal with the time-varying income status of countries, two separate models for low and middle-income Sub-Saharan countries will be estimated, which will make it easier to test the health-income hypothesis.

1.3 AIMS AND OBJECTIVES OF THE STUDY

The main objective of this study is to analyse the impact of health on economic growth in Sub-Saharan Africa from 2000-2016, using a novel health index.

This primary aim of the study will be achieved by means of the following specific objectives:

i. To compare the influence of health on economic growth between lower-income and middle-income Sub-Saharan Africa countries.
ii. To determine the direction of causality between health and economic growth in lower-income and middle-income Sub-Saharan Africa countries.
iii. To determine how health shocks, affect growth in lower-income and middle-income Sub-Saharan Africa countries over time.

1.4 HYPOTHESIS OF THE STUDY

The research objectives will be achieved based on the following null hypotheses:

i. Health has no statistical influence on economic growth in lower-income and middle-income Sub-Saharan Africa countries.

ii. There is no causality between health and economic growth in lower-income and middle-income Sub-Saharan Africa countries.
iii. Health shocks do not affect growth in lower-income and middle-income Sub-Saharan Africa countries over time.

1.5 CONTRIBUTION OF THE STUDY

This study contributes to the literature on economic development in different ways. Firstly, previous studies in the literature have relied on different indicators as proxy variables for health. For example, Weil (2007) used adult height, age of menarche and adult survival rate, and Besciu and Androniceanu (2017) employed life expectancy and infant mortality as health indicators, while Hansen and Lonstrup (2015) only relied on life expectancy. This study's contribution to the existing body of knowledge will be that it uses principal component analysis (PCA) to create an index that will be a proxy for health. PCA is an appropriate method for compressing multidimensional data into a single component. Secondly, health can also depend on income levels, which means that bicausality can exist. Previous studies have used instruments to measure this potential reverse effect of income levels, using 2SLS and 3SLS. However, there is the challenge of choosing appropriate instruments in the literature, with none of these techniques rendering reliable results. This study contributes by applying two Panel Vector Autoregressive (PVAR) models to investigate the relationship between health and economic growth. The first PVAR is for lower-income countries, while the second PVAR represents the middle-income Sub-Saharan Africa countries and will allow both health and economic growth to be endogenous. Thirdly, this methodology is also able to show how economic growth responds to health shocks in Sub-Saharan Africa countries over time.

Table 1.1: Lower-income and Middle-income Sub-Saharan Africa countries

Lower-income Sub-Saharan Africa countries	Middle-income Sub-Saharan Africa countries
1. Benin	1. South Africa
2. Burkina Faso	2. Congo Republic
3. Burundi	3. Botswana
4. Chad	4. Namibia
5. Madagascar	5. Mauritius
6. Comoros	6. Nigeria
7. Tanzania	7. eSwatini
8. Gambia	

Source: Generated by researcher.

1.6 LIMITATION OF THE STUDY

This dissertation will be limited to eight lower-income Sub-Saharan Africa countries and seven middle-income Sub-Saharan Africa countries. The main reason limiting this study to eight lower-income and seven middle-income countries, is the unavailability of data for the other countries. There are many variables that can be described as the determinants of economic growth, e.g. corruption and democracy, but all these variables are not included in this study because of the unavailability of data. There are also many variables that are described as health indicators, but because of the unavailability of data, the study is limited to only three variables, namely life expectancy, the prevalence of HIV and birth rate.

1.7 ORGANISATION OF THE STUDY

The rest of this study is outlined as follows:

CHAPTER ONE: INTRODUCTION

Chapter one of the study introduces the study. This chapter provides insight into the history of health in Sub-Saharan Africa countries and the effect of health on economic growth. This chapter also introduces the model the study will be employing, and further explains the problem statement, aim and contribution of the study to existing literature.

CHAPTER TWO: THEORETICAL LITERATURE REVIEW AND CHANNELS OF HEALTH ON ECONOMIC GROWTH

Chapter two explains the relevant theories that are determinants of economic growth and the role played by health on economic growth, as well as the conceptual literature based on the health and economic growth overview in Sub-Saharan Africa. This chapter also analyses the channels of health on economic growth.

CHAPTER THREE: EMPIRICAL LITERATURE REVIEW

Chapter three explains and focuses on existing literature from the other researchers, based on the relationship between health and economic growth in Sub-Saharan Africa countries and this chapter gives a preview of the studies on health and economic growth from an international perspective.

CHAPTER FOUR: METHODOLOGY OF THE STUDY

Chapter four introduces econometrics techniques, or the methodology that is most suitable and will be adopted by the study to investigate the relationship between health and economic growth. The Panel Vector Autoregressive model is considered to be the best model of the study. The study takes the advantages and disadvantages of this model into consideration. This chapter also includes model specifications, data collection methods and diagnostic tests under the PVAR.

CHAPTER FIVE: EMPIRICAL RESULTS AND INTERPRETATION

Chapter five presents the empirical results obtained by means of the Panel Vector Autoregressive model, as well as all the diagnostics tests.

CHAPTER SIX: CONCLUSION AND POLICY RECOMMENDATIONS

Chapter six summarises the results of the study. The conclusion of the study will be based on the results. This chapter will also present the policy recommendations based on the outcome of the study, after estimating the relationship between health and economic growth. This chapter articulates which areas need to be improved by future studies.

CHAPTER TWO

A REVIEW OF ECONOMIC GROWTH THEORY

2.1. INTRODUCTION

The aim of this chapter is to explain the role played by health in economic growth, as well as the theories that explain the determinants of economic growth. This chapter develops the theoretical framework for the health-economic growth nexus model by evaluating the relevant theories and determinants of health and economic growth. Furthermore, the chapter will determine the link and causality between the relevant theories of health and economic growth.

2.2 RELATED THEORIES OF THE STUDY

The most important theories of economic growth developed over time are the Solow Growth Theory, also known as the Exogenous Growth Theory, the Endogenous Growth Theory, the Lucas Growth Theory, and the Harrod-Domar Growth Theory. Each of these theories will be evaluated specifically with regard to the role of health in the models.

2.2.1 HARROD-DOMAR GROWTH THEORY

The Harrod-Domar Growth Theory was propounded by Domar in 1946. This theory emphasised the role that was played by physical capital in the form of savings and investment in the performance of economic growth. This theory of Domar (1946) stated that the main engines that accelerate the performance of economic growth are savings and investment. These two factors were regarded as being physical capital in the Cobb-Douglas production function. Domar (1946) emphasized the role that was played by savings and investment in the economic growth of a country, regardless of whether it was a developed or developing country. The Domar Growth Theory (1946) argued with the statement that a higher level of savings, automatically uplifted the level of investment.

2.2.2 SOLOW GROWTH THEORY (EXOGENOUS GROWTH THEORY)

Solow (1956) extended the Theory of Neo-classical Growth (Ramsey 1928) by elaborating on the role played by the factors of production capital and labour in influencing the output level of a country. Solow (1956) also included the role played by population growth in the economic growth of a country. The assumptions of the

Solow growth model were that capital accumulation and physical labour display the fixed returns on output yet reduce the marginal returns on capital (Kanono and Sello, 2016). The Solow model distinguished between a short-run and long-run model of economic growth. In the short run the economic growth of a country is determined by three factors, namely capital accumulation, physical labour and human capital, but in the long run it is determined by the progress in technology (Solow, 1956). Solow (1956) stated that economic growth was determined by the progress in technology and defined technology as a combination of knowledge, culture and experience that enhances economic growth in developing countries.

Solow (1956) applied the Cobb Douglas production function to explain the impact of labour and technology on economic growth. The Cobb Douglas production function includes physical labour, physical capital and physical output as the determinants of economic growth. This theory takes cognisance of the fact that there are many determinants of economic growth, but that labour, capital and technology contribute most to economic growth. The Cobb Douglas production function can be expressed as follows:

$$Y = T\, L^{\alpha 1} K^{\alpha 2} \quad (1)$$

where Y indicates the level of output in a country or its Gross Domestic Product, L and K refer to physical labour and physical capital in the form of investment and savings and T represents technology in the form of culture, knowledge and skills. Total factor productivity can be explained as follows:

$$T = \frac{Y}{L^{\alpha_1}\, K^{\alpha_2}} \quad (2)$$

where α_1 and α_2 are the coefficients of labour and capital applied to measure the labour and capital share of output. If the coeffients are negative, we conclude that the returns to scale are decreasing. The neo-classical theory introduced by Ramsey (1928) emphasized the important role played by labour and capital in economic growth and was then extended by Solow, who examined the role played by population growth and technology progress in the economy of any country, but especially developing countries. Bonds and Leblebiciouglu (2010) stated that the Solow model was an exogenous growth model that explained the factors that determine the accumulation of capital in a country, denoting the levels of investment, but through savings and labour. According to Bonds and Leblebiciouglu (2010) the levels of output and savings are positively related, because an increase in the level of investment will automatically increase the level of output, but population growth has a negative impact on economic growth or level of output in a country. Depreciation also has a negative impact on economic growth in a country. The depreciation of assets, like machinery, reduces the level of output of country. Lucas (1988) and Romer (1990) extended the Exogenous Growth Theory of Solow, by including improvements in human capital through education and health, that contribute positively to the economic growth of countries.

2.2.3 ENDOGENOUS GROWTH THEORY

The Endogenous Growth Theory stated that the increase or improvement in economic growth was determined by an investment in human capital in the form of education and health. This study is based on the neo-classical theory that was used by Ramsey (1928) and Solow (1956) and later extended by Romer (1989), which helps us to understand the sources of economic growth in a country. The neo-classical theory stated that the factors determining a country's output are capital, labour and technology. This theory builds on a standard neo-classical growth model in which labour is defined as physical workers employed in production. It then re-defines labour as human capital, which is measured by health and education. Similar to the Solow (1956) growth model, the Endogenous Growth Theory starts with a Cobb-Douglas production function:

$$Y = AK^{\alpha} L^{1-\alpha} \quad (3)$$

where Y denotes the total production in an economy (GDP), A denotes technology, K denotes physical capital stock, and L denotes labour, while α and $1-\alpha$ point to input elasticity. Solow (1956) argued that an increase in capital input would lead to an increase in both output and the productivity of labour. However, since this theory does not accommodate the role of human capital, Mankiw and Romer (1992) suggested an augmented Solow-growth model by incorporating factors such as education attainment to represent the quality of human capital. Weil (2007) included both education and health as measures of human capital. Weil (2007) referred to this as the proximate effect of health on the level of income and the improved model took the following form:

$$Y = A K^{\alpha}(hL)^{1-\alpha} \quad (4)$$

where h represented health while the other variables were as defined before. Bloom and Finlay (2009) researched the role played by human capital, through the inclusion of health factors as well as education, in economic growth. The study found that human capital i plays a big role in the economic growth of a country, with education having a direct impact, while health has an indirect effect through labour productivity and higher returns on the input of labour. Boachie (2015) found that the health impact on human capital is one of the important determinants that control the economic growth of a country in the short or long run. The effect of health on economic growth becomes evident in the productivity of workers. A healthier person can work more effectively, both physically and mentally (Deaton, 2003).

2.2.4 LUCAS GROWTH THEORY

Lucas (1990) extended the growth theory of Romer (1986), which stated that human capital in the form of health was a determinant or engine of economic growth. The Lucas Growth Theory explained the role that was played by education, stating that education is a pillar of economic growth in developing countries. According to Bosupeng (2015), education plays a vital role because it includes knowledge and skills as part of human capital. The Lucas Growth Theory stated that, if a country increases its spending in education, it automatically also improves its level of production in human capital, because human capital accelerates the economic growth of a country. This theory of Lucas (1990) divided human capital into two categories, namely external and internal effects. The first category, the internal effect, explains human capital in the form of the knowledge and skills obtained by an individual after he/she has trained for particular employment. The second category is the external effect, where there is an exchange of ideas among individuals, which will then lead to an increase in human capital, as well as an improved level of output.

According to the studies of Agenor and Neanidis (2011) and Wang (2013), a country that increases its spending on human capital automatically also increases economic growth, because human capital is an engine that drives a fast improvement in technology. Healthier people contribute positively to economic growth, because it is easier for them to adapt to new technology (Ogundari and Abdulai, 2018). According to Li and Liang (2010), education and economic growth are positively related.

2.3 MEASUREMENT OF HEALTH AND A HEALTH INDEX

It is important to determine an indicator or measurement of health. In theory the most commonly applied proxy variables of health are life expectancy, infant mortality, death rate and adult survival rate. In Africa the health indicators impacting human capital normally include birth rate (BR), life expectancy (LE) and number of adult people (ages 15+) with the prevalence of HIV (PHIV). One of the contributions of this study is to compute a composite health index based on birth rate, life expectancy and adults above 15 years infected by HIV, using principal component analysis. The next section presents the empirical literature on health and economic growth.

$$h = e^{\beta_1 Health\ index} \quad (5)$$

The above equation states that, following Weil (2007), the relationship was explained by an exponential function. The betas (β_1) are the parameters that are associated with human capital. Substituting equation 5 with equation 4 yielded a new specification in the following form; Given that education is normally included in the technology parameter and capital (K), human capital (L) is expressed as follows:

$$Y = A\ K^{\alpha}(\ e^{\beta_1 Health\ index}\ L)^{1-\alpha} \quad (6)$$

The growth model can be algebraically rewritten as follows:

$$Y = \ AK^{\alpha}\ L^{1-\alpha}\ e^{\beta_1(1-\alpha)\ Health\ index} \quad (7)$$

Let λ be $\beta_1(1-\alpha)$, then equation (8) can be rewritten as,

$$Y = \ AK^{\alpha}\ L^{1-\alpha}\ e^{\ \lambda\ Health\ index} \quad (8)$$

Since the theory emphasizes the impact of health on labour productivity, equation 9 is divided by L on both sides in order to derive a labour productivity specification. This transformation leads to the following equation:

$$\frac{Y}{L} = A\ (\frac{K}{L})^{\alpha}\ e^{\ \lambda\ Health\ index} \quad (9)$$

This theoretical model is non-linear and cannot be estimated by using linear methods. To make the model estimable, equation 10 is expressed in logarithms, so that the final specification takes the following form.

$$\log\left(\frac{Y}{L}\right) = \log(A) + \alpha \log\left(\frac{K}{L}\right) + \lambda \text{ health index} \quad (10)$$

Changing the equation into a model by including an error term and panel data scripts, the model that will be estimated in this study is as follows:

$$\log\left(\frac{Y}{L}\right)_{it} = \delta + \alpha \log\left(\frac{K}{L}\right)_{it} + \lambda \ (Health\ index)_{it} + \varepsilon_{it} \quad (11)$$

In this case, subscripts i and t represent the country and time period, respectively, and ε is the error term, while $\delta = \log A$.

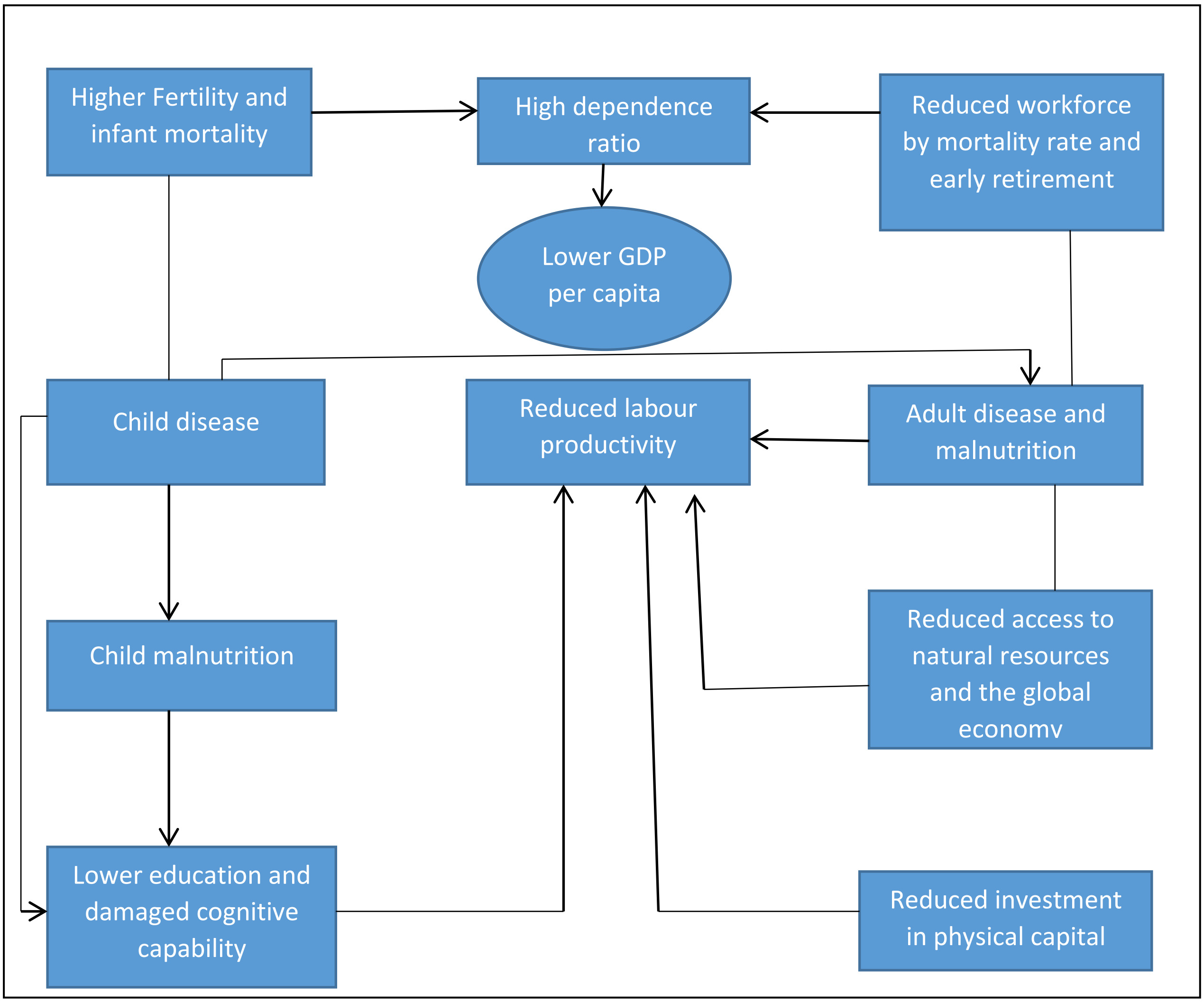
2.3.1 THE RELATIONSHIP BETWEEN HEALTH AND INCOME

Health affects the economic growth of a country through at least the following three channels: a direct relationship between the health of individuals and their earnings, an indirect effect of health on the levels of education of the people and the effect of health as a physical capital investment. Figure 2.1 summarizes the channels of how health affects the economic growth of a country very well.

The first channel, a worsened health status of the people, will lead to a loss of individual income due to a decrease in labour productivity, i.e. the number of hours people work and participate in the labour force will decline (Luft, 1979). These losses will have an effect on the population's level of wealth and that will lead to a decline in the economic growth of a country and the social well-being of its population. In figure 2.1 the higher fertility rate and infant mortality will increase the dependence ratio and that will lower the GDP per capita of the individuals in the country. Figure 2.1 also states that a worsening in the health status of the people affects the adult disease levels, leads to malnutrion and reduces labour productivity, which will lead to a lower GDP per capita income. The second indirect channel comprises education levels. Health affects education because the health status of individuals affects their learning ablility and school attendance (Sachs, 2001; Cutler and Lleras-Muney, 2006). Another second channel is displayed in figure 2.1 below by the relationship between fertility rate and infant mortality and their effect on the levels of education. The high infant mortality rate also tends to increase the fertility rate (Sachs, 2001). In general, the increase in infant mortality and fertility rate will affect education because the resources that are supposed to be available to parents for investing in further education will be affected. The relationship between health, education and economic growth is strongly positive if you link them to technological progress (Howitt, 2005).

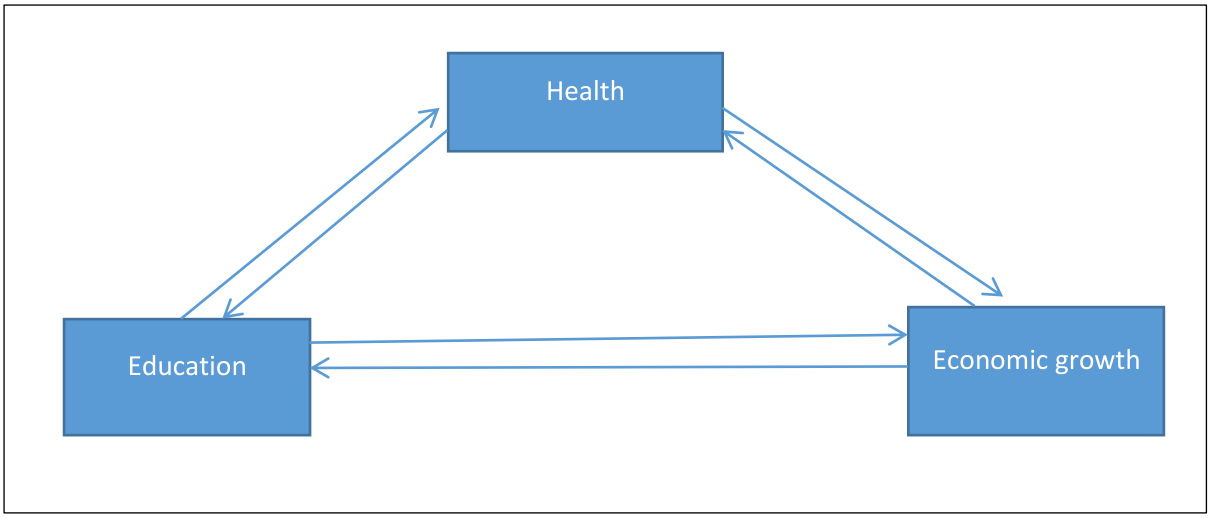
The third channel links health to economic growth, as explained by the effect of health on physical capital investment. This relationship can be forged by the savings rate or health externalities, while poor health conditions reduce the life expectancy of individuals (Sachs, 2001). Health externalities refer to chronic disease, i.e. HIV/AIDS, especially reducing the investment rate in developing countries where poverty and health are closely related (Sachs, 2001). Developing countries have a high rate of HIV/AIDS that leads to a decline in economic growth because an increase in the turnover of labour will also allow the absenteeism rate to increase and that will increase the training costs (Sachs, 2001).

Figure 2.1: CHANNELS OF HEALTH AND INCOME



Source: Frimpong, (2012)

Figure 2.2: THE RELATIONSHIP BETWEEN HEALTH, ECONOMIC GROWTH AND EDUCATION



Source: Porcas (2012)

Figure 2.2 above explains the important role played by education and health in economic growth. The question arises what would happen to the levels of education and productivity if a country were to improve the health status of its people. Various authors have explained the role played by education in the economic growth of a country. An improvement in the health status of the people leads to an improvement in their education and a healthy lifestyle, while decreasing their health inequalities (Ricci and Zachariades, 2006; Cutler and Lleras-Muney, 2010). The link between the level of education and the health status of people is explained by various authors. The role played by education and health in economic growth in the Sub-Saharan Africa region both contribute positively to their economic growth (Cutler and Lleras-Muney, 2006, Silles, 2009 and Cutler and Lleras–Muney, 2010). Education and health are the main pillars within the three channels that explain the relationship between education and health status (Porcas, 2012). The education and health of individuals are related through productive efficiency, time preference and allocative efficiency. The channels articulating the link between human capital, health status and economic growth are explained in figure 2.2 above. Health affects education and also economic growth directly because better education among individuals is determined by health and a higher level of productivity is also determined by health

(Porcas, 2012). If the level of education among individuals improves, it will lead to an increase in their health levels as explained by two of the channels. In the first place, if the level of education within a population increases, that will lead to people spending more money on health care because they are educated, and if there is an increase in education, people will spend more time on developing their health (Porcas, 2012).

2.4 CONCLUSION OF THE CHAPTER

Chapter two is divided into three parts. The first part analyses the relevant theories of economic growth. The second part explains the channels of health and income in Sub-Saharan Africa countries and the relationship between health, education and economic growth. The last part explains the channels of health, education and economic growth. Related theories of economic growth that are employed by the study are listed as follows: Solow's Growth Theory, also known as the Exogenous Growth Theory; the Harrod-Domar Growth Theory; Endogenous Growth Theory and Lucas Growth Theory. Solow (1956) extended the theory of Ramsey (1928). Solow's growth theory emphasized the importance of physical capital, physical labour and accumulated technology in the form of skills, culture and knowledge for the economic growth of country. The Endogenous Growth Theory emphasises the vital role that human capital plays in the form of health in the economic growth of a country. The Lucas Growth Theory explains the role played by human capital in the form of education in economic growth, and lastly the Harrod-Domar Growth Theory explains the important role played by savings as physical capital towards economic growth. The second part of this chapter explains the channels of health and income, in the form of a diagram. The study is based on the Endogenous Growth Theory developed by Romer (1989), which states that the economic growth of a country is determined by labour, human capital and technology.

CHAPTER THREE

EMPIRICAL LITERATURE REVIEW

3.1 INTRODUCTION

In this chapter the study analyses the relationship between health and economic growth in Sub-Saharan Africa regions. In this context, the long-term causality between health and economic growth will be examined. The study will follow the Endogenous Growth Theory. The Endogenous Growth Theory of the neo-classical economic school of thought, originally proposed by Solow, only includes technology and labour as inputs for production. The theory represented by the production function model has been augmented by accommodating human capital as an input for growth (Mankiw et al., 1992). The Endogenous Growth Theory of the neoclassical economic school of thought was propounded by Solow. This theory emphasizes the importance of technology, physical capital and labour for the economic growth of a country (Mankiw *et al.*, 1992). Health is determined by health indicators, e.g. life expectancy, birth rate and the prevalence of HIV and AIDS, while economic growth is represented by GDP per capita. The data on health indicators and economic growth are obtained from one data source, the World Bank database.

The relationship between health and economic growth has been investigated for more than 30 years, and the empirical enquiry about this relationship remains ongoing. However, the various studies available in the literature have mostly been conducted in Latin American and other developed countries, despite the existence of well-established theories on health and economic growth based on the augmented Solow and Endogenous Growth models. The empirical results remain varied. The impact of health on economic growth could be at the micro and macroeconomics levels. At the macro level and from the seminal article of Barro and Sala-Martin (1992), several studies have analysed the influence of health on economic growth. Barro (1996) worked on a sample of 84 countries, showing that an improved life expectancy of 10% as the indicator of health leads to an increase in GDP growth from 0.52% to 0.62%. From the panel data of 104 countries, using a convergence approach, Bloom *et al.* (2001) established that an increase in life expectancy of one year as a health indicator leads to a growth of 2.6 to 4% in GDP. By the same logic, Bloom and Sachs (1998), Gallup *et al.* (1999), Bloom *et al.* (1999), and Lorentzen *et al.* (2008) show that an increase in life expectancy as a health indicator has a positive effect on economic growth. Aghion *et al.* (2012) established a positive and significant relationship between life expectancy as health indicator and economic growth. Other authors reached the conclusion that an initial high level of health, as well as a rapid improvement in health, have a significant positive impact on the GDP per capita as a proxy variable of economic growth. Contrary to this, Acemoglu and Johnson (2007) could not find a positive relationship between an improvement in life expectancy at birth as an indicator of health and economic growth. The results of their study tend to rather show that innovations in the field of health increase or accelerate the growth of a population and, therefore, cause a lower per capita income. Similarly, using data from reliable income countries, the results obtained by Barro and Lee (2010) show a negative relationship between life expectancy as a proxy for health, and economic growth.

At the micro-economic level, Schultz and Tansel (1992), Strauss and Thomas (1998), Schultz (1999a), Schultz (1999b), Savedoff and Schultz (2000), and Schultz (2002), show that health has a positive impact on economic growth through the increase in worker productivity. Although most studies find a positive relationship between health and economic growth (Ogundari and Awukose, 2018; Horodnic and Botezat, 2015; Zaman *et al.*, 2015; Biggs, 2010; Aghion, 2010; Cetin and Evecit, 2010; Temiz and Karkmaz, 2007; Canning and Sevilla, 2004; Aslan and Menegaki, 2016), there is a significant portion of empirical literature that confirms otherwise. Hansen and Lønstrup (2015) raise the question by what this empirical divergence of findings is explained. The study of Hansen and Lønstrup (2015) found a negative relationship between health and economic growth after the study employed the Two Second Least Squares model (2SLS). However, there are still several outstanding and contentious issues in the literature that, if addressed differently and appropriately, might shed more light on how health affects economic growth.

Other studies that found the same results as the results of Lønstrup (2015) are Malik (2006) and Kar and Taban (2003). Firstly, there is no agreement on how health can be best measured. The current approach in the literature uses different indicators of health, which are usually life expectancy, mortality rates and health expenditure. This practice has at least two limitations. Firstly, these indicators are often correlated, making it difficult to partial out the effect of each health indicator on economic growth. Secondly, it is difficult to reach a solid conclusion about health and economic growth in cases where two different indicators appear with different signs in the same model. The few available cross-country panel studies on Sub-Saharan Africa mostly address the issue of time-invariant, unobserved heterogeneity across countries, while failing to adequately deal with time-varying heterogeneity such as the country's income status. It may be inappropriate, for example, to control for time-invariant heterogeneity and assume that the effect of health on economic growth in Sub-Saharan Africa is homogenous across all the income groups in the region. There is a possibility that the way health affects growth depends on the income status of a country, and failure to consider this may bias the effect of health. Studies conducted on health and economic growth in the context of lower-income and middle-income Sub-Saharan countries are very limited.

This study will add to this limited evidence by comparing the effect of health on economic growth between lower-income and middle-income countries for a group of Sub-Saharan economies in a panel data framework. It has been shown theoretically and empirically that health is one of the factors that can enhance or inhibit the growth capabilities of a country. Therefore, the effect of health on economic growth across income groups in Sub-Saharan countries will be compared. This study will be a useful way of determining whether good health indicators can explain the economic progress in middle-income Sub-Saharan Africa countries and lower-income Sub-Saharan Africa countries from 2000-2016. From the existing literature, there are mixed results on health and economic growth. The previous studies used a different methodology to investigate the relationship between economic growth and health. The results of the relationship between health and economic growth are not an obvious prediction because researchers obtained different results. Some found a positive relationship, while others found the opposite. Finlay (2007), for instance, analysed the causal effect of health measured by the influence of crude death rates on economic growth, controlling for education only. The results indicated no association between crude death rates and growth.

3.2 INTERNATIONAL EMPIRICAL LITERATURE ON HEALTH AND ECONOMIC GROWTH

The empirical studies conducted internationally show the different results of different researchers. Most of the results of the researchers show a significant and positive effect of health on economic growth (Tai and Chur-Chao, 2015; Li and Huang, 2009; Yang and Chen, 2019; Spiteri and Brockdorf, 2019 and Hartwing, 2010). All the above researchers investigated the impact of health on economic growth, finding a significant positive relationship. Other researchers, who investigated the relationship between health and economic growth from an international perspective (Incatarau and Horodnic, 2015), examined the relationship between the health status of the population and economic development in Romania with data spanning from 1996-2012. The study employed Generalized Method of Moments (GMM) to investigate the relationship; the study found that if the population's health increase affects the economic growth by decreasing the production of labour, the labour supply will automatically decrease. Cervellati and Sunde (2011) examined the effect of life expectancy on economic growth for data spanning the period from 1940 to 2000 and found a positive relationship between life expectancy as proxy variable of health and economic growth. Solow (1965) established the growth model by stating that the factors that contribute to the economic growth of a country are labour and capital, when assuming that technology levels like knowledge, education and experience remained fixed.

Romer (1989) extended the growth theory of Solow (1989) by introducing the importance of human capital in the form of health and education. The augmented Solow theory (1956) stated that human capital in the form of education and health plays a vital role in the economic growth of any country. Owen, (1997), Bloom (2004), and Weil (2007) found that the output of a country improved by the availability of these factors within the human capital, labour, and with the help of technology. Most of the studies examined the effect of health on economic growth, employing human capital in the form of health in the economic growth of a country by using the augmented Solow model (Bloom, 2004 and Weil, 2007, Kurt, 2015 and Boachie, 2017). Several empirical results concluded that human capital contributes positively to the economic growth of a country. Human capital plays a vital role in economic growth in either developing or developed countries. The studies suggest that human capital in the form of health plays a vital role in the economic growth of a country, because they believe that the output in a country is increased by a healthy person because he/she is active and able to produce more output. The study intends to investigate the impact of health on production and level of economic growth at micro and macro level in Sub-Saharan Africa countries. Akhmat *et al*. (2014) investigated the Granger causality between population health and economic growth in East Asia, the Middle East, South Africa and the Sub-Saharan Africa countries with data spanning from 1975 to 2011. The study employs the Panel Error Correction Model. They found that causality exists between health and economic growth and that these are positively related. Cebeci and Ay (2018) examined the effect of health on economic growth in BRICKS countries. The study employed a panel data analysis to investigate this effect, with a data spanning from 2000 to 2014 and found a significant positive effect between health and economic growth. Health and economic growth are significantly positively related and this relationship supports the Endogenous Growth Theory (Aghion *et al.*, 2010). The study found this positive relationship after investigating the OECD countries. Dincer and Yiksel, (2019) examined the relationship between health and economic growth in emerging economies from 1996 to 2016. The study employed Pedroni Panel co-integration and the Dumitrescu Hurling Panel Causality method to examine the relationship and found a positive relationship between health and economic growth in the long run. However, the study found no immediate causality relationship between health and economic growth.

Hassan and Kalim (2012) argue that, if there is a long-run relationship and triangular causality between education, health and economic growth in Pakistan, by conducting time series analysis from 1972 to 2009, and the variables used in this study are per capita education expenditures and per capita health expenditures and real GDP per capita, the results indicate that there is no Granger causality between per capita health expenditures and real GDP per capita in the short run. On the other hand, there is two-way causality among real GDP per capita, per capita education expenditures and per capita health expenditures in the long run. Sülkü and Caner (2011) did a study on the long-run association between per capita GDP, population growth rate and per capita health spending. In the analysis, the Johansen multivariate co-integration test was applied for Turkey for the period between 1984 and 2006. The findings proved that there was multivariate co-integration between population growth, health expenditure and gross domestic product. Ozturk and Topcu (2014) investigated whether there is any interaction between health expenditure and economic growth in the G8 countries, on data spanning from 1995 to 2012. The study investigated the relationship by using panel data for the eight countries. They found that health expenditure and economic growth are related in the short run, because health expenditure affects economic growth, and they also found that economic growth affects health expenditure in the long run. Pradhan (2010) investigated whether health spending has an influence on economic growth. The study employed 11 Organisation for Economic Co-operation and Development (OECD) countries. The study employs a panel co-integration approach to investigate the relationship in the data from 1961 to 2007. The study found that, if health spending improves, it automatically leads to an increase in economic growth and the increase in economic growth automatically leads to an increase in health spending. Weil (2007) investigated the impact of health on individual per capita income. The study found that if health is not taken into consideration in different countries, that will lead to a low GDP per capita income ratio among individuals. Health is categorised as a vital determinant of economic growth that affects the level of production if it is poor, especially in developing countries (Tai *et al.*, 2015). Easterlin and Prakash (2013) examined the relationship between economic development and gender equality by using the panel data of 146 countries. The study found that the relationship between gender equality and economic development is positive. Bloom and Canning (2019) investigated the relationship between health and economic growth in developed countries. Economic growth is divided into a micro and a macro level. The study investigated the relationship in data spanning from 1970 to 2010 and employed the Panel GMM model. The study found a direct positive relationship between health and economic growth on a macro level. However, on a micro level health had a small effect on economic growth.

Johnson (2007) similarly examined the link between disease and economic development. Using a Two-Stage Least Squares (TSLS) approach and data observed from 1940 to 1980, the study found no evidence that a higher life expectancy accelerates economic growth. In fact, the results showed a negative relationship between life expectancy and income per capita. Clark (2011) stated that the relationship between income and infant mortality is negative in the sense that, if the income of individuals increases, the infant mortality will decrease, but that income and life expectancy are positively related and both lead to positive economic development in developed countries. Spiteri *et al.* (2019) investigated whether economic development has an impact on health outcome in countries in Europe. The data spanned 2003 to 2014. The results of the study were unique in the sense that they found that the relationship between economic development and health outcome is statistically significant in a U shape relationship. If income increases it will lead to an increase in mortality rate and a decline in the level of development. Spiteri *et al.* (2019) also prioritised the importance of the improvement of technology in healthcare and again the study stated that an improvement in the healthcare system played an important role in economic development. Gong *et al.* (2012) investigated the impact of health on economic growth throughout provinces of China and they found that health and economic growth are positively related and that economic growth is related to the health levels of individuals in the Chinese provinces. Taban (2006) examined whether causality existed between economic growth and health in Turkey from 1980 to 2000, and the study found that there was no causality between economic growth and health, concluding that the relationship between health and economic growth was negative. The study of Malik (2006) examined whether a relationship existed between health and economic growth in India from 1980 to 2003.The study measured economic growth by Gross National Income and health by life expectancy, infant mortality and fertility rate. The Two Stage Least Squares (2SLS) model was employed and the study found no relationship between health and economic growth. AK (2012) investigated whether there was any relationship between health expenditure, life expectancy and economic growth in Turkey, and found that there was none in the short run, but a relationship existed in the long run. The study of Arora (2001) found that if a country improved the health of individuals, it simultaneously increased the economic growth of a country in the long run.

Jamison *et al.* (2003) and Gyimah-Brempong *et al.* (2004) examined the effect of health on GDP per capita income and economic growth. The study found that if a country increases its investment in health, that leads to an increase in GDP per capita income and the level of output. Other authors found that an improvement in health in the developing countries encouraged economic growth in the short run and increased the income of the people in the long run. Bhargava (2001) examined the relationship between health and economic growth, employing the adult survival rate as the proxy variable representing population health. The study found that health and economic growth are positively related. Most of the studies found that health as human capital plays a vital role in the economic growth or level of output of a country (He, 2009; Aghion *et al.*, 2010 and Arthur, 2013), except for the findings of Acemoglu and Johnson (2007). Their study found the opposite results, because the study found that health reduces the GDP per capita income of people. If the numbers of the people increase, it leads to a decrease in GDP per capita income. Kurt (2015) examined the government health expenditure and economic growth in Turkey by using the Feder-Ram Model and monthly data from 2006 to 2013. Their study found a positive relationship between government health expenditure and economic growth. Li and Huang (2009) investigated the relationship between health and education and economic growth in China from 1978 to 2005. They found that health and education are positively related to economic growth in China. Ercelik (2018) investigated the relationship between health and economic growth in Turkey from 1980 to 2015, employing the Autoregressive Distributed Lag Model. The study found a positive relationship between health and economic growth, but in the long run. Churchill *et al.* (2015) conducted a study to investigate the relationship between government expenditure in education and health, and economic growth. The study used the Multilevel Linear Model (MLM) and the variables were GDP per capita, the share of government expenditure in GDP, and the investment in human and physical capital. They found that the relationship between government expenditure on education and economic growth was positive, but government expenditure on health and economic growth was negative.

Bloom (2004) investigated the impact of health as indicated by life expectancy and human capital in the form of education on Gross Domestic Product per capita income. The study employed 2SLS estimates to investigate the relationship. The study found a positive relationship between health and economic growth and discovered that if health improves, it does not increase the output from labour alone, but even causes an increase in capital accumulation. The study of Incaltarau *et al.* (2015) examined the relationship between health and economic development in Romania, by employing data spanning from 1996 to 2012, and found a positive relationship between health and economic development. The study of Granados (2012) investigated whether health and economic growth were co-integrated in England and Wales from 1840 to 2000, with health represented by life expectancy at birth and economic growth denoted by GDP per capita. The study found that health and economic growth were not co-integrated. According to the study of Ngangue and Kourty (2015), the relationship between life expectancy as a proxy variable for population health and economic growth is positive, but the income levels are not significant. Acemoglu and Johnson (2007) examined the relationship between health and economic growth for 75 European countries. The study found a negative relationship between health and economic growth. Mayer (2001) investigated the effect of health on the level of economic growth in Latin American Brazil and Mexico by using adult survival rate as the proxy variable that represented health. The study found that, if a country improves the health of its population that leads to an increase in economic growth. Barro and Lee (2010) examined the relationship between life expectancy and economic growth and found a negative relationship between life expectancy used as proxy variable for health and economic growth. Sharma (2018) examined this relationship for developed countries with data collected between 1870 and 2013. The study employed the Generalised Method of Moment (GMM) estimator and found a positive association between health indicators and economic growth. The study of Ogunleye (2014) examined the impact of health on economic growth in the Sub-Saharan Africa countries. The study employed the General Method of Moment (GMM) model to investigate the relationship between health and economic growth in Sub-Saharan Africa and found that health was not related to economic growth in the Sub-Saharan Africa countries. Bhargava *et al.* (2001) examined the impact of health indicators on economic growth in developed and developing countries by using data spanning from 1965 to 1990 and panel data. It found positive results, but the results were not strong on the relationship between the health indicators and the economic growth of developing and developed countries.

Ozturk and Topcu (2014) investigated whether causality existed between health and economic growth in the G8 countries, by using panel data and found that there is one way causality between health and economic growth in that health affected economic growth in the short run, but in the long run economic growth affected health. Bloom *et al.* (2004) also investigated the relationship between health and economic growth. They found that the relationship was positive and that, if life expectancy as a proxy for health increased by at least one year, it would lead to an increase in level of output by 4%. Musai (2011) examined the relationship of government expenditure to health and economic growth by employing Autoregressive Distributed Lag (ARDL) on data spanning from 1970 to 2007. The study found that economic growth and government expenditure were positively related and concluded that, if government spent more on health indicators, that would lead to an improvement in economic growth. Atilgan *et al.* (2017) investigated whether health expenditure and economic growth were related by using the Autoregressive Distributed Lag Model (ARDL), and found that economic growth and health expenditure were positively related. According to Stewart (2005), economic growth denoted by gross domestic product per capita and human capital denoted by life expectancy and education were strongly related. Temiz and Korkmaz (2007) examined whether there was any relationship between health and economic growth in Turkey. Life expectancy and infant mortality rates employed as proxy variables for health and GNP denoted economic growth. They found a negative relationship in one-way causality and a positive relationship in two-way causality.

Cetin and Ecevit (2010) examined the effect of health on the economic growth of OECD countries from 1990 to 2006. The study employed the panel OLS method to investigate the effect, and found no significant results on the effect of health on economic growth. Norohna *et al.* (2010) investigated the relationship between health and economic growth in Brazil from 1990 to 2000. Health was represented by the percentage of people dying from cancer and diabetes, and economic growth by Gross Domestic Product per capita. The study found a significant positive relationship between health and economic growth. Hena *et al.* (2019) investigated whether good health had a positive and significant impact on the economic growth of selected developed countries from 2000 to 2016, and found a positive direct relationship between health and economic growth. The study also found that, if people were healthier, it attracted the development and prosperity of the individuals in a country.

3.3 EMPIRICAL FINDINGS ON SUB-SAHARAN AFRICA COUNTRIES ABOUT HEALTH AND ECONOMIC GROWTH

The Canning and Sevilla (2004) study employed the Two Least Squared (2SLS) method to examine the relationship between health and economic growth and found positive results. They also found that an improvement in the life expectancy of the population in a year automatically increased the level of their output by 4% and the labour productivity of the employees improved if the life expectancy of the population increased. There are not many studies on Sub-Saharan Africa countries that compare the middle-income and lower-income groups. Ngangue and Kouty (2015) examined the effect of life expectancy on Gross Domestic Product per capita income for less developed countries. With data spanning from 2000 to 2013, the study did find positive results for the relationship between life expectancy and economic growth in developing countries, but the results were mixed. The study investigated lower-income and middle-income groups, but the results were not conclusive and made it difficult for policymakers to draw accurate conclusions on the relationship between health and economic growth, because the results were not significant.

Lorentzen (2008) examined the casual relationship between health and economic growth for a selection of 98 countries; Akram *et al.* (2008) examined the relationship between health and economic growth specifically in Pakistan. There are few studies that investigated the impact of human capital in the form of health on economic growth in SSA by doing a comparitive study on their income (Onisanwa, 2014 and Babatunde, 2014). However, investigating the impact of human capital in the form of health on economic growth will help the policymakers, because they will be able to conclude from the empirical results whether there is any impact of health on economic growth in countries that are not on the same level, like middle-income and lower-income countries (Ogundari, 2016). Adeyemi and Ogunsola, (2019) examined the relationship between human capital development in the form of health and economic growth in Nigeria from 1980 to 2013. The study employed the Autoregressive Distributed Lag (ARDL) model to investigate this relationship, and found it positive, but statistically insignificant. Ngangue and Kouty (2015) examined the relationship between these two for 141 developing countries. Hansen *et al.* (2013) examined the relationship between health and economic growth for a selected 47 developing countries. Eggoh, Houeninvo and Sossou (2015) investigated the connection between human capital and economic growth in 49 African countries for the period between 1996 and 2010. In this study, education and health-related variables were used as indicators of human capital. In addition, traditional cross-section and dynamic-panel techniques were used to be able to investigate the connection between the variables. The test results suggested that economic growth is affected in a negative way by education and health expenditures. Ogundari and Awukuse (2018) investigated the relationship between human capital denoted by health and education and economic growth for 35 countries in the Sub-Saharan Africa region for data spanning from 1980 to 2008. The study employed the System Generalized Method of Moments (SGMMS) model, and found results stating that both human capital measures have a positive relationship with economic growth in Sub-Saharan Africa countries. Desbordes (2011) examined the relationship between health and economic growth in 47 selected countries and Cervellati and Sunde (2011) also examined the same relationship for countries that are in Sub-Saharan Africa.

The study of Barro and Lee (2010) investigated the relationship between health and economic growth in lower-income and high-income Sub-Saharan Africa countries from 1985 and 1995. The health proxy variable was life expectancy. The study employed the Gross Countries Ordinal Least Squared Method (GOLS) to investigate the relationship. They found results that supported the studies of Kar and Taban (2003), Yumusak and Yildirim (2009); and Hansen and Lønstrup (2015) because all of them found a negative relationship between health and economic growth. Babatunde (2012) investigated the relationship between health and economic growth in Nigeria from 1980 to 2008. This study employed an 3SLS estimator to investigate the relationship between the two variables, and found that there is a positive relationship between health and life expectancy and that income per capita increased by a 1%, leading to an increase in life expectancy of 0.043%. Thus, it is commonly reported in the literature that improvements in health can have a positive effect on health in Sub-Saharan Africa and that poor health can be a constraint on the region's growth prospects. Other researchers found a positive relationship between health and economic growth (Dolado *et al.*, 1996); Cetin and Ecevit, 2010); Halici-Tuluce *et al.*, 2016) and Bedir, 2016). Frimpong and Adu (2012) examined the impact of population health on economic growth in Sub-Saharan Africa from 1970 to

2010. This study differed from other studies because it employed the Autoregressive Distributed Lag Model. They found that population health and economic growth in Sub-Saharan Africa are negatively related. Eggo, Houeninvo and Sossou (2015) examined the relationship between human capital and economic growth in 49 selected African countries. The human capital denoted by health and education for data spanning from 1996 to 2010 indicated that, if corruption levels increase, underinvestment and inefficient expenditure cause education and health to have a negative impact on the economic growth of African countries. Halici-Tulice and Dogan (2016) investigated whether health has any influence on economic growth in lower-income and high-income countries. The study employed panel data to investigate data spanning from 1995 to 2012, finding a significant positive influence of health on economic growth. Aboubacar and Xu (2017) investigated the relationship between health and economic growth in selected African countries. The study employed the Panel GMM model to investigate the relationship, and found a significant positive relationship between health and economic growth with health indicators that were the best determinants of economic growth.

Novignon and Lawanson (2017) investigated the relationship between health and economic growth in 45 Sub-Saharan African economies. The study employed Random and Fixed-effect models to investigate the relationship between the two with data spanning from 1995 to 2011. Health was represented by child health outcomes and economic growth by Gross Domestic Product per capita. The study found a significant positive relationship between child health outcomes and economic growth in Sub-Saharan Africa economies. Ogundari and Awokuse (2018) investigated the impact of human capital on economic growth in 35 selected Sub-Saharan Africa countries. The study employed data from 1980 to 2008 to investigate the relationship between human capital in the form of health and economic growth, by employing the Generalized Method of Moment (GMM), and found that human capital in the form of health was positively related to economic growth in Sub-Saharan Africa countries and that if population health increased by 10%, it lead to an increase in economic growth of 4.9%. Temitope and Bola (2013) investigated the relationship between health and economic growth in Nigeria from 1977 to 2010. The study employed the Co-integration method to investigate this relationship and found it to be positive. Eggo and Sossou (2015) investigated whether there was a connection between human capital and economic growth in 49 African countries from 1996 to 2010. The human capital in the study was represented by health and education, and the study found that the economic growth in African countries was affected by human capital in the form of both education and health in a way that had a negative impact on the relationship between health and education and economic growth. Oni (2014) investigated the relationship between health and economic growth in Nigeria from 1970 to 2010. The study employed the Multiple OLS model to investigate this relationship, and found a significant positive relationship between health and economic growth in Nigeria. Ogundari and Abdulai (2004) investigated the impact of education and health care on economic growth in Nigeria. The study that speeds up an improvement in education and health to the people, will improve the level of economic growth of a country, and people will also adapt easily to new technology if they are healthier and educated. The studies of Ogundari and Awukose (2018), and Aboubacar and Xu (2017) both investigated the contribution of health to economic growth in Sub-Saharan Africa. Both Studies employed the System Generalized Method of Moment model in the study and worked on data from 1980 to 2008. The studies found that health is an engine that accelerates economic growth in Sub-Saharan Africa. Most studies found positive results for the relationship between health and economic growth, but some studies had a different outcome.

Zaidi and Saidi (2018) employed the Panel Autoregressive Distributed Lag (PARDL) model to analyse the relationship between health and economic growth in Sub-Saharan Africa from 1990 to 2015, finding a strong positive relationship. Odubunmi *et al.* (2012) examined the relationship between health and economic growth in Nigeria from 1970 to 2009. The study employed the co-integration method to examine the relationship between the two. The study found a strong positive relationship between health and economic growth in Nigeria.

3.4 CONCLUSION OF THE CHAPTER

This chapter analysed the empirical results of previous researchers or authors on the relationship between health and economic growth and discussed the importance and recent empirical findings that would assist in improving different researchers' understanding of the impact of health on economic growth in the Sub-Saharan Africa region. The empirical results of researchers that are presented in this chapter are mixed because some researchers found strongly significant positive results on the relationship between health and economic growth, while others found the opposite. This chapter is divided into two parts. The first part discusses the relationship between health and economic growth in the international empirical-literature context in the developed countries of the world. The second part discusses the relationship between health and economic growth found in the empirical literature on the Sub-Saharan Africa region. The study examined the international and Sub-Saharan empirical results equally intensively with an aim to acquire strong or robust knowledge on the selection of the variables that are taken into consideration to examine the impact of health on economic growth.

CHAPTER FOUR

RESEARCH METHODOLOGY AND DATA

4.1 INTRODUCTION

The primary purpose of this chapter is to explain and discuss the technique and model specification used in this study. In terms of organization, the chapter is divided into six sections namely section 4.1 which is essentially the introductory part, section 4.2 which explains the Panel Vector Autoregressive model specification, section 4.3 which covers the estimating procedure, section 4.4 which outlines Granger causality tests, section 4.5 which covers diagnostic tests and section 4.6 which focuses on panel impulse responses and variance decomposition functions.

4.2 DATA DESCRIPTION

There are 47 countries in Sub-Saharan Africa, but only 8 countries are depicted as lower-income, and 7 as middle-income countries by the World Bank. In this study, the objective is to compare the effect of health on economic growth between low-income and middle-income Sub-Saharan Africa countries. To achieve this, 8 low-income and 7 middle-income Sub-Saharan economies were selected. The selection of these countries was based purely on the availability of data on the key variables relevant to this study, particularly those related to health. In terms of the sampling period, the study covers the period 2000–2016, again dictated by data availability. These considerations yield two panel datasets of the following dimensions N=7, T=17 for low-income countries and N=8, T=17 for middle-income countries. Data on all variables were sourced from the World Development Indicators (WDI), which is a reliable data source at international level. The description of variables is provided in later sections, after the model specification.

4.2.1 DATA ISSUES AND SOURCES

The study employed secondary data, retrieved from one data source, the World Bank Data (WB), under the World Development Indicators (WDI). The variables that are employed by the study are explained as follows; GDP per capita (constant 2010), trade (% of GDP), gross fixed capital formation (% of GDP), labour force participation rate (% of total population, ages 15-64) and health. The study employs principal component analysis to create a health index by combining the following variables, life expectancy at birth, crude birth rate (per 1000 people) and the total prevalence of HIV (% of population, ages 15-49).

Table 4.1 LIST OF VARIABLES

Variables	Proxy of the variable	Data source	Unit measurement
Economic growth (GDPPER)	GDP per capita income	WDI	Percentage
Export of goods and services (TO)	Trade as percentage of GDP	WDI	Percentage
Physical labour (LA)	Labour force participation rate	WDI	Percentage
Physical capital (GFCF)	Gross fixed capital formation (% of GDP)	WDI	Percentage
Life expectancy (LE)	Life expectancy at birth	WDI	Percentage
Number of people who were born every year (BR)	Crude birth rate, (per 1000 people)	WDI	Percentage

Number of people who received ARVS for HIV /AIDS (PHIV)	Prevalence of HIV, total (population)	WDI	Percentage

Source: Generated by researcher (WDI database).

4.2.2 JUSTIFICATION OF THE SELECTED VARIABLES

The following variables are employed by the study to investigate and analyse the impact of health on economic growth by doing a comparison for middle-income and lower-income Sub-Saharan Africa countries, i.e. GDP, health, trade openness, labour and gross fixed capital formation. A researcher is driven to select all these macroeconomic variables, because they are strongly supported by the empirical studies in chapter three and by the theory of neo-classical growth in chapter two of the study. The ε_{it} is a stochastic error term that represents the errors that are taken into account in a model.

Table 4.2: SUMMARY OF THE METHODOLOGY ESTIMATION OF THE STUDY

N	Tests	Instruments	Comments
1	Descriptive statistics	Mean, medium, maximum, minimum, skewness and kurtosis.	To measure the central tendency and dispersion of the variables.
2	Unit root	Augmented Dickey Fuller (ADF). Levin Lin and Chu, Im Pesaran and Fisher Type tests.	To test the order of integration of variables to avoid running a spurious regression.
3	Lag-length selection criteria	Akaike Information Criteria (AIC), Hannan-Quinn Criteria (HQC) and	To determine the specific number of lags in an equation.

		Schwartz Information Criteria (SIC).	
4	Impulse Response Function (IRF)	Pvairf	To check the reaction of the macroeconomic variables in a model, if there is one per cent increase in standard deviation or a shock in the error term.
5	Granger causality test	Wald test	To determine the direction of causality between the X and Y variables in a model. This test checks whether variable X causes variable Y in a model.
6	Diagnostic tests	Heteroskedasticity test, Serial Breuch-Godfrey test and Normality test.	To test whether the residuals confirm with classical regression assumptions.
7	Stability	AR root graph	To check whether a model is stable or not.

Source: Generated by researcher.

4.2.3 DATA TRANSFORMATION

This section on data transformation explains how the variables are transformed. One variable is transformed into a logarithm, and this is GDP per capita, a proxy variable for economic growth. Growth is then measured as the percentage of changes in this variable. The remaining variables, health, trade openness, gross fixed capital formation and labour are not transformed into logarithms since they are in percentages. Consequently, the coefficients can be viewed as elasticity.

4.2.4 COMPUTING OF HEALTH VARIABLE

As previously explained in chapter one of the study, the study employed different health indicators to compute the health index. Due to the lack of a single measure of health, the study employs Principal Component Analysis (PCA) to create a health index. The study introduces PCA in order to reduce the health indicators, i.e. crude birth rate, life expectancy and prevalence of HIV/AIDS, into one index. This method helps with the dimensionality reduction of many indicators and it improves the algorithmic performance by removing correlated features in the data. The health indicators are many, but due to data unavailability, the study was limited to only four health variables as given expression in equation (12).

$$HEALTH = Prevalence\ of\ HIV, total(\%\ of\ GDP) + Birth\ rate\ (per\ 1000\ people) + life\ expectancy\ at\ birth, total\ (years) \quad (12)$$

4.3 MODEL SPECIFICATIONS

The Panel Vector Regressive model consists of the following variables that are all treated as endogenous variables in the model, namely the GDP per capita (GDPPER), health index (HEALTH), trade openness (TO), gross fixed capital formation (GFCF) and labour (LA). The health indicators, i.e. life expectancy, birth rate and prevalence of people who have HIV/AIDS will be combined by the study so that they will form one health index. The equation of the reduced PVAR for the above endogenous variable is represented by the following linear equation:

$$Y_{it} = \beta_0 + Y_{it-1}A_1 + Y_{t-2}A_2 + \cdots + Y_{it-p+1}A_{1p-1} + Y_{it-p}A_p + \tau_i + \epsilon_{it} \quad (13)$$

where Y_{it} represents a (5×1) vector of system variables (GDP per capita, health index, gross fixed capital formation, trade openness and labour), β_0 is a (5×1) vector constant, Y is a (5×5) matrix of coefficient estimates, and ε is a vector of the white noise error term, I is a cross identifier and s represents the maximum lag length of each variable. The main aim of this section was to outline and explain the methodology in chapter five and how it will be utilized. No previous study has used the Panel Vector Autoregressive (PVAR) model to investigate the relationship between the health and economic growth for lower-income and middle-income Sub-Saharan Africa countries. This section of the study will start by testing the data for the panel unit root, whether it is stationary or not.

4.3.1 MODEL ESTIMATION

Equation (13) can be estimated with the standard one-way fixed effects estimator. However, having a dynamic regressor in the system creates a common panel estimation problem known as the Nickell bias (Nickell, 1981). The Nickel bias is essentially a type of endogeneity that particularly arises when the unobserved heterogeneity, τ_i in this case, is eliminated using the fixed effects estimator in dynamic models (Judson and Owen, 1999). Although this parameter bias approaches zero as $t \rightarrow \infty$, Judson and Owen (1999) show that one may understate or overstate the true coefficient by 30 per cent even when T=30. In this study, the panel time dimension is 17 (i.e., t=2000-2016) which makes it critical to address the Nickell bias (1981). Following Arellano and Bover (1995), this study estimated equation (1) using the Generalized Method of Moments (GMM) which uses Forward Orthogonal Deviation (FOD) to eliminate unobserved heterogeneity.

4.4 VARIABLE DESCRIPTION

This section explains and justifies the inclusion of explanatory variables in the specifications of interest.

4.4.1 GROSS FIXED CAPITAL FORMATION (GFCF)

According to Anwer and Sampath, (1999), investment in infrastructure is an engine of economic growth especially for less developed countries. This is also supported by the neoclassical growth theory of Solow (1965). The study uses gross capital formation as proxy variable for investment. According to Solow (1965), the increase in investment is expected to increase production and facilitate an increase in economic growth.

4.4.2 HEALTH

Health can be viewed as a dimension of human capital and therefore matters as a determinant of economic growth especially in developing countries. Measured as an index, a positive relationship between health and economic growth is expected.

4.4.3 TRADE OPENNESS

Trade openness measures the degree of international trade between countries. This variable is empirically measured as the sum of imports and exports of goods and services. The study uses trade openness (% GDP) as a proxy variable for trade openness. Many scholars have found a strong significant positive relationship between economic growth and trade openness. Hence a positive relationship is expected.

4.4.4 ECONOMIC GROWTH

The study employed changes in the logarithm of GDP per capita as a proxy variable for economic growth. Economic growth is the dependent variable in the reduced form specification, while other variables are explanatory variables.

4.4.5 PHYSICAL LABOUR

The study used labour participation rate as a proxy variable for physical labour. Labour can be explained as the physical work done by workers. The Endogenous Growth Theory and Cobb Douglass production function state that labour and capital play an important role in promoting sustained economic growth.

4.5 ESTIMATING PROCEDURE

This section of the study explains the estimating procedure the study will employ in chapter five of the study. The procedure of running the two equations that will include the following variables (GDPPER, HEALTH, LA, GFCF and TO) will be performed in chapter five. The first VAR model represents the low-income Sub-Saharan Africa countries and the second Vector Autoregressive (VAR) model represents the middle-income Sub-Saharan Africa countries.

4.5.1 PANEL UNIT ROOT TEST

Since a panel dataset contains a time dimension, it is important to understand the underlying data generating process for each variable by means of non-stationarity tests. In the main, a series is considered stationary when its mean and variance are not a function of time (Gujarati, 2004). The variance of such a series will be finite and its theoretical correlogram will diminish with lag length. There are several tests available for testing non-stationarity in panel data. Since these tests are more complementary than they are competing, a total of three panel non-stationarity tests were employed, namely the Levin and Lin test (1992), the Im Pesaran and Shin test (1997) and the Fisher type test (1999). The Augmented Dickey Fuller test was formulated by Dickey and Fuller (1981) and was extended from the Dickey Fuller test to the Augmented Dickey Fuller test, which can be expressed in an equation as follows:

$$\Delta X_t = \alpha_0 + \beta_t + \sigma X_{t-1} + \sum \rho \Delta X_{t-1} + \varepsilon_t \tag{14}$$

The above equation is the ADF equation and it states that the variable of X is only stationary if σ becomes negative, or if σ is not zero but different from zero. The error term is denoted by ε_t.

4.5.1.1 LEVIN AND LIN TEST

The Levin and Lin test (1993) is an extension of the Augmented Dickey Fuller test and is used to test the stationarity of the variable in the equation. Levin and Lin (1993) and Chu (2002) both take the null hypothesis into consideration and conclude that each individual's time series in a panel contains the unit root, compared to that in the alternative hypothesis. The Alternative hypothesis concludes that each individual's time series is stationary. The Levin and Lin that allows heterogeneity among the variables is explained as follows by the Augmented Dickey Fuller regression.

$$\Delta y_{it} = \propto_i + \text{C} y_{i,t-1} + \sum_{k=1}^{o_i} \delta_k \, \Delta \, y_{t,t-k} + \beta_t + \mu_i \quad (15)$$

4.5.1.2 IM PESARAN AND SHIN TEST

The Im Pesaran and Shin test (1999) is another method of testing the unit root, and is also known as the IPS test. This test was propounded after the Levin and Lin test (1992) and also takes heterogeneity into consideration. The IPS can be explained as follows

$$\Delta y_{it} = \propto_i + \text{C} y_{i,t-1} + \sum_{k=1}^{o_i} \delta_k \, \Delta \, y_{t,t-k} + \beta_t + \mu_{it} \quad (16)$$

This test is the same as the Levin and Lin test because both of them are taking the heterogeneity problem into consideration, but the IPS takes heterogeneity based on a coefficient like $\text{C} y_{i,t-1}$ in the above equation is taken into consideration as well. The IPS test is different to the LL test, because it assumes that the coefficients among the variables are the same, i.e. $\text{C}_1 = \text{C}_2 = \text{C}_3 = \text{C}_N$ and all the coefficients are under alternative hypothesis tests. The t-bar statistic can be explained as follows.

$$\bar{t} = \frac{1}{N} \sum_{k=1}^{p} \propto_1 , \propto_1 = \frac{\hat{\text{C}}_i}{\hat{\sigma}_{\hat{\text{C}}_i}} \quad (17)$$

The equation above is used to measure the individual variables of the Dickey Fuller test on the t-bar statistics, but for a cross-section the IPS employs the standardized t-bar static (Karlsson and Lothgren, 2000).

4.5.1.3 FISHER TYPE TEST

The Fisher type test was proposed by Maddala and Wu (1999) and extended by Choi in (2001). This test differs from the other tests in the sense that the Fisher type test does not hold any assumptions, and it has a chi-square and two degrees of freedom. The main aim of this test of Maddala and Wu (1999) was to test the unit root among the variables, and this test merges the p values from a unit root test with the variables in a model of panel data. The Fisher Type test is identical to the IPS test in the sense that they both merge the information of the individual unit root tests, both tests also taking the availability of heterogeneity into consideration and being specific to Alternative hypotheses, unlike LL where the test specifically considers the Null hypothesis. The Fisher Type test can be explained as follows in a regression:

$$\alpha = -2 \sum_{i=1}^{p} \log \tau_i \tag{18}$$

where τ_i represents the unit root probability of a Dickey Fuller test and tests each individual variable in a cross sectional i by sticking to an alternative, unlike the LL test that concentrates on a null hypothesis.

4.6 PANEL GRANGER CAUSALITY TEST

The Granger causality test is based on the intuition that one variable causes the other if its lags contain information that can predict future values of the other variable. The Granger (1969) test was formulated with the aim of determining the directions of the variables in the panel of data. The Granger causality test will test the direction between health, trade openness, gross fixed capital formation; labour and GDP per capita in the lower and middle-income Sub-Saharan Africa region from 2000 to 2016. The Granger causality test explains the direction between variable X and variable Y in a model. The Granger causality test states that, variable X causes variable Y or both variables cause each other in panel data. The Granger causality test has a null and an alternative hypothesis. The null hypothesis states that no causality exists between variable X and variable Y , while the alternative hypothesis states that causality does exist between variable X and variable Y in the panel data. The Granger causality test can be explained by the following equations:

$$\Delta Y_t = \sum_{k=1}^{p} \sigma_k \, \Delta Y_{t-1} + \sum_{i=1}^{p} \rho_i \, \Delta X_{t-1} + \mu_{1t} \tag{19}$$

$$\Delta X_t = \sum_{k=1}^{p} \beta_k \Delta X_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-1} + \mu_{2t} \tag{20}$$

The above two equations explain the causality or directions between the two variables X and Y.

4.7 PANEL VECTOR AUTOREGRESSIVE (PVAR) MODEL

To establish the relationship between health and economic growth, this study applied a Panel Vector Autoregressive model in which all variables are treated as endogenous. Use of the Panel Vector Autoregressive (PVAR) model is necessitated by the need to address the endogeneity of health due to the potential feedback effect. Health may affect economic growth through productivity, but there is also a natural tendency that a country's health care system improves as the economy grows. Failure to address this endogeneity may lead to a parameter bias that does not disappear asymptotically. Following the work of Lutkepohl (2005) and Abrigo and Love (2016), the Panel Vector Autoregressive model applied in this study takes the following form.

$$Y_{it} = \beta_0 + Y_{it-1}A_1 + Y_{t-2}A_2 + \cdots + Y_{it-p+1}A_{1p-1} + Y_{it-p}A_p + \tau_i + \epsilon_{it} \qquad (21)$$

where,

$Y_{it} \ = \ 1 \times k$ vector of endogenous variables

$\beta_0 =$ constant error term

$A \ \ = k \times k$ matrices of unknown parameters to be estimated

$\tau_i \ \ = 1 \times k$ vector of country-specific fixed effects

ϵ_i = idiosyncratic disturbance term.

The vector Y_{it} comprises economic growth, the health index, trade openness, labour, and gross capital formation. Parameter τ_i serves to control for unobserved heterogeneity. These are essentially time-invariant factors such as religion, geographical location, and culture, that are specific to each country. Failure to control for such factors may give rise to heterogeneity of endogeneity if they are correlated with the right-side variables (Lin, and Wooldridge, 2019). Parameter, ϵ_{it} is homoscedastic, normally distributed, and free from serial correlation. It is also assumed to have the following characteristics:

$$E(\epsilon_{it} = 0), E(\epsilon'_{it}\epsilon_{it}) = \textstyle\sum, \text{ and } E(\epsilon'_{it}\epsilon_{is}) = 0 \text{ for all } t > s \qquad (22)$$

As assumed in Holtz-Eakin, Newey and Rosen (1988), the countries share a common underlying data generating process which makes the reduced-form parameters $A_1, A_2, \ldots, A_{p-1}, A_p$ common among them. The next section outlines the estimation technique.

4.7.1 LAG LENGTH SELECTION CRITERIA

When estimating a panel vector autoregression model, it is important to select the optimal lag which ensures that the system is dynamically stable and free from serial correlation (Asteriou and Hall, 2007). To achieve this in this study, the Akaike Information Criterion (AIC), the Schwarz Bayesian Information Criterion (BIC) and the Hannan-Quinn Criteria (HQN) will be used, and the optimal lag will be that which minimizes these criteria. Each of these three criteria is explained shortly.

4.7.1.1 AKAIKE INFORMATION CRITERION (AIC) AND BAYESIAN INFORMATION CRITERION (BIC)

Equation (23) expresses the AIC.

$$AIC = In \mid \sum \mid + \frac{2pk^2}{T-p} \quad \& \quad \text{SIC} = In \mid \sum \mid + \frac{pk^2 In(T-p)}{T-p} \tag{23}$$

where $\sum$ denotes the residuals variance of the covariance matrix, p denotes the lag length, pk^2 denotes the number of parameters and the letter T denotes the sample size of the variables.

4.7.1.2 HANNAN-QUINN CRITERION (HQC)

The Hannan-Quinn Criterion (HQC) can be expressed by the formula below:

$$HQC_\alpha = log_\alpha + \left(\frac{2log\ log\ m}{m}\right) \tag{24}$$

where log_α explains the log likehood, $2log$ denotes the number of parameters and m denotes the number of observations.

4.7.2 IMPULSE RESPONSE FUNCTION (IRF)

The Impulse Response Functions help in analysing how the variable of interest, namely economic growth, reacts to shocks in each of the variables in the system. In particular, they enable the study to establish how economic growth responds to a one unit shock in health. Generalized Impulse Response Functions were used and, therefore, the issue of ordering variables was not important. The Impulse Response Function helps the study to analyse how the economic growth proxies for Gross Domestic Product and health react if there is a one-unit change to a standard deviation of residuals. The Impulse Response Function explains the reaction of the variables in a model if there is a shock or innovation. The shock is where the standard deviation is added in error term. The Impulse Response Function was established in order to assess the effect on economic and monetary variables in a model if there are shocks or innovations of the variable response, and for how long (Munyengwa, 2012).

The Impulse Response Function (IRF) explains the effect of one standard deviation shock on the endogenous variable from another variable in the system. Most of the studies employ VAR to estimate the relationship between health and economic growth. This study differs in the sense that it uses a Panel Vector Autoregressive model to capture the impulse response functions for analysing the shocks, and also to test the response of the variables if the standard deviation adds in error term. The impulse response function is there to analyse the shock between the variables after there has been a change in the standard deviation (Bernanke and Blind, 1988). This study is different from previous studies by two mechanisms: Firstly the study uses the Panel Vector Autoregressive model to examine the relationship between health and economic growth. Secondly, the impulse response functions of many countries that are from Sub-Saharan Africa will be analysed in one study, unlike the previous studies. According to Lutkepohl (2005) and Hamilton (1994), the model Panel Vector Autoregressive model is stable if the companion matrix is below 1 and the modulus is inside the cycle.

4.7.3 VARIANCE DECOMPOSITION FUNCTIONS OR FORECAST ERROR DECOMPOSITION

The variance decomposition function is used subsequent to the impulse response functions and basically assists in the interpretation of the unrestricted Vector Autoregressive (VAR) model once it has been fitted. Technically, the variance decomposition function indicates the amount of information each variable contributes to the other variable in the auto regression, explaining how much of the forecast error variance of each variable can be attributed to the exogenous shock to the other variables. It specifically determines the proportion of variation of the dependant variable explained by each of the independent variables. In the present case, the study seeks to examine the importance of health shocks on economic growth.The variance decomposition comes after the reaction of the variables, if there is a shock or innovation in impulse response function because of a standard deviation being added in the error term. The forecast error decomposition assists in the interpretation of the unrestricted Vector Autoregressive (VAR) model once it has been fitted.

The variance decomposition in the VAR model indicates the amount of information each variable contributes to the other variable in the auto regression, explaining how much of the forecast error variance of each variable can be attributed to the exogenous shock to the other variables. It determines the proportion of variation of the dependant variables explained by each of the independent variables. The variance decomposition explains how much of the future uncertainty of one time series is due to future shocks to other time series in the system.

4.8 DIAGNOSTICS TESTS

The study will consider several diagnostic tests to ensure that the results from the Panel Vector Autoregressive (PVAR) model are reliable and that no critical assumptions are violated. The specific diagnostics tests that will be employed in this study are the Jarque-Bera test for residuals normality, the serial correlation test, the stability and heteroskedasticity tests.

4.8.1 VAR STABILITY CONDITION

The eigenvalue stability test was used to test the stability of the panel vector autoregressive model. The stability test plays a vital role because an unstable model will affect the impulse response function and the variance of decomposition will be biased (Munyengwa, 2012). The model will be considered stable if the root lies inside the unit circle.

4.8.2 HETEROSKEDASTICITY TEST

Heteroskedasticity occurs when the residual variance is not uniform across observations. It can be differentiated into two categories namely pure and impure heteroskedasticity. Pure heteroskedasticity takes place if the variance of the residuals and the mean are constant and not changing over time, and the impure heteroskedasticity takes place if the variance of the residuals are changing over time

(Studenmund, 2001). There are three tests that one can use to check whether the errors are heteroskedasticity or not. These are the Breusch-Pegan test, the White test, and the Park test (Studenmund, 2001). The study will employ the Breusch-Pegan test in this study to test for heteroskedasticity.

4.8.3 RESIDUALS NORMALITY TEST

The test for residual normality is used to test whether the residuals are normally distributed or not. To test for this, the study will employ the Jarque-Bera test. Residuals are considered to be normally distributed if the probability value is above 10 per cent significance level.

4.9 CONCLUSION OF THE CHAPTER

The main aim of this chapter was to discuss the econometric tools or techniques that will be employed by the study in chapter five, in order to obtain the robust results of the effects of health on economic growth in SSA. This chapter introduced the importance of a stationarity test in time series before other econometrics tests are conducted., The study also introduces the econometric methodology that will be employed by the study to estimate the relationship between the macroeconomic variables, e.g. two PVAR models, since the main aim of the study is to do a comparison between middle-income and lower-income countries from Sub-Saharan Africa (SSA). This chapter also discusses the variables that will be employed by the study, as well as the source from where the data will be retrieved. The study employs annual data spanning from 2000 to 2016. It also employs five variables to estimate the shocks of each variable. The study employs Stata 14 and the Eviews 9 software to investigate the relationship between health and economic growth in Sub-Saharan Africa countries. This chapter discusses the diagnostics test that is aligned with the Panel Vector Autoregressive (PVAR) model as an extended model of the Vector Autoregressive (VAR) model, that will be employed by the study. The next chapter, namely chapter five, will discuss and interpret the empirical results after the Panel Vector Autoregressive (PVAR) model has been estimated.

CHAPTER FIVE

EMPIRICAL RESULTS AND INTERPRETATION OF PANEL VECTOR AUTOREGRESSIVE (PVAR) MODEL

5.1 INTRODUCTION

The aim of this chapter is to present and discuss the empirical results of the study on health and economic growth for a selected set of lower-income and middle-income Sub-Saharan economies. As indicated in the previous chapter, the Panel Vector Autoregressive (PVAR) model is estimated separately for lower-income and middle-income Sub-Saharan economies, respectively. The chapter is divided into six sections. Section 5.1 serves as the introductory part of the chapter. Section 5.2 proceeds to present results from the principal component index in which the health variable is computed for both low-income and middle-income Sub-Saharan economies. Summary statistics both in tabular and graphical form are then presented in section 5.3. In section 5.4 the correlation matrix of the variables is presented with the aim of assessing the degree of collinearity among the regressors. Section 5.5 presents results from panel non-stationarity tests with the objective of understanding the underlying data-generating process. Subsequent to non-stationary tests, section 5.6 then proceeds to present regression results, impulse response functions, variance decomposition, Granger causality and all the corresponding diagnostic tests.

5.2 DESCRIPTIVE STATISTICS

The summary statistics play a vital role in quantitative analyses because they provide a preliminary sense of data dispersion. This allows the researcher to assess the need for any necessary data transformation in cases where the dataset still exhibits outliers. As Table 5.1(a) shows, a typical lower-income Sub-Saharan countries in the sample experienced an average annual per capita growth of 0.20 per cent. This is slightly lower than the 0.29 per cent average annual growth experienced in middle income Sub-Saharan countries (see Table 5.1 (b)). Gross fixed capital formation accounted for about 21 per cent and 22 per cent of GDP in low-income and middle-income Sub-Saharan countries, respectively. These numbers are low by international standards. The trade variable shows an average value of 49, indicating that trade in lower-income Sub-Saharan economies accounted for 49 per cent of the

GDP. For middle-income Sub-Saharan countries, the number is considerably higher, namely 90 per cent of GDP. This indicates that middle-income Sub-Saharan economies participate more in global trade than their low-income counterparts.

Table 5.1 (a) : SUMMARY STATISTICS – LOWER-INCOME SSA

Variable	Obs	Mean	Std. Dev.	Min	Max
GROWTH	136	0.202163	0.656826	-2.66725	3.970971
GFCF	136	21.13669	8.422555	2.78	59.72
LA	136	72.1986	14.24987	42.27	90.34
TO	136	49.04015	16.84346	20.96	126.35
HEALTH	136	1.18288	0.839067	0.0095	3.1062

Note: Growth = economic growth (%), LA = labour, GFCF= Gross fixed capital formation, TO = Trade openness, HEALTH = Principal component health index

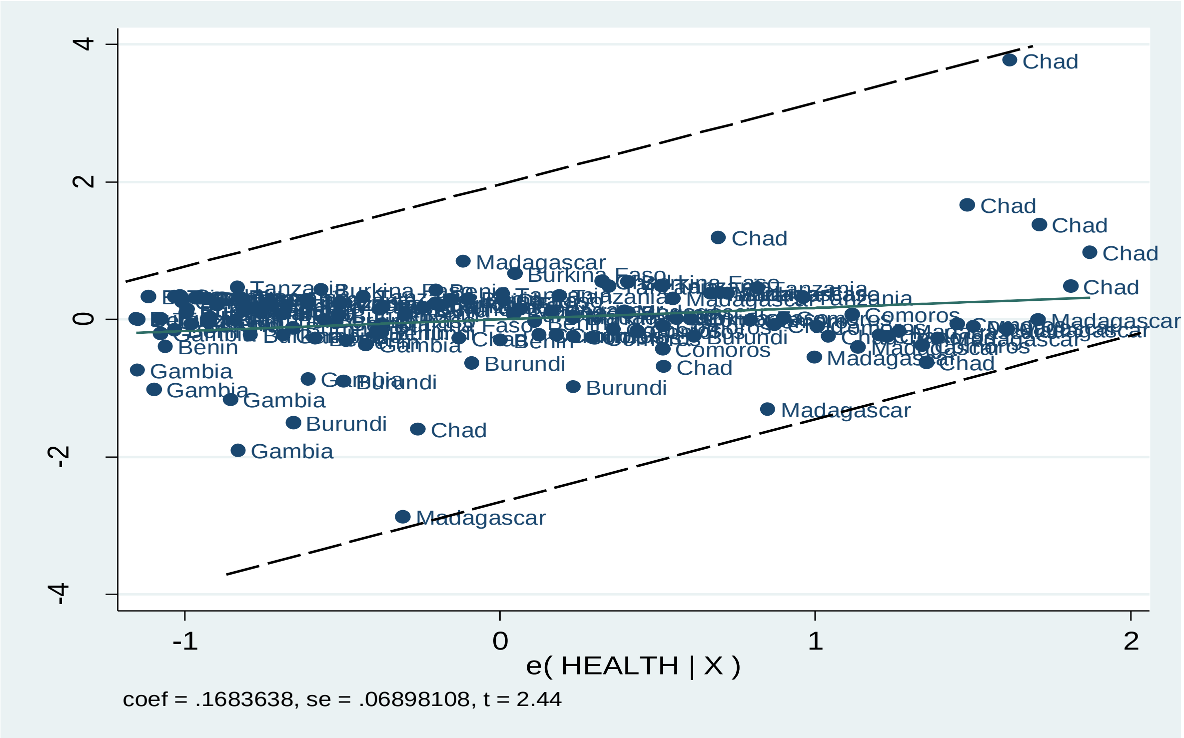
Table 5.1 (b): SUMMARY STATISTICS – MIDDLE-INCOME SSA

Variable	Obs.	Mean	Std. Dev.	Min	Max
GROWTH	119	0.298711	0.354222	-1.12658	1.616064
GFCF	119	22.48622	6.10965	11.82	41.01
LA	119	60.65235	6.285231	51.13	73.96
TO	119	93.07	33.95041	20.72	175.8
HEALTH	119	1.006939	0.885666	0.0051	3.1704

Note: Growth = economic growth (%), LA = labour, GFCF = Gross fixed capital formation, TO = Trade openness, HEALTH = Principal component health index

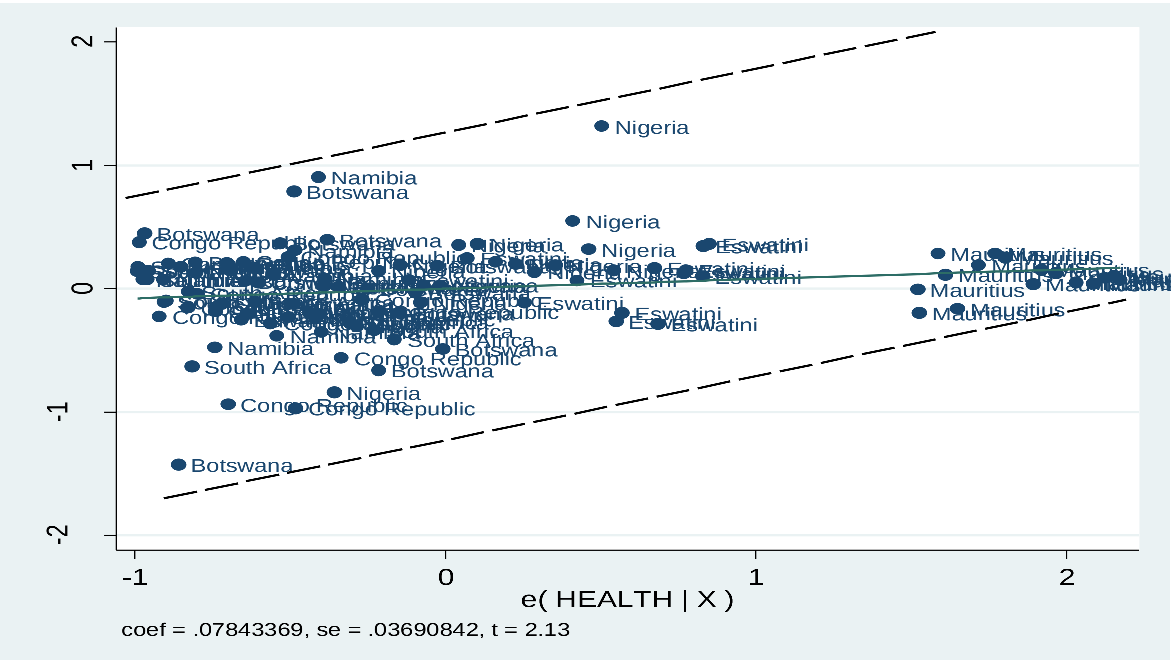
As a first preliminary exercise, the study presents a scatter plot of health and economic growth condition on unobserved country-specific heterogeneity. There are two insights emerging from Figure 5.1 (a) and Figure 5.2 (b). The first is that there is a clear positive association between the health index and economic growth in both lower-income and middle-income Sub-Saharan countries. Economic growth is higher in countries with better health and vice versa. The corresponding test statistics are considerably higher, suggesting that the association between health and growth displayed in Figure 5.1 (a) and Figure 5.1 (b) is statistically significant. Secondly, the data set does not seem to exhibit a significant presence of atypical observations which would pose an estimation in the regression section.

Figure 5.1 (a) : HEALTH AND ECONOMIC GROWTH IN LOWER-INCOME SSA



Source: Generated by researcher.

Figure 5.1 (b): HEALTH AND ECONOMIC GROWTH IN MIDDLE-INCOME SSA

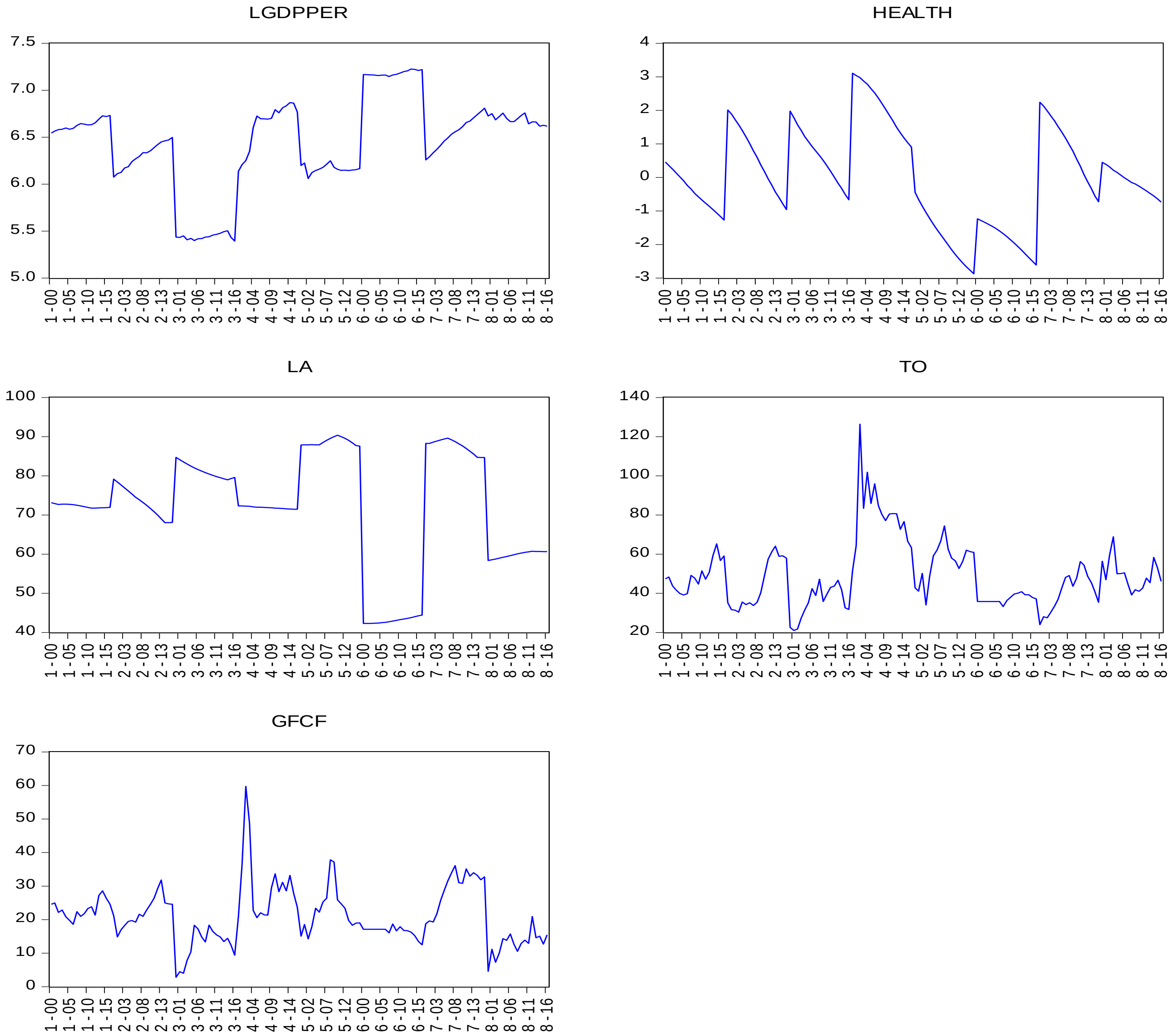


Source: Generated by researcher

5.3 DATA DESCRIPTION

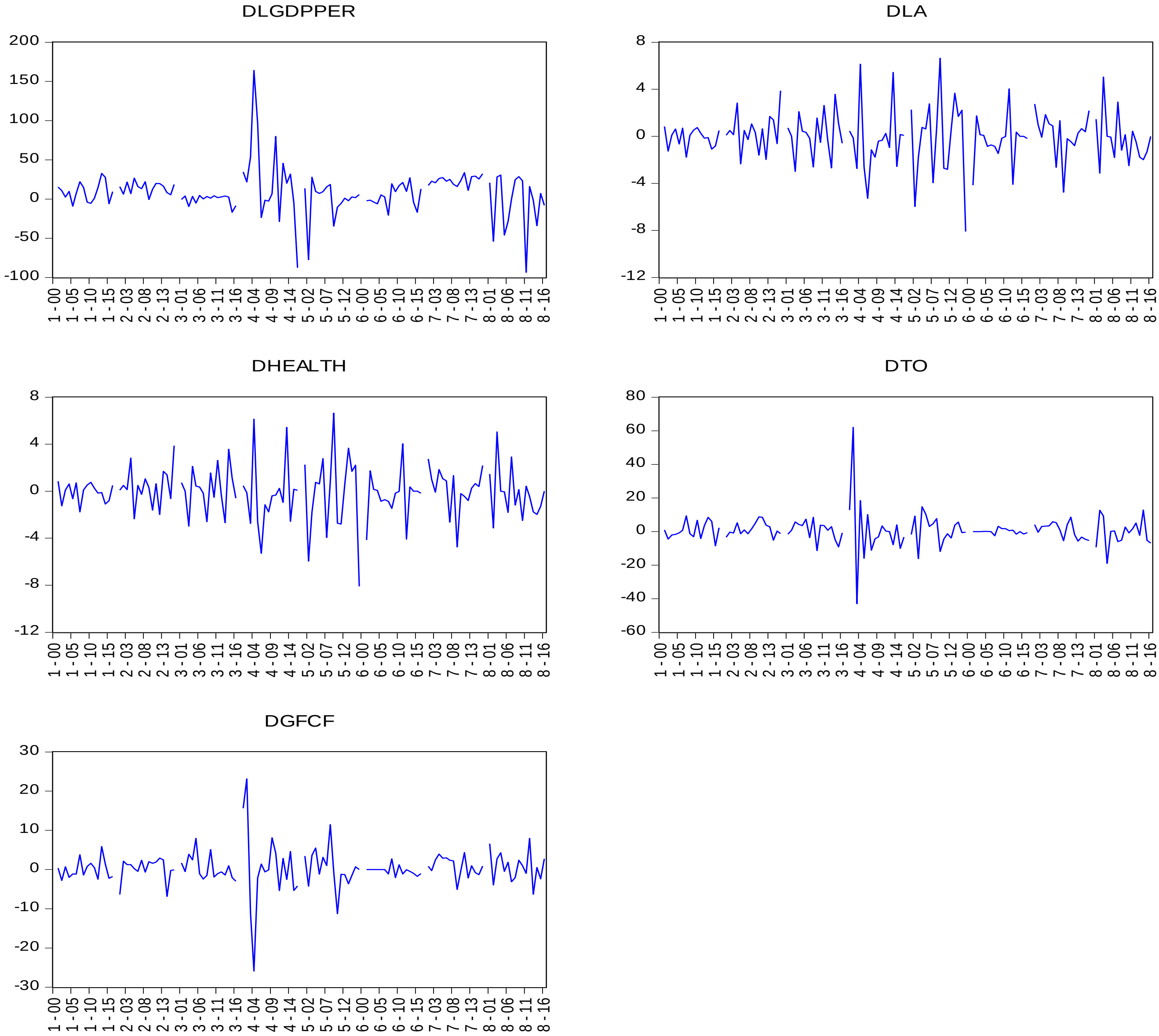
Next in Figure 5.2, the study conducts a preliminary examination of data both graphically in levels and after first difference. This is an informal way of inferring the underlying data generating process.

Figure 5.2 (a) GRAPHICAL PLOTS OF THE VARIABLES IN LEVEL FORM FOR LOWER-INCOME SUB-SAHARAN AFRICA COUNTRIES



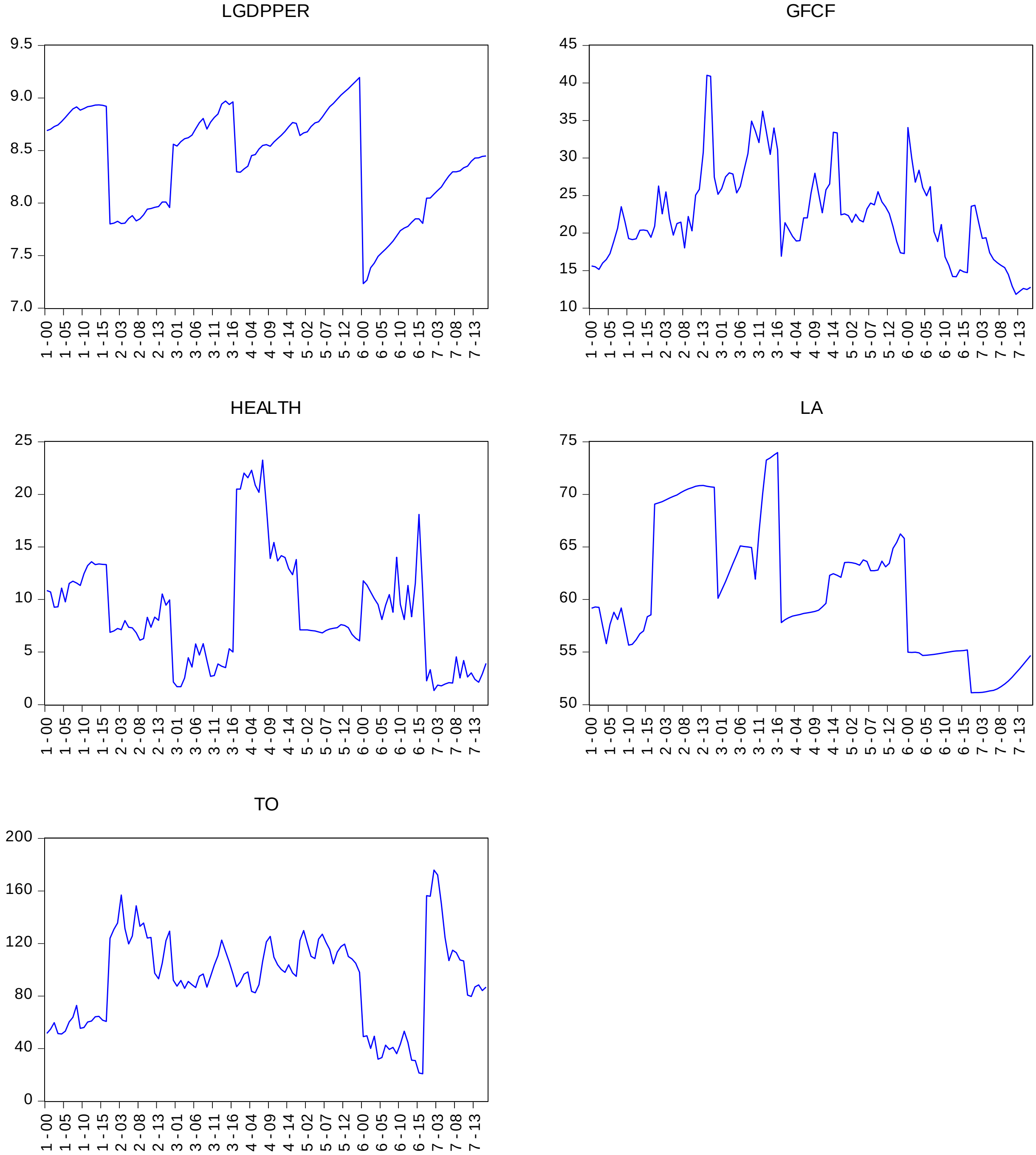
Source: Generated by researcher (World Bank data).

Figure 5.2 (b) Graphical plots of the variables in first difference for lower-income Sub-Saharan Africa countries



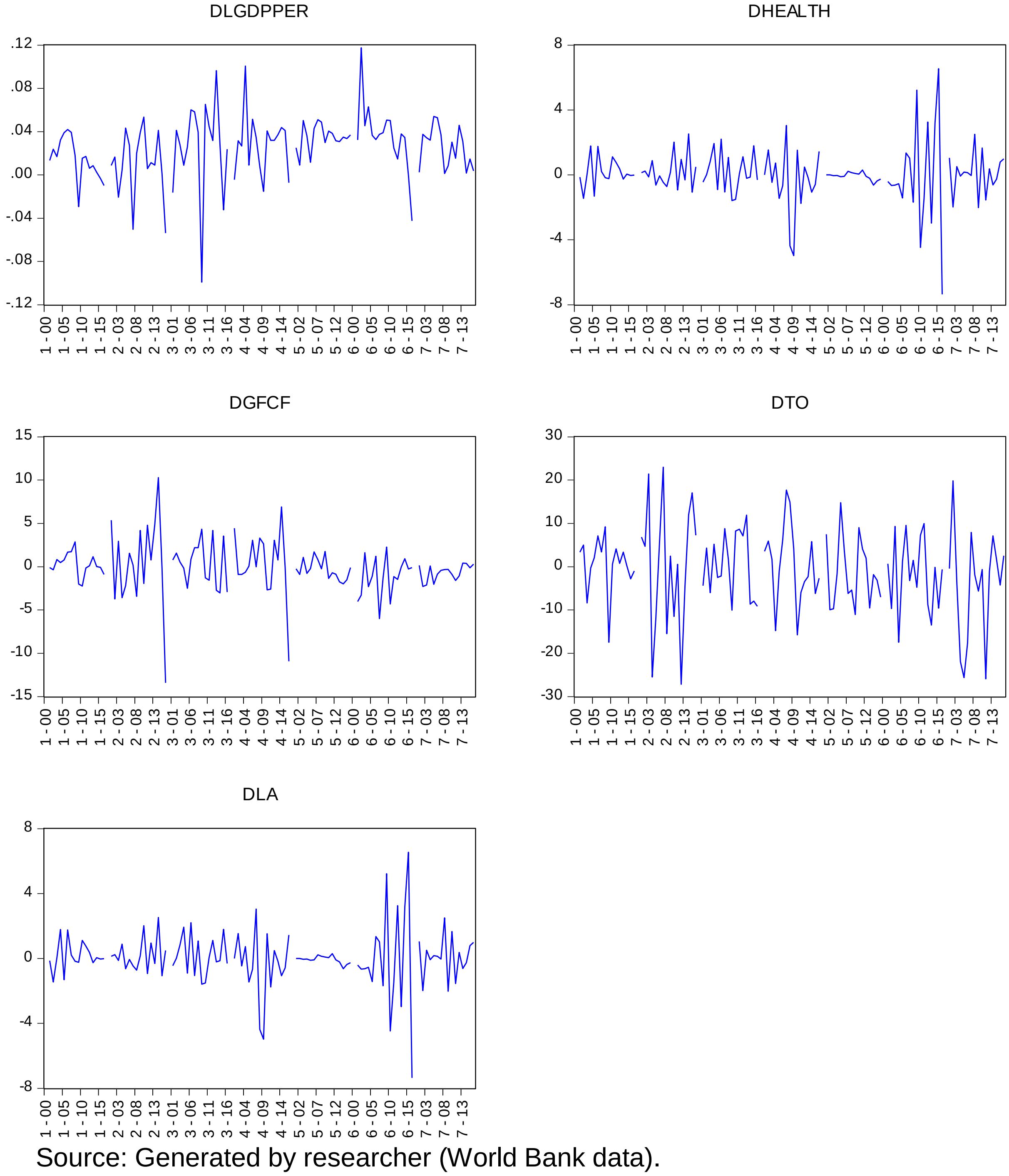
Source: Generated by researcher (World Bank data).

Figure 5.3 (a): GRAPHICAL PLOTS OF VARIABLES IN THE LEVEL FORM FOR MIDDLE-INCOME SUB-SAHARAN AFRICA COUNTRIES



Source: Generated by researcher (World Bank data).

Figure 5.3 (b) GRAPHICAL OF VARIABLES IN FIRST DIFFERENCE FOR MIDDLE-INCOME SUB-SAHARAN AFRICA COUNTRIES



Source: Generated by researcher (World Bank data).

5.4 CORRELATION MATRIX

Tables 5.2 (a) and 5.2 (b) present correlation coefficients for low-income and middle-income Sub-Saharan economies, respectively. These tables seek to achieve at least two things. Firstly, they intend to measure the degree of linear association between explanatory variables as high correlation may compromise hypothesis testing and make it difficult to partial out the effect of colinear variables. As a rule of thumb, multicollinearity is suspected if the pairwise correlation coefficient between two variables is above 0.90 (Asteriou and Hall, 2010). Secondly, it serves as a preliminary way of establishing the expected signs between economic growth and the explanatory variables.

As Tables 5.2(a) and 5.2(b) clearly show, there is hardly any suspicion of multicollinearity as all correlation coefficients are lower than the 0.9 mark. Secondly, for both low-income and middle-income Sub-Saharan countries, there seems to be a positive correlation between economic growth and the computed health index. In addition, and perhaps more importantly, the correlation coefficient of economic growth and health appears to be relatively sizeable, albeit high, in low-income Sub-Saharan countries than in middle-income Sub-Saharan countries.

Table 5.2 (a): PAIRWISE CORRELATION MATRIX FOR LOWER-INCOME SSA

	GROWTH	GFCF	LA	TO	HEALTH
GROWTH	1				
GFCF	0.069	1			
LA	0.2105	0.5475	1		
TO	0.0743	0.2287	0.4089	1	
HEALTH	0.2304	-0.1231	-0.1015	0.2339	1

Table 5.2(b): PAIRWISE CORRELATION MATRIX FOR MIDDLE-INCOME SSA

	GROWTH	GFCF	LA	TO	HEALTH
GROWTH	1				
GFCF	0.0443	1			
LA	0.8012	0.3057	1		
TO	0.058	0.5721	0.0687	1	
HEALTH	0.1087	0.174	0.0106	0.2642	1

Having established that multicollinearity was hardly prevalent in the data, the study proceeded with a regression analysis. As indicated in the methodology section, the first step was to perform unit root tests in order to establish the order of integration and assess the need for differencing each variable involved in the analysis.

5.5 PANEL UNIT ROOT TEST FOR STATIONARITY

The study conducted three panel unit root tests, namely the Levin and Lin test, Fisher Type test and Im Pesaran test. The main aim of running the unit root test is to check the stationarity of the variables to avoid the spuriousness of a regression. The reason for letting the study employ all three tests, is to check for robustness. However, it is important to note that the IPS test is primarily considered to be the baseline specification due to its immunity to cross-sectional dependence, which is normally problematic in panel data. In cases where the variable was found to be non-stationary after second differencing, results of non-stationarity after the first difference are not reported in Tables 5.3 (a) and 5.3 (b), due to space. Only the results of the highest order at which the variable becomes stationary, are presented. Evidently, in all cases, growth is stationary in levels, however trade openness and gross capital formation are stationary after differencing, while health and labour are stationary after second differencing.

Table 5.3 (a): PANEL UNIT ROOT TESTS FOR LOWER-INCOME SSA

Order	LLC TEST (Probability)		IPS TEST (Probability)		FT TEST (Probability)	
	Level	**Difference**	**Level**	**Difference**	**Level**	**Difference**
I(0)	0.0000*** GROWTH		0.0000*** GROWTH		0.0000*** GROWTH	
I(2)	0.7361	0.0000** DDHEALTH	0.3015 HEALTH	0.0000*** DDHEALTH	0.7519 HEALTH	0.0000*** DDHEALTH
I(1)	0.4367	0.0000*** DTO	0.2967 TO	0.0000*** DTO	0.0774 TO	0.0000*** DTO
I(2))	0.4643 LA	0.0000*** DDLA	0.5645 LA	0.000*** DDLA	0.4165 LA	0.0000*** DDLA
I(1)	0.2567 GFCF	0.0001*** DGFCF	0.5543 GFCF	0.0000*** DGFCF	0.5143 GFCF	0.0000*** DFCF

Note: The statistical significance levels at 10%, 5% and 1% are represented by *, ** and ***. D = first difference, DD means second difference. In all cases, the tests are based on specifications with intercept and no trend since the trend component entered insignificantly at 10% level.

Table 5.3 (b): PANEL UNIT ROOT TESTS FOR MIDDLE-INCOME SSA

Order	LLC TEST (Probability)		IPS TEST (Probability)		FT TEST (Probability)	
	Level	**Difference**	**Level**	**Difference**	**Level**	**Difference**
I(0)	0.0000*** GROWTH		0.0000*** GROWTH		0.0000 GROWTH	
I(2)	0.3425 HEALTH	0.0000*** DDHEALTH	0.5652 HEALTH	0.0000*** DDHEALTH	0.2216 HEALTH	0.0000*** DDHEALTH
I(1)	0.0691* TO	0.0000*** DTO	0.3953 TO	0.0000*** DTO	0.6440 TO	0.0000*** DTO
I(2))	0.8361 LA	0.0000*** DDLA	0.7839 LA	0.0000*** DDLA	0.6192* LA	0.0000** DDLA
I(1)	0.2345 GFCF	0.0200** DGFCF	0.3859 GFCF	0.0001*** DGFCF	0.6091 GFCF	0.0000*** DGFCF

Note: The statistical significance levels at 10%, 5% and 1% are represented by *, ** and ***. D = first difference, DD means second difference. In all cases, the tests are based on specifications with intercept and no trend since the trend component entered insignificantly at 10% level.

The results in Table 5.3 (a) and 5.3 (b) provide two insights. Firstly, the variables have a mixed order of integration, which means there is no need for co-integration testing since co-integration requires variables of the same order to be integrated. Secondly, trade openness and gross capital formation need to be differenced once, while health and labour need to be differenced twice before proceeding with the Panel Vector Autoregressive VAR results in order to avoid estimating a spurious regression. This is important since the GMM algorithm used in estimating the panel VAR in this study requires the stationarity condition of variables for parameter consistency. When estimating the panel VAR, the first important step is to determine the optimal lag selection (Abrigo and Love, 2015). This is presented in the next sub-section.

5.6 SELECTION ORDER LAG CRITERIA

According to Andrews and Lu (2001), the Vector Autoregressive model has three main tests to determine the number of lags in the model and these are the MAIC also known as Akaike Information Criteria, MBIC also known as Schwartz Criteria and MQIC also known as Hannan-Quinn Criteria. These are the tests applied in this study for both lower-income and middle-income Sub-Saharan Africa countries. As Tables 5.4 (a) and 5.4 (b) show, the, MBIC, MAIC and the MQIC chose 1 as the optimal order since this is the order which produces the least number of these three criterions. According to Abrigo and Love (2016) and Lada and Wojcik (2007), the optimal lag is one which is associated with the lowest MAIC, MBIC and MQIC values.

Table 5.4 (a) LAG SELECTION CRITERIA FOR LOWER-INCOME SSA

Lag	J p-value	MBIC	MAIC	MQIC
1	0.24	-175.8347	-43.61516	-97.18119
2	0.29	- 87.90212	-21.7923	48.57536
3	0.30	.	.	.

Source: Estimated by the researcher (Stata 14, pvarsoc)

Table 5.4 (b) LAG SELECTION CRITERIA FOR MIDDLE-INCOME SSA

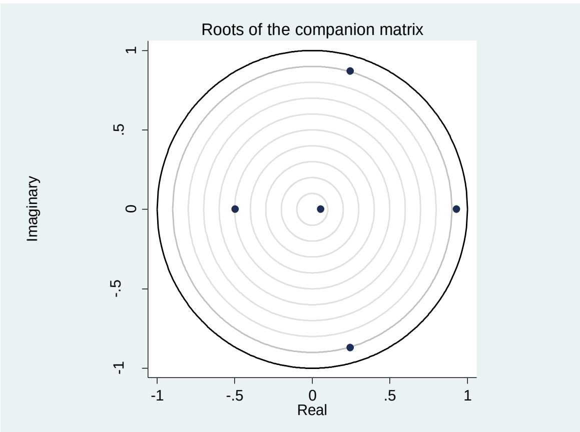
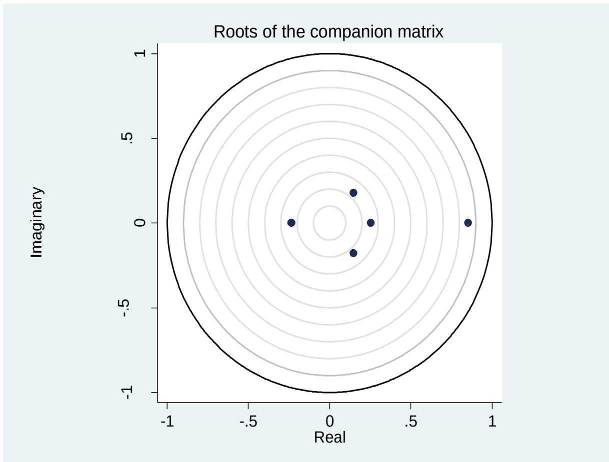
Lag	J p-value	MBIC	MAIC	MQIC
1	0.30	-173.5491	-45.33166	-97.15923
2	0.71	-93.43724	-29.32854	-55.24232
3	0.45	.	.	.

Source: Estimated by the researcher (Stata 14, pvarsoc)

5.7 VECTOR AUTOREGRESSIVE STABILITY TEST

The study employed the AR and polynomial root table to examine the stability of the Vector Autoregressive (VAR) model. The study employed the Eigenvalue test to examine whether the model is stable or not. According to Abrigo and Love (2015), if a model is stable, that means the probability is less than 1 and the modulus lies inside the circle. The Panel VAR model is stable if the modulus is inside the circle and that explains why dependant or endogenous variables in Vector Regressive models (VAR) are not stationary at level form. First difference must take place so that the variable becomes stationary (Lutkepohl and Poskitt, 1991). From the estimated results of the stability test, the study estimated two stability tests, the first one representing lower-income and the second one representing middle-income Sub-Saharan Africa countries. Figure 5.3 (a) is for model 1 and represents the Eigenvalue stability for lower-income Sub-Saharan Africa countries; figure 5.3 (b) is for model 2 and represents the middle-income Sub-Saharan Africa countries. The probability of an eigenvalue for lower-income Sub-Saharan Africa is 0.92 and the modulus is 0.92, which concludes that the model is stable because the probability is less than 1 and the modulus is inside the circle. The modulus of model 2 for middle-income Sub-Saharan Africa countries is 0.96, thus less than 1, but very close to 1.

According to the rule based on both stability results, the PVAR model for both models is stable because the modulus for both models is less than 1 and all the points lie within the root circle. The impulse response function and the variance of the decomposition will be estimated by the study, since both models are stable and satisfy the rules of the VAR model.

<table>
<tr><th>Figure 5.4 (a) AR root graph for lower-income Sub-Saharan Africa countries</th><th>Figure 5.4 (b) AR root graph for middle-income Sub-Saharan Africa countries</th></tr>
<tr><td>Inverse Root of AR Characteristic Polynomial

</td><td>Inverse Root of AR Characteristic Polynomial

</td></tr>
</table>

Source: Researcher created own table, computed using Stata 14.

AR ROOT TABLES

Table 5.5 (a) AR root table for lower-income Sub-Saharan Africa countries			**Table 5.5 (b) AR root table for middle-income Sub-Saharan Africa countries**		
Eigenvalue			**Eigenvalue**		
Real	**Imaginary**	**Modulus**	**Real**	**Imaginary**	**Modulus**
0.9297	0	0.9297	0.9689	0	0.9689
0.2451	0	0.9044	0.7830	0	0.7830
0.2451	0	0.9044	0.2640	0	0.2640
-0.4953	0	0.4953	-0.1881	0	0.1881
0.0541	0	0.0541	-0.0197	0	0.0197
All the eigenvalues lie inside the unit circle. The PVAR satisfies the stability conditions.			All the eigenvalues lie inside the unit circle. The PVAR satisfies the stability conditions.		

Source: Researcher own computed using Stata 14.

5.8 PANEL VECTOR AUTOREGRESSIVE (PVAR) MODEL ESTIMATION

Two Panel Vector Autoregressive models for both low-income and middle-income Sub-Saharan countries were estimated. In these estimations, it is important to note that one lag was initially used for lower-income Sub-Saharan Africa countries but yielded results that suffered from serial correlation. As a corrective measure, an additional lag was included, and this eliminated the autocorrelation problem. In other words, the panel VAR model for the lower-income group was estimated with two lags instead of one driven by the need to address autocorrelation. For the middle-income group, there was no evidence of autocorrelation and therefore the one lag selected in the previous section was applied. Since, according to Lutkepohl (2005), point estimates of the panel VAR are of less importance and cannot be meaningfully interpreted, the panel VAR coefficients are not presented in this chapter (although they are attached in appendix). What is presented subsequently are the results from impulse response functions and the variance decomposition.

5.9 PRINCIPAL COMPONENT ANALYSIS (PCA)

As indicated in the previous chapter, health was computed as an index from three indicators namely life expectancy at birth, the prevalence of HIV (total % of population), and birth rate (crude per 1000 people), based on the principal component analysis. The results of this exercise for lower-income and middle-income Sub-Saharan countries are presented in Tables 5.6(a) and Tables 5.6(b), respectively. In both cases, they show that the first two components contribute about 95 per cent variation of the overall index and these are life expectancy and birth rate. Life expectancy explains 73 per cent and 59 per cent, which means that, in the majority of previous studies, the use of life expectancy alone as a proxy for health may be necessary, but not sufficient. Looking at the eigenvectors, birth rates and life expectancy are high in the first component for middle-income countries. For low-income countries, the same variables load is high in the third component.

Table 5.6 (a) HEALTH INDEX FOR LOWER-INCOME SUB-SAHARAN AFRICA COUNTRIES

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.18809	1.52449	0.7294	0.7294
Comp2	.663599	.515289	0.2212	0.9506
Comp3	.14831	.	0.0494	1.0000

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Unexplained
LLE	-0.6303	0.2835	0.7228	0
BR	0.6169	-0.3823	0.6879	0
PHIV	0.4713	0.8795	0.0661	0

Source: Generated by researcher.

Table 5.6 (b) HEALTH INDEX FOR MIDDLE-INCOME SUB-SAHARAN AFRICA COUNTRIES

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.76814	.691283	0.5894	0.5894
Comp2	1.07686	.921852	0.3590	0.9483
Comp3	.155004	.	0.0517	1.0000

Principal components (eigenvectors)

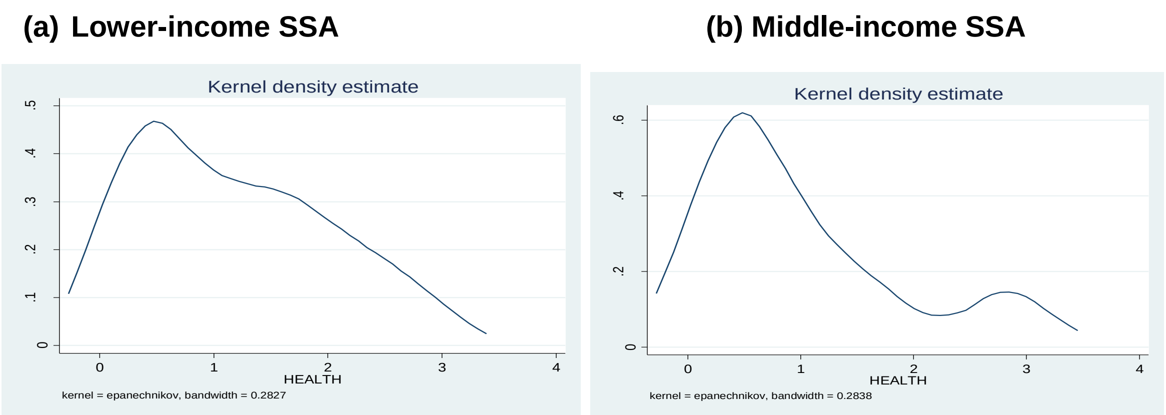
Variable	Comp1	Comp2	Comp3	Unexplained

LLE |	0.7227	0.0528	0.6892 |	0
BR |	0.6142	0.5065	0.6052 |	0
PHIV |	0.3171	0.8606	0.3985 |	0

Source: Generated by researcher.

Having computed the health index for each of these two sets of countries, Figure 5.5 displays its Kernel density distribution. The kernel density estimation is essentially a non-parametric way of estimating the probability density function of a series, which is the health index in this particular case. Both graphs (a) for lower-income and (b) for middle-income Sub-Saharan Africa countries are positively skewed implying that population health is better in only a few countries, with a large number of countries showing a huge scope for improving population health. The intention of this study is therefore to establish how such potential population health improvements in these two sets of Sub-Saharan countries would affect economic growth.

Figure 5.5: HEALTH INDEX KERNEL DENSITY ESTIMATE FOR LOWER-INCOME AND MIDDLE- INCOME SSA (2000 – 2016)

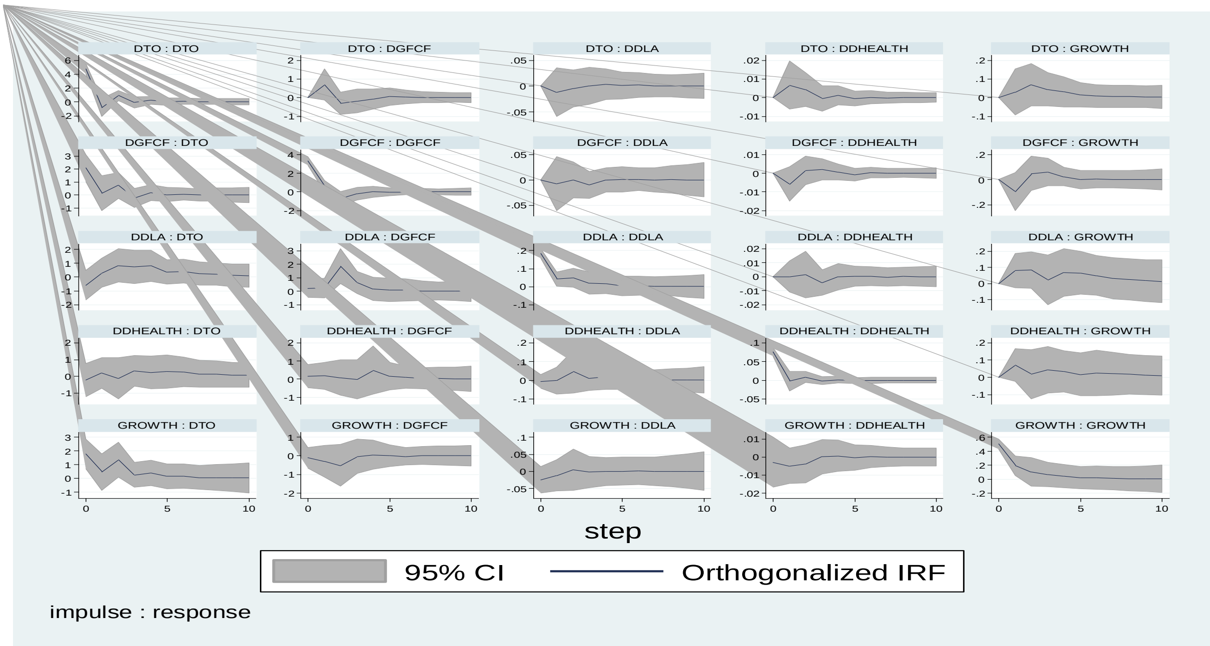


Source: Generated by researcher.

5.10 IMPULSE RESPONSE FUNCTION (IRF) RESULTS

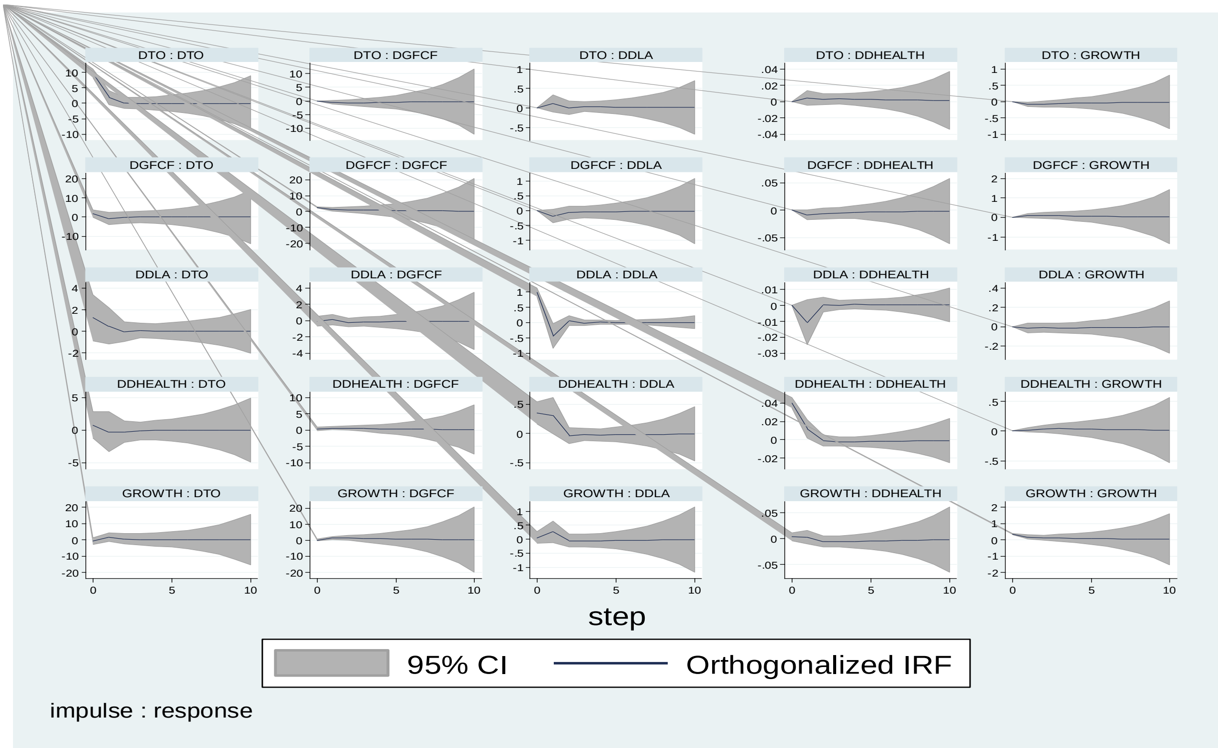
Impulse response functions show responses of reactions of a dynamic system in response to a shock in the system. In this study, interest was in establishing the dynamic reaction of economic growth to a positive shock on the health index for low-income and middle-income Sub-Saharan countries. Therefore, only the responses of economic growth to shocks in the remaining variables in the system are given attention. The results of the impulse response functions are displayed graphically in Figure 5.6 (a) and 5.6 (b) for low-income and middle-income countries, respectively. For the former group of countries, Figure 5.6 (a) shows a positive gradual increase in economic growth following a positive health shock. The gradual increase in economic growth lasts about 4 years from which economic growth becomes steady at a much higher level. This is confirmatory to the result observed in previous studies that health is a fundamental determent of economic growth in low-income countries. With regards to other variables, Figure 5.6 (b) confirms that shocks in terms of trade are detrimental to economic growth. There is a general decline in economic growth following a one-standard deviation in the terms of trade variable. This observation echoes the general view that terms of trade shocks facilitate macroeconomic instability and retard economic growth in commodity-dependent economies. As expected, the response of economic growth to an upward shock in gross capital formation is initially negative which is not surprising since initial investment costs may be growth-retarding in the initial stages. Beyond 2 years, economic growth starts to pick up substantiating the view that the benefits of investment accrue over time. A shock in labour also facilitates a positive increase in economic growth which becomes steady after about 3 years as predicted by economy theory. Noteworthy is that while a positive growth effect of health is observable for low-income countries, there does not seem to be a systematic association between health and economic growth for middle-income economies. In other words, the response of economic growth to a one standard deviation shock in health is weak at best for middle income countries. This result could be taken to suggests that the marginal effects of health improvements on economic growth decline with per capita income.

FIGURE: 5.6 (A) LOWER-INCOME SUB-SAHARAN AFRICA COUNTRIES IMPULSE RESPONSE FUNCTION



Source: Estimated by researcher.

Figure 5.6 (b) MIDDLE-INCOME SUB-SAHARAN AFRICA COUNTRIES IMPULSE RESPONSE FUNCTION



Source: Estimated by researcher

5.11 VARIANCE OF DECOMPOSITION OF VECTOR AUTOREGRESSIVE (VAR) MODEL

Variance decomposition functions show the importance of each shock in the system. In this particular case, they provide a way of establishing the relative importance of health shocks on economic growth. As Table 5.7(a) and 5.7(b) indicate, much of the variation in economic growth is explained by its own shocks for both low-income and middle-income Sub-Saharan countries. Health shocks account for 2.7 per cent and 3.4 per cent of variation in economic growth in low-income and middle-income sub-Saharan countries, respectively. Interestingly for low-income sub-Saharan economies, health shocks explain much of the economic growth dynamics, 2.7 per cent relative to terms of trade shocks, 2.6 per cent. For middle-income sub-Saharan countries, labour seems to be the least important variable as it explains only 0.4 per cent of economic growth dynamics. This may indicate the fact that countries become less labour intensive and more capital intensive as the economy develops. This possible explanation is further supported by the fact that capital formation is found in Table 5.7(b) to account for much of growth dynamics in middle-income Sub-Saharan countries, 14.9 per cent, than in lower-income Sub-Saharan countries, 4.2 per cent (see Table 5.7 (a)).

Table 5.7 (a): Variance decomposition of growth for lower-income SSA

	GROWTH	DDHEALTH	DDLA	DGFCF	DTO
GROWTH					
0	0.000	0.000	0.000	0.000	0.000
1	1.000	0.000	0.000	0.000	0.000
2	0.931	0.016	0.021	0.030	0.003
3	0.893	0.016	0.040	0.034	0.017
4	0.874	0.020	0.040	0.044	0.022
5	0.857	0.023	0.052	0.044	0.024
6	0.845	0.024	0.063	0.044	0.025
7	0.848	0.025	0.069	0.043	0.025
8	0.835	0.026	0.071	0.043	0.026
9	0.833	0.027	0.072	0.043	0.026
10	0.832	0.027	0.074	0.042	0.026

Source: Estimated by researcher

Table 5.7 (b): Variance decomposition of growth for middle-income SSA

	GROWTH	DDHEALTH	DDLA	DGFCF	DTO
GROWTH					
0	0.000	0.000	0.000	0.000	0.000
1	1.000	0.000	0.000	0.000	0.000
2	0.901	0.003	0.001	0.047	0.048
3	0.827	0.010	0.002	0.089	0.072
4	0.783	0.018	0.003	0.113	0.083
5	0.758	0.023	0.003	0.127	0.089
6	0.742	0.028	0.003	0.135	0.092
7	0.731	0.030	0.036	0.141	0.095
8	0.724	0.032	0.004	0.144	0.097
9	0.719	0.033	0.004	0.147	0.098
10	0.715	0.034	0.004	0.149	0.099

Source: Estimated by researcher

5.12 GRANGER CAUSALITY

Having determined the importance of health shocks on economic growth, the next step was to conduct Granger causality tests in order to establish the direction of causality. This procedure is necessitated by the fact that correlation does not always imply causality and it is therefore crucial to determine if the relationship between health and economic is causal. In Table 5.8 (a), the null hypothesis of no Granger causality from health to economic growth is rejected at 10 per cent level. On the other hand, the null hypothesis of no Granger causality from economic growth to health cannot be rejected at 10 per cent level in Table 5.8 (b) as the probability value is 0.158. These two results jointly suggest unidirectional causality running from health to economic growth and not the other way round. In the context of middle-income countries, there is no evidence of causality between health and economic growth. This means the causal effect of health on economic growth is only relevant in lower-income Sub-Saharan countries. Apart from health, there is also evidence of unidirectional causality running from labour to economic growth in the context of low-income Sub-Saharan economies. This latter results further supports the result presented earlier which is that labour is more critical in lower-income sub-Saharan countries than in their middle-income counterparts.

Table 5.8 (a): Granger causality for lower-income SSA – GROWTH

GROWTH		Chi2	Df	Prob
DHEALTH	→ GROWTH	5.409	2	0.067
DDLA	→ GROWTH	4.742	2	0.093
DGFCF		3.622	2	0.164
DTO		2.045	2	0.360
ALL		11.243	8	0.188

Source: Estimated by researcher.

Table 5.8 (b) Granger causality for middle-income SSA – HEALTH

	Chi2	Df	Prob
GROWTH	3.686	2	0.158
DDLA	0.238	2	0.888
DGFCF	4.552	2	0.103
DTO	4.396	2	0.111
ALL	8.470	8	0.389

Source: Estimated by researcher.

Table 5.8 (c): Granger causality for lower-income SSA – GROWTH

GROWTH		Chi2	Df	Prob
DHEALTH		0.666	1	0.414
DDLA		0.000	1	1.000
DGFCF	→ GROWTH	2.825	1	0.093
DTO	→ GROWTH	5.513	1	0.019
ALL	→ GROWTH	8.812	4	0.066

Source: Estimated by researcher.

Table 5.8 (d) Granger causality for middle-income SSA – HEALTH

DDHEALTH		Chi2	Df	Prob
GROWTH		0.178	1	0.673
DDLA		2.030	1	0.154
DGFCF	→ DDHEALTH	3.308	1	0.069
DTO		0.911	1	0.340
ALL		4.532	4	0.339

Source: Estimated by researcher.

5.12 DIAGNOSTIC TESTS FOR LOWER-INCOME AND MIDDLE- INCOME SUB-SAHARAN AFRICA COUNTRIES

5.12.1 Serial correlation and heteroskedasticity test results for lower-income Sub-Saharan Africa countries

The study performed the diagnostics tests with the aim of determining the reliability and the robustness of the PVAR model. The results of the serial correlation test for lower-income Sub-Saharan countries are displayed as appendix A, table 5.10 (a) and the VAR residuals heteroskedasticity is displayed as appendix A, table 5.10 (b). The Null hypothesis states that there is no serial correlation between the residuals, while the Alternative hypothesis states that there is serial correlation between the residuals. Since the probability of the LM test is above 5%, we conclude that there is no serial correlation between the residuals and we accept the Null hypothesis and reject the Alternative one. According to the VAR residuals heteroskedasticity, the probability that concludes that there is no heteroskedasticity between the residuals is above 5%. Therefore, we accept the Null hypothesis and reject the Alternative.

5.12.1.1 Serial correlation results for lower-income and middle-income Sub-Saharan Africa countries

Table 5.9 (a) Panel Vector Autoregressive (PVAR) serial correlation LM test for lower-income Sub-Saharan Africa countries

Lags	**LM – Stat**	**Probability**
1	29.17090	0.2568
2	35.44392	0.0805
3	17.40094	0.8667

Source: Estimated by researcher.

Table 5.9 (b) Panel Vector Autoregressive (PVAR) serial correlation LM test for middle-income Sub-Saharan Africa countries

Lags	**LM – Stat**	**Probability**
1	31.03538	0.1878

2	33.69764	0.1145
3	31.30244	0.1792

Source: Estimated by researcher.

The two tables above explain the results of the LM test after testing whether serial correlation exists between the residuals. Table 5.9 (a) is for lower-income Sub-Saharan Africa countries. However, table 5.9 (b) represents the middle-income Sub-Saharan Africa countries. In table 5.9 (a), at lag 1, the LM statistic is 29.17 and the probability is 0.25. According to Stundmund (2001) the serial correlation between the residuals exists if the probability is below 5% and if the probability is above 5% we can conclude that there is no serial correlation between the residuals. According to the LM test above for lower-income Sub-Saharan Africa countries at lag 1 the probability is 0.25, at lag 2 the probability is 0.08 and at lag 3 the probability is 0.8667. To all lags where the probability is above 0.05, we can conclude that there is no serial correlation between the residuals. We accept the Null hypothesis that states that there is no serial correlation between the residuals and we reject the Alternative hypothesis that states that there is serial correlation between the residuals. Table 5.9 (b) represents the middle-income Sub-Saharan Africa countries. At lag 1 the probability is 0.18, at lag 2 the probability is 0.11 and at lag 3 the probability is 0.17. From lag 1 to lag 3 all the probabilities are above 0.05. Therefore, we can conclude that there is no serial correlation between the residuals; so we accept the Null hypothesis and reject the Alternative.

5.12.1.2 Heteroskedasticity tests results for lower-income and middle-income Sub-Saharan Africa countries

Table 5.10 (a) Panel Vector Autoregressive (PVAR) heteroskedasticity results for lower-income Sub-Saharan Africa countries

Join Test		
Chi-Squared	Df	Probability
535.4284	150	0.5034

Source: Estimated by researcher.

Table 5.10 (b) Panel Vector Autoregressive (PVAR) heteroskedasticity results for middle-income Sub-Saharan Africa countries

Join Test		
Chi-Squared	Df	Probability
200.7916	150	0.2436

Source: Estimated by researcher.

Table 5.10 (a) contains the heteroskedasticity results for lower-income Sub-Saharan Africa countries and table 5.10 (b) the heteroskedasticity results for middle-income Sub-Saharan Africa countries. According to Stundmund (2001), if a probability is below 0.05 we can conclude that heteroskedasticity exists between the results. However, if a probability for the Breuch Began test is above 0.05, we can conclude that no heteroskedasticity exists between the residuals. The probability from table 5.10 (a) is 0.50, and from table 5.10 (b) it is 0.24. In both tables the probabilities are above 0.05; so we can conclude that there is no heteroskedasticity between the residuals. Therefore, we accept the Null hypothesis and reject the Alternative.

5.12.1.3 Residual normality test results for lower-income and middle-income Sub-Saharan Africa countries

Table 5.11 (a) Panel Vector Autoregressive (PVAR) normality results for lower-income Sub-Saharan Africa countries

Component	**Jarque – Bera**	**Df**	**Probability**
1	2.335784	2	0.5876
2	3.755237	2	0.9063
3	2.726272	2	0.6759
4	2.495676	2	0.7913
5	25.352403	2	0.6917
Joint	34.66496	10	0.0002

Source: Estimated by researcher.

Table 5.11 (b) Panel Autoregressive (PVAR) normality results for middle-income Sub-Saharan Africa countries.

Component	Jarque – Bera	Df	Probability
1	203.3354	2	0.6067
2	5.755237	2	0.6899
3	2.726272	2	0.6597
4	194.4956	2	0.7864
5	6.352403	2	0.7746
Joint	412.6649	10	0.0001

Source: Estimated by researcher.

Tables 5.11 (a) and 5.11 (b) above explain the normality of the variables after employing the Cholesky test. The first table represents the lower-income Sub-Saharan Africa countries and the second table represents the middle-income Sub-Saharan African countries. The residuals are normally distributed in a model if the Jarque Bera is above 0.5, and if the Jarque Bera is below 0.5 we can conclude that the residuals are not normally distributed (Gujarati, 2004; Stundmund, 2001). In table 5.11 (a) all the probabilities are above 50%, meaning that the residuals are normally distributed to a model. In table 5.11 (b) all the probabilities of Jarque Bera are above 50%, meaning that the residuals are normally distributed to a model. Based on the results above, both for lower-income and middle-income Sub-Saharan Africa countries, we accept a Null hypothesis that states that the residuals are normally distributed, and reject an Alternative hypothesis that states that the residuals are not normally distributed.

5.13 CONCLUSION

In chapter five the study examined the relationship between health and economic growth for lower-income and middle-income countries in the Sub-Saharan African region. The study employed the PVAR model and all other tests under the PVAR model, as explained in the previous chapter of the study. The empirical analysis of the study was estimated by employing the five macroeconomic variables. All the results of the entire study are estimated by means of Eviews 9 and Stata 14. The variables that were employed by the study are listed as follows: Gross Domestic Product per capita income, gross capital formation, trade openness, labour and health. The health variable is computed by combining three variables, birth rate per 1000 people, life expectancy and prevalence of HIV/AIDS in adults above 15 years. In chapter five the study started with a data description, tested the stationarity of each selected variable in a model and did co-integration tests. After the co-integration tests the Panel Vector Autoregressive (PVAR) models for both lower-income and middle-income Sub-Saharan African countries were estimated. The empirical results for all the tests were summarised, displayed and followed by an interpretation for each test. The chapter also displayed the results for impulse response functions, lag length selection criteria and the variance of the decomposition. This chapter also displayed and interpreted the results of the diagnostics tests for serial correlation, the heteroskedasticity tests and the residuals normality tests. The following chapter will analyse the results from this chapter and suggest a policy and recommendations based on the results obtained.

CHAPTER 6

CONCLUSION AND POLICY RECOMMENDATIONS

6.1 INTRODUCTION

This chapter of the study provides a summary of the entire dissertation, policy recommendations and the findings of the study. This chapter also discusses the limitations and areas for future studies.

6.2 SUMMARY OF THE ENTIRE STUDY

The main aim of the entire study was to estimate the relationship between health and economic growth and do a comparative study for lower-income and middle-income Sub-Saharan Africa countries from 2000 to 2016. In the process of investigating the relationship between health and economic growth, the study provides a theoretical framework in chapter two, discussing the economic theories. The four theories of economic growth are discussed in the study and listed as follows: the exogenous Growth Theory, the Harrod-Domar Growth Theory, the Lucas Growth Theory and the Neo-classical or endogenous Growth Theory. All the above theories in the study are discussed with the aim of explaining the relationship between health and economic growth. The aim of the study was to examine and discuss the influence of health on economic growth for low-income and middle-income Sub-Saharan Africa countries. The goal of the study was achieved through the following objectives:

1. To compare the influence of health on economic growth between lower- and middle-income Sub-Saharan Africa countries.
2. To determine the direction of causality between health and economic growth in lower-income and middle-income Sub-Saharan Africa countries.
3. To determine how health shocks affect growth in lower- and middle-income Sub-Saharan Africa countries over time.

Economic growth in Sub-Saharan Africa countries is denoted by GDP per capita and health is denoted by the health index after combining the three health indicators life expectancy, birth rate and prevalence of HIV/AIDS amongst people of ages +15. Due to the unavailability of other data on the Sub-Saharan Africa region, the study is limited to employing only these three health indicators. Chapter two also discusses the channels of health and income and the channels that explain the relationship between health, education and economic growth.

Chapter three provides the empirical literature from previous researchers after they investigated the relationship between health and economic growth. Chapter three is divided into two parts; the first part discusses the international empirical literature on health and economic growth and the second part discusses the empirical literature from Sub-Saharan Africa countries. Chapter three also gives a summary of the findings and the methods that were employed by previous studies to investigate the relationship between health and economic growth.

Chapter four explains the methodology that was employed by the study to investigate the relationship between health and economic growth for lower-income and middle-income Sub-Saharan Africa countries. This chapter discusses the data sources and the model specifications and also the justification of the variables that were selected by the study in chapter five.

Chapter five discusses the tests for stationarity between the variables. These tests are the Levin and Lin test, the IM Pesaran and the Fisher Type test. Chapter four also discusses the Panel Vector Autoregressive (PVAR) model as the model employed by the study to estimate the relationship between health and economic growth. In addition this chapter discusses the economic techniques that form part of the Vector Autoregressive model, like impulse response functions, lag length selection, variance of the composition and the diagnostic tests.

Chapter five is there to provide the methodology of the study and analyse the results of all the Vector Autoregressive (VAR) model techniques utilized with an aim of achieving the objective of the entire study. In chapter five the study starts by interpreting the results after checking whether stationarity exists for each variable selected by the study, and it is found that all the variables are stationary after first difference. After the unit root tests, the study tests for co-integration between the variables. The study employed the Pedroni test as most appropriate test for co-integration. After the co-integration test the study estimates the unrestricted Panel Vector Autoregressive (PVAR) model and also the impulse response functions, lag length selection criteria and the variance of the composition. In addition, this chapter also estimates and interprets the diagnostics tests, such as the serial correlation and stability tests.

6.3 SUMMARY OF THE ENTIRE RESULTS AND POLICY RECOMMENDATIONS

The main aim of the study was to examine the influence of health on economic growth in lower-income- and middle-income Sub-Saharan Africa countries. The researcher takes into consideration all the macroeconomic variables that are employed in the study, as well as the econometrics techniques for empirical analysis. Most of the macroeconomic variables were taken from the study of Ogundari and Awokuse (2018), while the study employed the system generalized method of moment (SGMM) to investigate the contribution of health and education towards economic growth. The study found a positive significant contribution by all macroeconomic variables on economic growth in both lower and middle-income Sub-Saharan African countries from 2000 to 2016.The dependent variable economic growth in the study is expressed by Gross domestic product per capita (GDPPER), with the explanatory variables being gross capital formation (GFCF), labour (LA), trade openness (TO) and health. The Health variable is created by combining birth rate, life expectancy and the prevalence of HIV/AIDS amongst people of ages +15. Previous studies found a positive influence of health on economic growth, but most of the studies were done on developed countries. According to Chakraborty (2004), the improvement in health in less developed countries lead to an increase in human capital. The improvement in health meant that a larger number of people joined the labour force, and that the fertility rate declined, which would cause economic growth to accelerate (Bloom and Prettner, 2015).

The study tests the stationarity between the variables by employing the Augmented Dickey Fuller test. All the variables were not stationary at level form, so the study applied first difference and all the variables become stationary. The Granger causality test is performed by the study to test the direction between the variables and to be justified by employing the impulse response function and the variance of the composition. Diagnostics tests are performed by the study to test whether the models passed all the tests. The first objective of the study was to estimate the relationship between health and economic growth for lower-income and middle-income Sub-Saharan Africa countries. The coeffients for the short-run estimates of the independent variables show positive signs. The results of the diagnostics tests state that both models are stable, while there is no serial correlation between the residuals and no heteroskedasticity. That means that both models for lower-income and middle-income Sub-Saharan Africa countries were best fit. The relationship between health and economic growth is highly significant and it makes economic sense because it supports the economic theory that is followed by the study, Neoclassical growth theory and the empirical literature, as discussed in chapter two and chapter three of the study. Based on the findings of the study, health plays a vital role in increasing economic growth. That means government spending should increase in the health sector.

If government spends more on health, that will make health spend more on awareness to educate people about how to avoid certain diseases like tuberculosis, HIV/AIDS and diabetes. The increase in government spending will help the health sector to purchase vaccines to prevent certain diseases like Covid 19 pandemic and malaria, which in turn and will increase economic growth for Sub-Saharan Africa countries in the long run, because the level of absenteeism will fall, the productivity of adult people will improve and the production output level will rise because people are healthier and more active. The Sub-Saharan Africa countries have a serious problem, because the number of people who have passed away, are increasing daily due to Covid 19 pandemic. The government of each country must increase their spending on health, so that their country can buy the vaccines and other protection to protect the population from infection by Covid 19 pandemic. Then the people can go back to work, increasing the output of companies and subsequently the economic growth of Sub-Saharan Africa countries, because they will be healthier.

6.4 LIMITATIONS OF THE STUDY AND SUGGESTED AREAS OF RESEARCH FOR UPCOMING RESEARCHERS

The first limitation of this study is that the countries that are categorised as low- and middle-income countries are more than 20, but due to the unavailability of data the study only selected eight lower-income and seven middle-income Sub-Saharan Africa countries. The second limitation is that there are many variables that could not be described as the determinants of economic growth, e.g. corruption and democracy, due to the unavailability of data on other countries. The third possible limitation of the study is that there are many indicators of health, but the study employed only three indicators for PCA because of the unavailability of data, namely life expectancy at birth, prevalence of HIV and birth rate, which were combined to create a health index. However, for future research the study recommends the following:

- Firstly, that the study employs four indicators for health, since it might have left out an important indicator, and indicate which are positive and which are negative. The study recommends that, in future research, a health index is created with other variables.
- Secondly, that the study employs only 8 countries from lower-income Sub-Saharan Africa and 7 from the middle-income Sub-Saharan Africa region for the period between 2000 and 2016. The future studies should increase the number countries, the date spanning and the other variables.

6.5 CONCLUSION

This chapter summarises the results of the whole dissertation, discusses the policy recommendations, and highlights the limitations of the study. The areas that need to be taken into consideration by upcoming researchers are also discussed in this chapter of the study. In the summary of the study, health and economic growth have been investigated in developed countries, since there are few studies that conducted a research based on developing or Sub-Saharan Africa countries, and there is still a gap. The researchers found inconsistent results on health and economic growth, the findings of the study and the empirical results of the study obtained after employing econometrics techniques and two Vector Autoregressive (PVAR) models for panel data. The first Panel Vector Autoregressive (PVAR) model represents lower-income and the second middle-income Sub-Saharan Africa countries from 2000 to 2016. The study found a strong positive, significant relationship between health and economic growth for lower-income Sub-Saharan Africa countries. However, it found a positive, but not significant, relationship between health and economic growth in middle-income Sub-Saharan Africa countries. The empirical results support the theory that follows by the study neoclassical growth theory.

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Results of appendices: Appendix A

Table 3.1: Selected studies investigating the relationship between health and economic growth for both international and Sub-Saharan studies

Author(s)	**Country and sample specification**	**Method**	**Empirical results**
Hansen and Lønstrup (2015)	• Developed countries • 1940-2000	2SLS estimates	The relationship between economic growth and life expectancy at birth in developed countries is negative but insignificant.
Ngangue and Kourty (2015)	• Developing countries • 2000-2013	Generalized Method of Moments (GMM)	The relationship between economic growth and life expectancy is positive, but these results were insignificant in lower-income to middle-income countries.
Halici -Tuluce *et al.* (2016)	• Low-income and high- income economies • 1995-2012 • 1997-2009	Generalized Method of Moment (GMM)	The relationship between economic growth and private health expenditure is negative, while public health and economic growth are both negative but statistically significant.
Incaltarau *et al.* (2015)	• Romania • 1996-2012	Generalized Method of Moment (GMM)	The relationship between health and economic growth is

			parallel. If health improves, it leads to an increase in economic growth.
Ercelik (2018)	• Turkey • 1980-2015	Autoregressive Distributed Lag Model (ARDL)	The relationship between health and economic growth is positive, but only in the long run.
Ozturk and Topcu (2014)	• G8 Countries • 199-2012	Panel Error Correction Model (PECM)	Health expenditure affects economic growth in the short run and economic growth affects health expenditure in the long run.
Pradhan (2010)	• OECD countries • 1961-2007	Panel Co-integration Approach	Health spending affects economic growth in the short run and economic growth affects health spending in the long run. Health spending and economic growth are positively related in the short run and in the long run.
Bargava *et al.* (2001)	• Developed and developing countries • 1965-1990	Panel Random-effect model	The relationship between health and economic growth is positive but weak in both developing and

			developed countries.

Source: Generated by researcher.

Author(s)	**Countries and time period**	**Method**	**Empirical results**
Mayer (2001)	• Latin American Countries • 1950-1990	Panel ARDL	An improvement in health in a country leads to an increase in economic growth.
Akhmat *et al.* (2014)	• East Asia, Middle East, South Asia and Sub-Saharan countries • 1975-2011	Panel ECM model	Granger causality exists between health and economic growth and they are positively related.
Ogundari and Awukose (2018)	• Sub-Saharan Africa countries • 1980-2018	Generalized Method of Moments (GMM)	The relationship between human capital and economic growth is positive and they found that if population growth increased by 10%, it lead to an increase in economic growth of 4.9%.
Babatunde (2012)	• Nigeria • 1980-2008	3SLS Estimator	The relationship between income per capita and life expectancy is positive.

			The study also found that if income increases by 1%, it lead to an increase in life expectancy of 0.043%.
Taban (2006)	• Turkey • 1980-2000		The relationship between health and economic growth is negative.
Altigan *et al.* (2017)	• Turkey • 1975-2013	Autoregressive Distributed Model (ARDL)	The study found a positive relationship between health and economic growth. The study also stated that if health improved by 1%, economic growth would automatically increase by 0.434%.
Kurt (2015)	• Turkey • 2006-2013	Feder-Ram Model	The study found that the relationship between government expenditure, and health and life expectancy were positively related to economic growth in Turkey.
Sharma (2018)	• Developed countries • 1870-2013	Generalised Method of Moment (GMM)	The study found a positive association between health indicators and economic growth in developed countries.
Canning and	• Developed	Two Least	The study found a

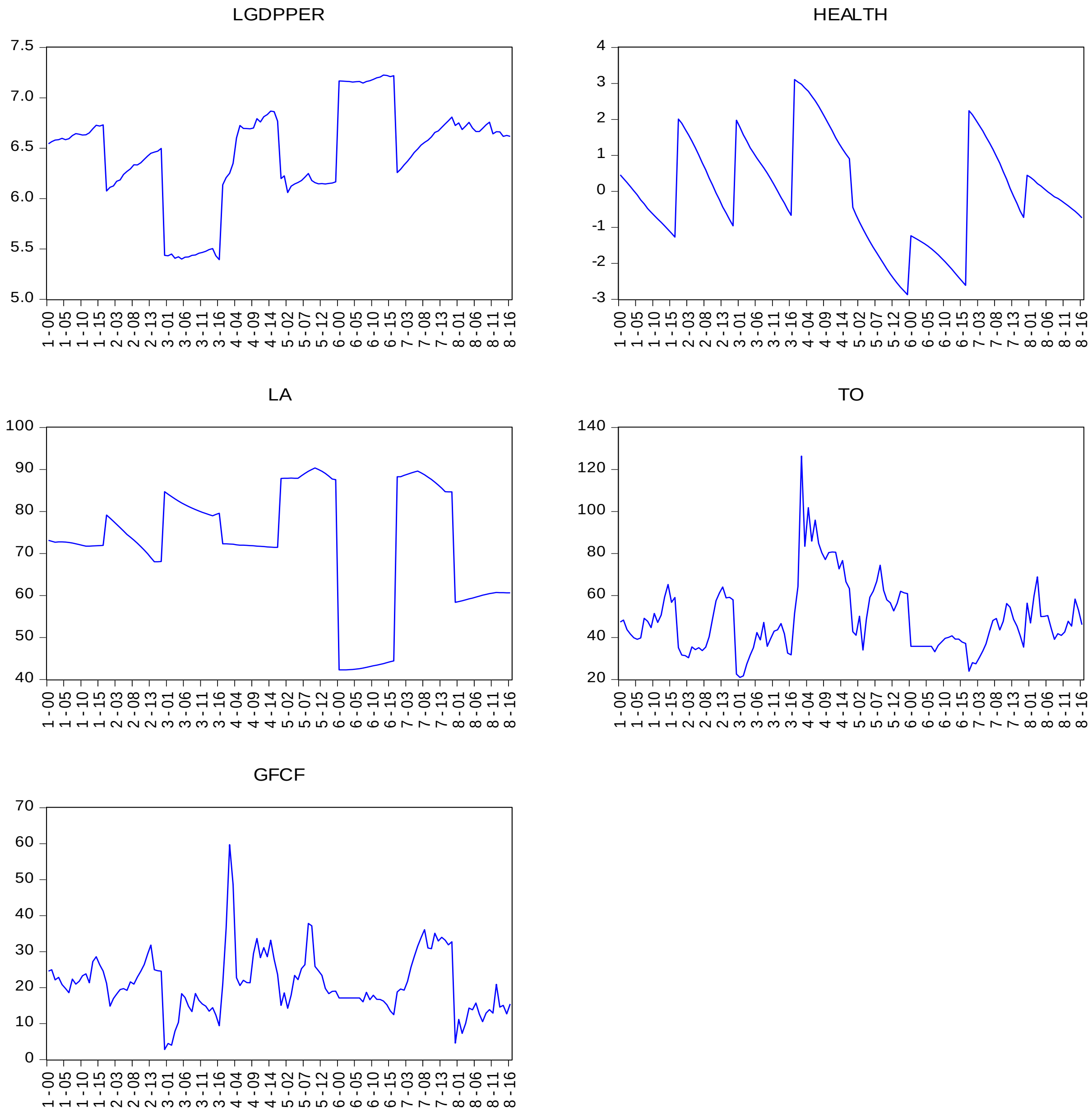
Sevilla (2004)	countries • 1940-2000	Squared Method (2SLS)	positive relationship between health and economic growth.
Zaidi and Saidi (2018)	• Sub Saharan Africa countries • 1990-2015	Panel ARDL model	The study found a strong positive relationship between health and economic growth in Sub- Saharan Africa.
Oni (2014)	• Nigeria • 1970-2010	Multiple OLS model	The study found a positive significance between health and economic growth.
Novignon and Lawanson (2017)	• Sub-Saharan Africa countries • 1995-2011	Random and Fixed-effect models	The study found a significant positive relationship between health and economic growth.
Bloom and Canning (2019)	• Developed countries	Panel GMM model	A direct positive relationship between health and economic growth at the macro level, but a small impact of health on economic growth at the micro level.
Odubunmi *et al.* (2012)	• Nigeria • 1970-2009	Co-integration	The relationship between health and economic growth is positive.
Dincer and Yuksel (2019)	• Emerging economies • 1996-2016	Pedroni Co-integration Method and	Pedroni found a positive relationship between health and

		Dumitrescu Hurlin Panel-causality method	economic growth in the long run. The Dumitrescu hurling panel causality method revealed no causality relationship between health and economic growth in emerging economies from 1996-2016.
Aslan and Menegaki (2016)	• G7 high-income countries • 1980-2009	Autoregressive Distributed Lag (ARDL) model	The study found a significant positive relationship between health and economic growth in the long run.
Adeyemi and Ogunsola (2019)	• Nigeria • 1980-2013	Autoregressive Distributed Lag (ARDL) model	The relationship between health and economic growth is positive.

Source: Generated by researcher

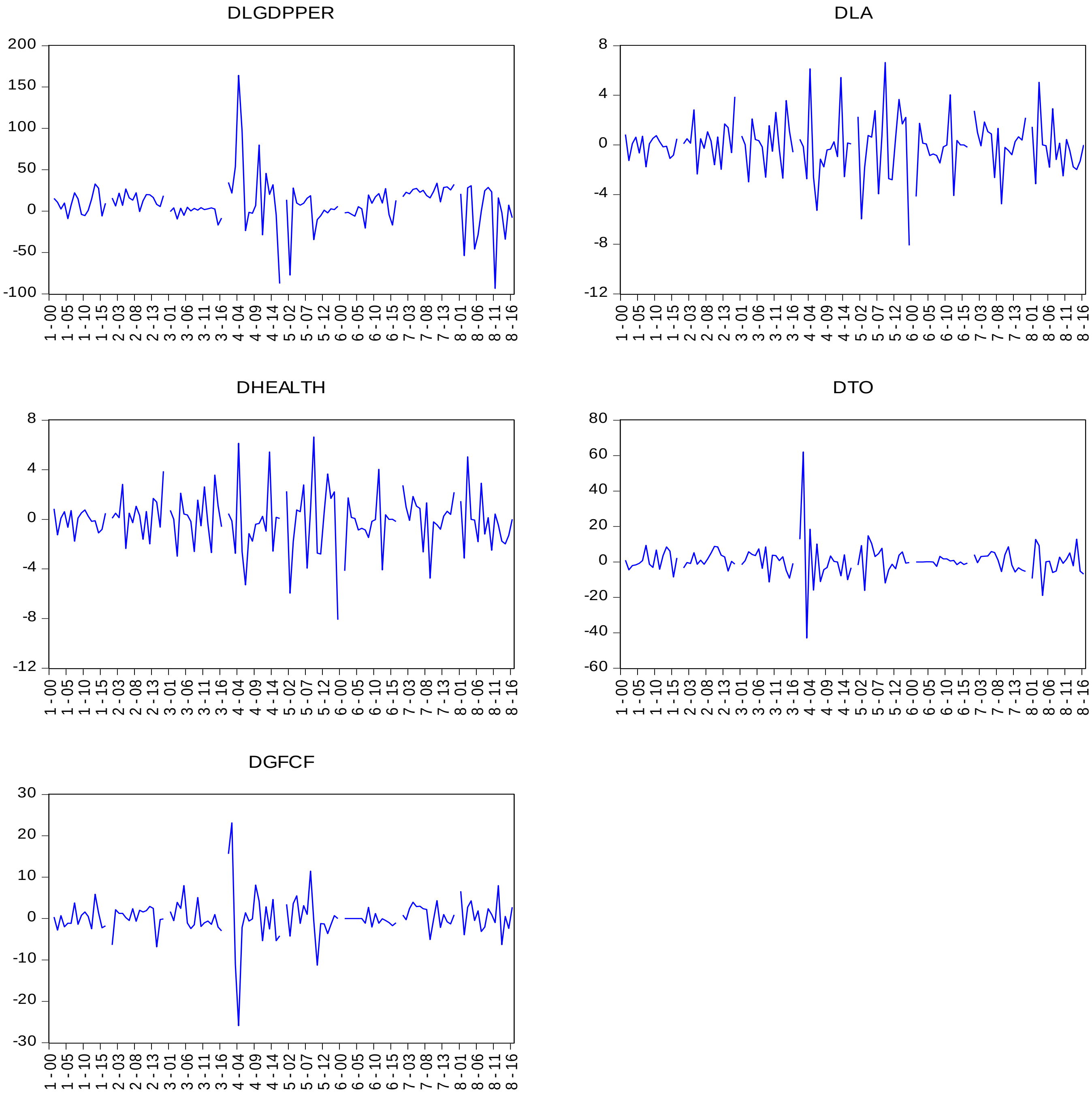
Appendix A : PVAR results (Mode 1) lower-income for Sub-Saharan Africa

Figure 5.1 (a) Unit root test at level form



Source: Estimated by researcher.

Figure 5.1 (b) Graphical unit root test after first difference



Source: Estimated by researcher.

Table 5.3 (a): Panel unit root stationarity test results for lower-income Sub-Saharan Africa countries

Variables	T Statistics	Probability =0.05%	Lag length	Integrated order	Restriction
GROWTH	-3.0344	0.0000	1	I(0)	Intercept and no trend
HEALTH	-9.0384	0.7361	0	I(0)	Intercept and no trend
DHEALTH	-4.8047	0.1189	0	I(1)	Intercept and no trend
DDHEALTH	-15.8346	0.0000	0	I(2)***	Intercept and no trend
TO	-4.2476	0.4367	1	I(0)	Intercept and no trend
DTO	-9.4767	0.0000	0	I(1)***	Intercept and no trend
LA	-5.8671	0.4643	1	I(0)	Intercept and no trend
DLA	-10.0287	0.1154	0	I(1)	Intercept and no trend
DDLA	-4.0520	0.0000	0	I(0)***	Intercept and no trend

DGFCF	-2.6545	0.0001	0	I(1)***	Intercept and no trend

Source: Estimated by researcher (10% *, 5%** and 1%***).

5.4 (a) Lag selection criteria for lower-income Sub-Saharan Africa countries

Lag	J p-value	MBIC	MAIC	MQIC
1	0.24	-175.8347	-43.61516	-97.18119
2	0.29	- 87.90212	-21.7923	48.57536
3	0.30	.	.	.

Source: Estimated by the researcher (Stata 14, pvarsoc)

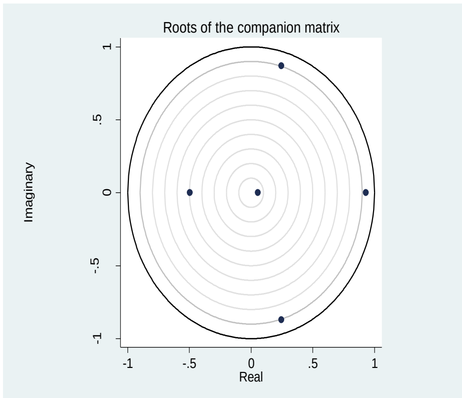
Figure 5.3 (a) AR root graph for lower-income Sub-Saharan Africa countries

Eigenvalue Stability

Eigenvalue		
Real	**Imaginary**	**Modulus**
0.9297	0	0.9297
0.2451	0	0.9044
0.2451	0	0.9044
-0.4953	0	0.4953
0.0541	0	0.0541

All the eigenvalues lie inside the unit circle. PVAR satisfies stability condition.

Root of the companion matrix



Source: Estimated by researcher.

Table 5.6 (a) Health index for lower-income Sub-Saharan Africa countries

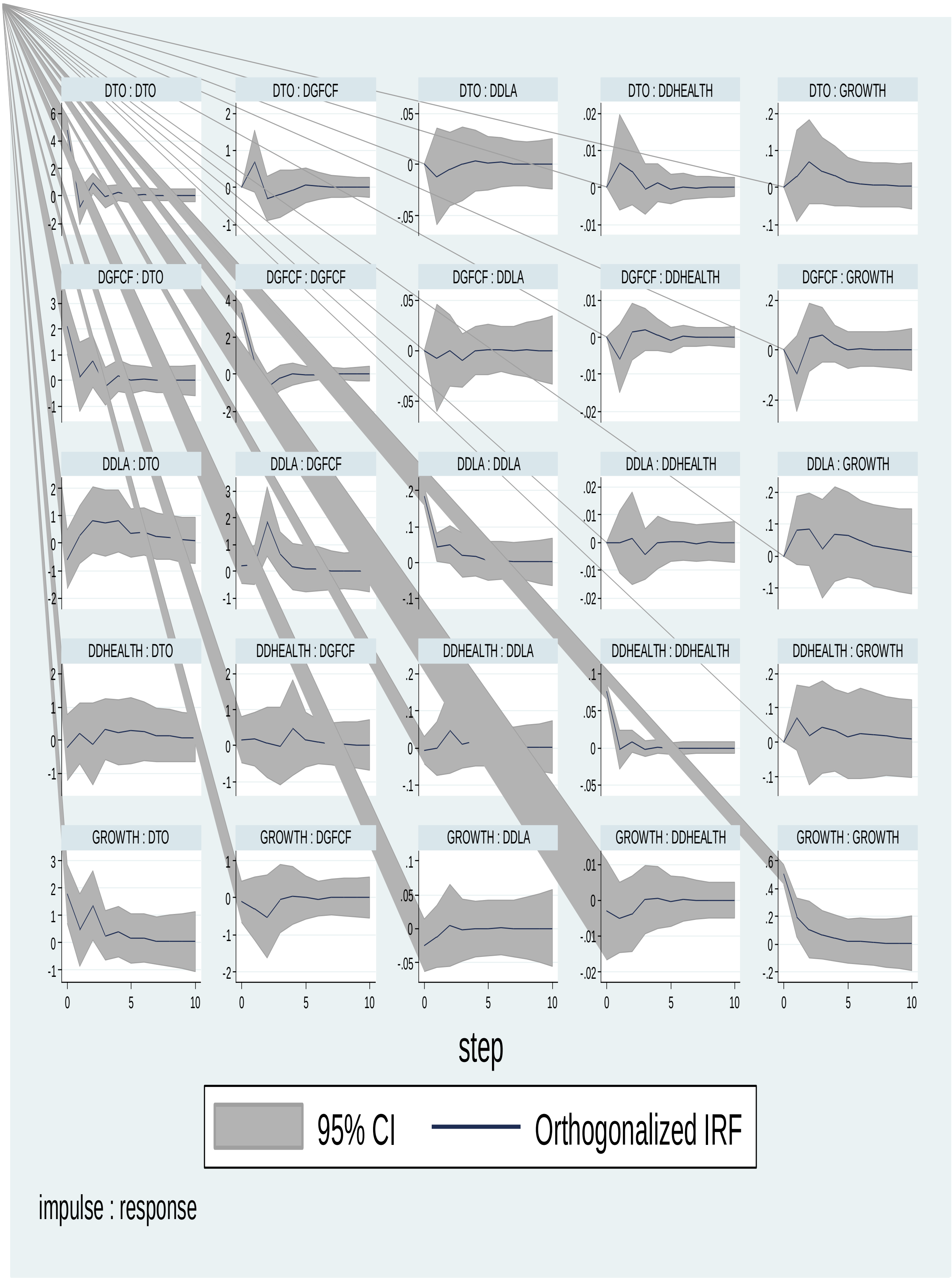
Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.18809	1.52449	0.7294	0.7294
Comp2	.663599	.515289	0.2212	0.9506
Comp3	.14831	.	0.0494	1.0000

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Unexplained
LLE	-0.6303	0.2835	0.7228	0
BR	0.6169	-0.3823	0.6879	0
PHIV	0.4713	0.8795	0.0661	0

Source: Generated by researcher.

Figure 5.5 (a) Impulse response function for lower-income countries



Source: Estimated by researcher.

Table 5.7 (a) Variance of decomposition of growth for lower-income Sub-Saharan Africa countries

Forecast-error variance decomposition

Response variable and Forecast horizon	Impulse variable GROWTH	DDHEALTH	DDLA	DGFCF	DTO
GROWTH					
0	0	0	0	0	0
1	1	0	0	0	0
2	.9308892	.0158866	.0207635	.0295138	.0029468
3	.8932943	.0156644	.0396943	.0343305	.0170165
4	.8737057	.020467	.0397603	.0439414	.0221256
5	.8565813	.0231293	.0515753	.0443505	.0243637
6	.8452815	.0235985	.0628173	.043709	.0245936
7	.8381981	.0249754	.0689449	.0433371	.0245444
8	.8348774	.0260936	.0713095	.0431668	.0245528
9	.8327054	.0268311	.0728152	.0430522	.0245961
10	.8316616	.027152	.0735712	.0429974	.0246177
DDHEALTH					
0	0	0	0	0	0
1	.0014649	.9985351	0	0	0
2	.0055065	.9811038	2.94e-06	.0058341	.0075527
3	.0079624	.9750234	.0003776	.0060928	.0105437
4	.0079341	.9715071	.0032848	.0067336	.0105404
5	.0080043	.9710946	.0032862	.0067959	.0108189
6	.0080271	.9709108	.0032943	.0069291	.0108386
7	.0080381	.9708734	.003303	.0069432	.0108423
8	.0080389	.9708491	.0033231	.0069431	.0108458
9	.0080398	.9708423	.0033265	.0069434	.010848
10	.0080401	.9708413	.0033265	.0069439	.0108482
DDLA					
0	0	0	0	0	0
1	.0183621	.0012086	.9804293	0	0
2	.0210559	.0012043	.9725414	.0014133	.0037851
3	.0191954	.0529082	.9227458	.0012626	.003888
4	.0190268	.0549883	.9186057	.0035405	.0038388
5	.0187592	.0614005	.9122835	.0034913	.0040655
6	.0187394	.0620923	.9115704	.0034969	.0041009
7	.0187302	.0629992	.9105122	.0035202	.0042381
8	.0187258	.063048	.9104531	.0035232	.0042499
9	.0187309	.0631354	.9103419	.0035257	.0042662
10	.0187341	.0631556	.9103169	.0035255	.0042678
DGFCF					
0	0	0	0	0	0
1	.0012015	.0022348	.0041751	.9923885	0
2	.0085195	.0048646	.0083967	.9380409	.0401784
3	.0224447	.0040067	.2188806	.7197505	.0349175
4	.0219088	.003894	.2363088	.7020176	.0358708
5	.0217219	.0176901	.2342	.6907355	.0356524
6	.0216729	.0191846	.2341837	.6892155	.0357432
7	.0217131	.0197256	.2344135	.6883371	.0358107
8	.0217102	.0197932	.2344232	.6882573	.035816
9	.0217127	.0198671	.2344203	.6881785	.0358214
10	.0217123	.0198746	.2344405	.6881509	.0358216
DTO					
0	0	0	0	0	0
1	.1031365	.0016688	.0115142	.1415391	.7421414
2	.1065064	.0029061	.0139383	.1379584	.7386909
3	.1457989	.0029848	.0323667	.1377957	.6810538
4	.1443759	.0058216	.0463806	.1365516	.6668704
5	.1448299	.0069965	.0628905	.1338516	.6514315
6	.1445864	.0091472	.0658547	.1330179	.6473938
7	.1441077	.0108136	.0699123	.1321398	.6430265
8	.143879	.0113417	.071358	.131828	.6415935
9	.143705	.011871	.0724023	.1315896	.6404321
10	.1436451	.012067	.0727791	.1314989	.64001

FEVD standard errors and confidence intervals are not saved. Use option **save**.

Table 5.8 (a) Granger causality results for lower-income Sub-Saharan Africa countries

```
panel VAR-Granger causality Wald test
  Ho: Excluded variable does not Granger-cause Equation variable
  Ha: Excluded variable Granger-causes Equation variable
```

Equation \ Excluded	chi2	df	Prob > chi2
GROWTH			
DDHEALTH	5.409	2	0.067
DDLA	4.742	2	0.093
DGFCF	3.622	2	0.164
DTO	2.045	2	0.360
ALL	11.243	8	0.188
DDHEALTH			
GROWTH	3.686	2	0.158
DDLA	0.238	2	0.888
DGFCF	4.552	2	0.103
DTO	4.396	2	0.111
ALL	8.470	8	0.389
DDLA			
GROWTH	3.180	2	0.204
DDHEALTH	3.303	2	0.192
DGFCF	0.076	2	0.963
DTO	0.697	2	0.706
ALL	7.762	8	0.457
DGFCF			
GROWTH	1.144	2	0.564
DDHEALTH	0.479	2	0.787
DDLA	9.613	2	0.008
DTO	5.694	2	0.058
ALL	15.802	8	0.045
DTO			
GROWTH	3.520	2	0.172
DDHEALTH	0.832	2	0.660
DDLA	1.527	2	0.466
DGFCF	1.227	2	0.541
ALL	6.084	8	0.638

Source: Estimated by researcher.

Table: 5.9 (a) Panel Autoregressive model for lower-income Sub-Saharan Africa countries

```
Panel vector autoregresssion


GMM Estimation

Final GMM Criterion Q(b) =   1.03e-31
Initial weight matrix: Identity
GMM weight matrix:      Robust
                                                    No. of obs      =         96
                                                    No. of panels   =          8
                                                    Ave. no. of T   =     12.000
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
GROWTH						
GROWTH						
L1.	.3815911	.1625816	2.35	0.019	.062937	.7002452
L2.	.0118142	.109053	0.11	0.914	-.2019258	.2255543
DDHEALTH						
L1.	1.047796	.5964274	1.76	0.079	-.12118	2.216772
L2.	.0181773	.6729087	0.03	0.978	-1.3007	1.337054
DDLA						
L1.	.493637	.2904296	1.70	0.089	-.0755946	1.062869
L2.	.2299989	.1935439	1.19	0.235	-.1493402	.609338
DGFCF						
L1.	-.0328027	.0243796	-1.35	0.178	-.0805859	.0149804
L2.	.0229006	.0198116	1.16	0.248	-.0159295	.0617307
DTO						
L1.	.0063095	.0135643	0.47	0.642	-.0202761	.0328951
L2.	.0175801	.0123569	1.42	0.155	-.0066389	.041799
DDHEALTH						
GROWTH						
L1.	-.0151045	.0089293	-1.69	0.091	-.0326055	.0023965
L2.	-.00928	.0060877	-1.52	0.127	-.0212117	.0026518
DDHEALTH						
L1.	-.0242393	.1762647	-0.14	0.891	-.3697117	.3212331
L2.	.1329323	.0814436	1.63	0.103	-.0266943	.2925589
DDLA						
L1.	.008341	.0304425	0.27	0.784	-.0513252	.0680072
L2.	.0201334	.046688	0.43	0.666	-.0713735	.1116402
DGFCF						
L1.	-.0026566	.0012973	-2.05	0.041	-.0051992	-.0001139
L2.	-.0006652	.0008586	-0.77	0.439	-.0023481	.0010177
DTO						
L1.	.0013988	.0014687	0.95	0.341	-.0014798	.0042774
L2.	.0016702	.0010473	1.59	0.111	-.0003824	.0037228
DDLA						
GROWTH						
L1.	-.0036205	.0456782	-0.08	0.937	-.0931481	.085907
L2.	.0342734	.0379839	0.90	0.367	-.0401737	.1087204
DDHEALTH						
L1.	-.0075363	.4500442	-0.02	0.987	-.8896068	.8745342
L2.	.6371274	.5994226	1.06	0.288	-.5377192	1.811974
DDLA						
L1.	.2239851	.0995726	2.25	0.024	.0288265	.4191438
L2.	.2152387	.117155	1.84	0.066	-.0143809	.4448582
DGFCF						
L1.	-.0006205	.008163	-0.08	0.939	-.0166198	.0153788
L2.	.000884	.0040931	0.22	0.829	-.0071382	.0089063
DTO						
L1.	-.0024656	.0051643	-0.48	0.633	-.0125874	.0076561
L2.	-.0006904	.0038584	-0.18	0.858	-.0082527	.006872
DGFCF						
GROWTH						
L1.	-.9959368	.9474692	-1.05	0.293	-2.852942	.8610686
L2.	-.042236	.9092548	-0.05	0.963	-1.824343	1.739871
DDHEALTH						
L1.	2.820367	4.515962	0.62	0.532	-6.030757	11.67149
L2.	2.773815	4.463036	0.62	0.534	-5.973575	11.5212
DDLA						
L1.	1.64871	1.958317	0.84	0.400	-2.18952	5.48694
L2.	9.99413	3.281328	3.05	0.002	3.562846	16.42541
DGFCF						
L1.	.0823123	.1035042	0.80	0.426	-.1205521	.2851768
L2.	-.2322837	.1031923	-2.25	0.024	-.4345369	-.0300304
DTO						
L1.	.1455218	.0886667	1.64	0.101	-.0282618	.3193053
L2.	-.0447967	.0705963	-0.63	0.526	-.183163	.0935695
DTO						
GROWTH						
L1.	1.568756	1.333687	1.18	0.239	-1.045223	4.182734
L2.	2.113093	1.529087	1.38	0.167	-.883863	5.110049
DDHEALTH						
L1.	1.951595	6.43293	0.30	0.762	-10.65672	14.55991
L2.	-2.449959	8.524763	-0.29	0.774	-19.15819	14.25827
DDLA						
L1.	.9187536	2.844057	0.32	0.747	-4.655496	6.493003
L2.	4.007028	3.256299	1.23	0.218	-2.375201	10.38926
DGFCF						
L1.	.1453169	.2089518	0.70	0.487	-.264221	.5548548
L2.	.1682905	.1613703	1.04	0.297	-.1479894	.4845704
DTO						
L1.	-.1614254	.1486114	-1.09	0.277	-.4526983	.1298476
L2.	.1357538	.1124447	1.21	0.227	-.0846337	.3561413

Tables 5.10 (a) Serial correlation test for lower-income Sub-Saharan Africa countries

VAR Residual Serial Correlation LM Test
Null Hypothesis: no serial correlation at lag order h
Date: 07/15/20 Time: 20:36
Sample: 2000 2016
Included observations: 96

Lags	LM-Stat	Prob
1	29.17090	0.2568
2	35.44392	0.0805
3	17.40094	0.8667

Probs from chi-square with 25 df.

Table 5.11 (a) Heteroskedasticity results for lower-income Sub-Saharan Africa countries

VAR Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Date: 07/15/20 Time: 20:26
Sample: 2000 2016
Included observations: 96

Joint test:

Chi-sq	Df	Prob.
535.4284	150	0.5034

Table 5.12 (a) Normality results for lower-income Sub-Saharan Africa countries

VAR Residual Normality Test
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 07/15/20 Time: 20:18
Sample: 2000 2016
Included observations: 96

Component	Skewness	Chi-sq	Df	Prob.
1	-1.917687	5.775804	1	0.1300
2	-0.414192	2.601913	1	0.1067
3	0.152076	0.350761	1	0.5537
4	1.756540	6.795736	1	0.4500
5	-0.614488	5.726866	1	0.0567
Joint		18.2511	5	0.2019

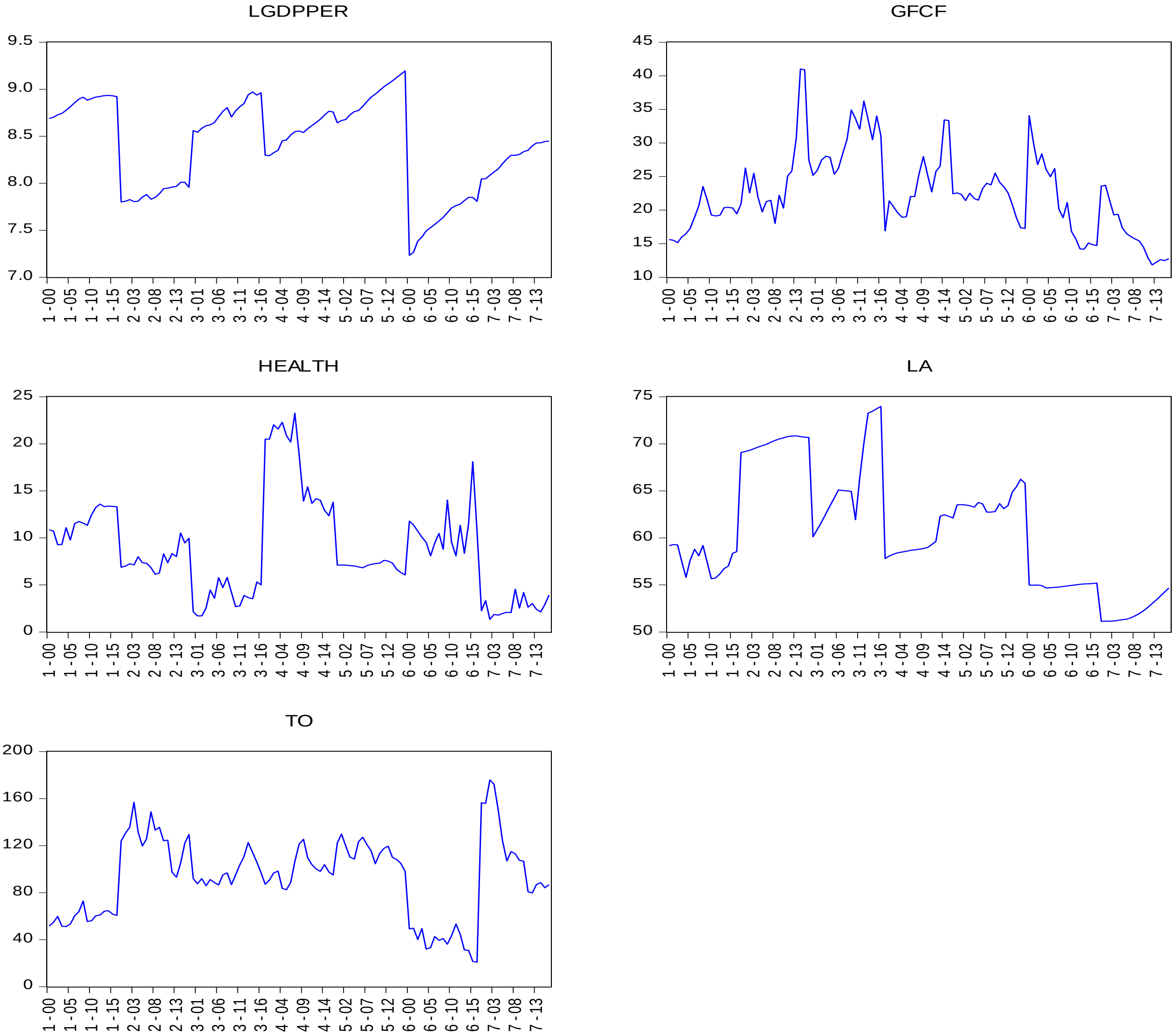
Component	Kurtosis	Chi-sq	Df	Prob.
1	9.238335	4.155963	1	0.8820
2	3.911946	3.153324	1	0.0758
3	3.791523	2.375511	1	0.1233
4	9.241299	1.766999	1	0.3200
5	3.406174	1.625538	1	0.4290
Joint		11.4138	5	0.0000

Component	Jarque-Bera	Df	Prob.
1	2.335784	2	0.5876
2	3.755237	2	0.9063
3	2.726272	2	0.6759
4	2.495676	2	0.7913
5	25.352403	2	0.6917
Joint	34.66496	10	0.0002

Results of appendices: Appendix B

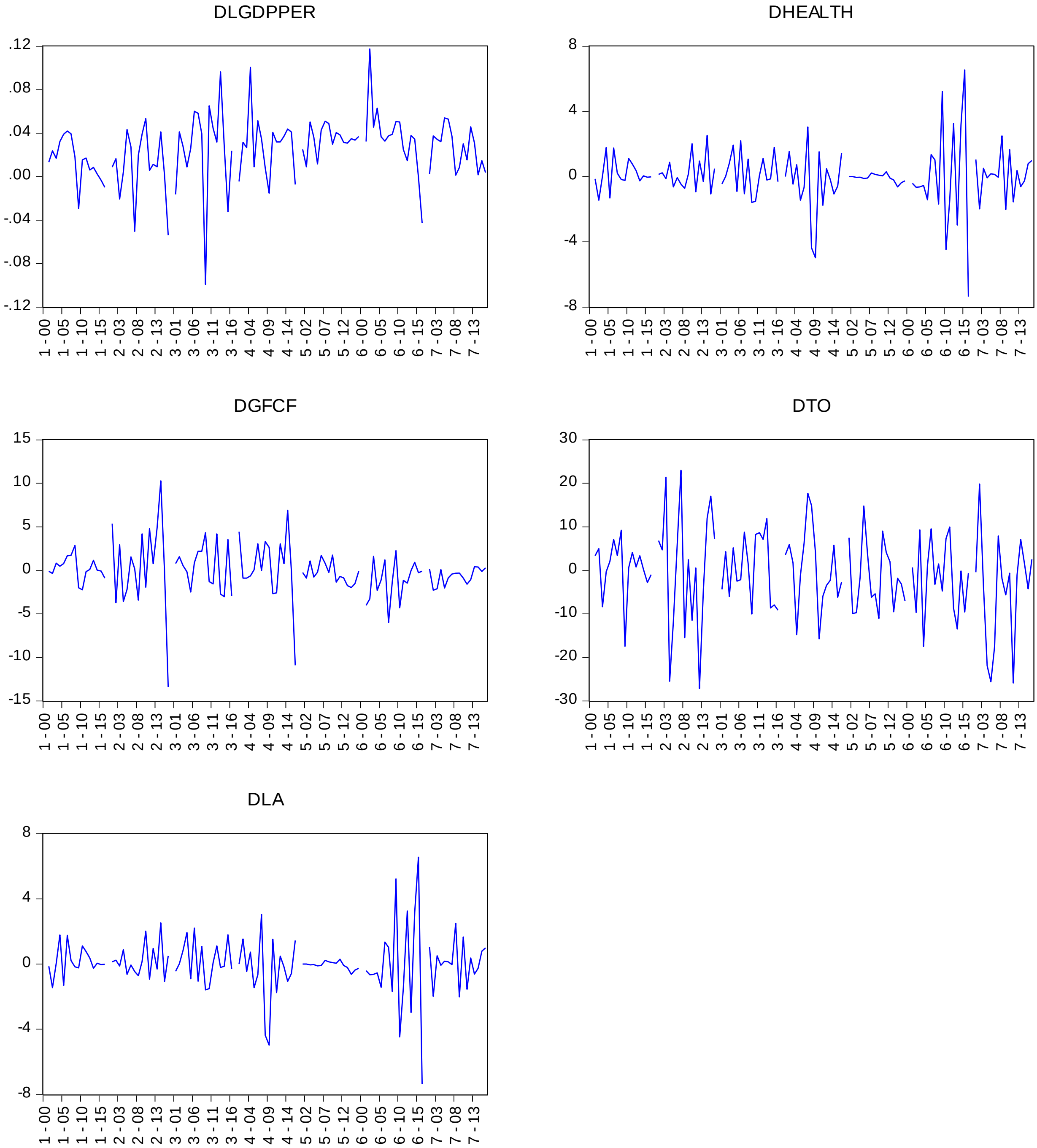
Appendix B : PVAR results (Mode 2) Middle - Income for Sub-Saharan Africa

Figure 5.1 (b) Unit root test at level form



Source: Estimated by researcher

Figure 5.1 (b) Graphical unit root test after first difference



Source: Estimated by researcher.

Table 5.3 (b) Unit root stationarity test results for middle-income Sub-Saharan Africa countries

Variables	T-Statistics	Probability	Lag length	Integrated order	Restriction
GROWTH	-4.6643	0.0000	1	I(0)***	Intercept and no trend
HEALTH	-3.6574	0.3425	0	I(0)	Intercept and no trend
DHEALTH	-10.5465	0.1567	0	I(1)	Intercept and no trend
DDHEALTH	-2.6767	0.0000	1	I(2)***	Intercept and no trend
TO	-8.7685	0.0691	0	I(0)*	Intercept and no trend
DTO	-5.6754	0.0000	1	I(1)***	Intercept and no trend
LA	-3.8767	0.8361	1	I(0)	Intercept and no trend
DLA	-5.8976	0.3654	0	I(1)	Intercept and no trend
DDLA	-6.7686	0.0.0000	1	I(2)***	Intercept and no trend
GFCF	-2.7865	0.2345	0	I(0)	Intercept and no trend

DGFCF	-1.5464	0.0200	1	I(1)**	Intercept and no trend

Source: Estimated by researcher (10% *, 5%** and 1% ***).

Table 5.4 (b) Lag selection criteria for middle-income Sub-Saharan Africa countries

Lag	J p-value	MBIC	MAIC	MQIC
1	0.30	-173.5491	-45.33166	-97.15923
2	0.71	-93.43724	-29.32854	-55.24232
3	0.45	.	.	.

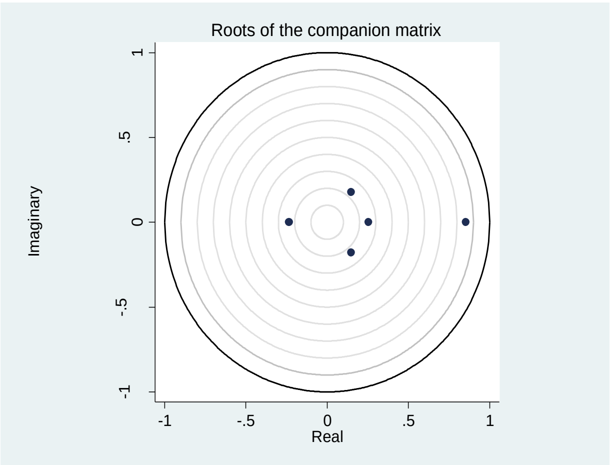
Figure 5.3 (b) AR root graph for middle-income Sub-Saharan Africa countries

Eigenvalue Stability

Eigenvalue		
Real	**Imaginary**	**Modulus**
0.9689	0	0.9689
0.7830	0	0.7830
0.2640	0	0.2640
-0.1881	0	0.1881
-0.0197	0	0.0197

All the eigenvalues lie inside the unit circle. PVAR satisfies stability condition.

Root of the companion matrix



Source: Estimated by researcher (pvarstable, graph).

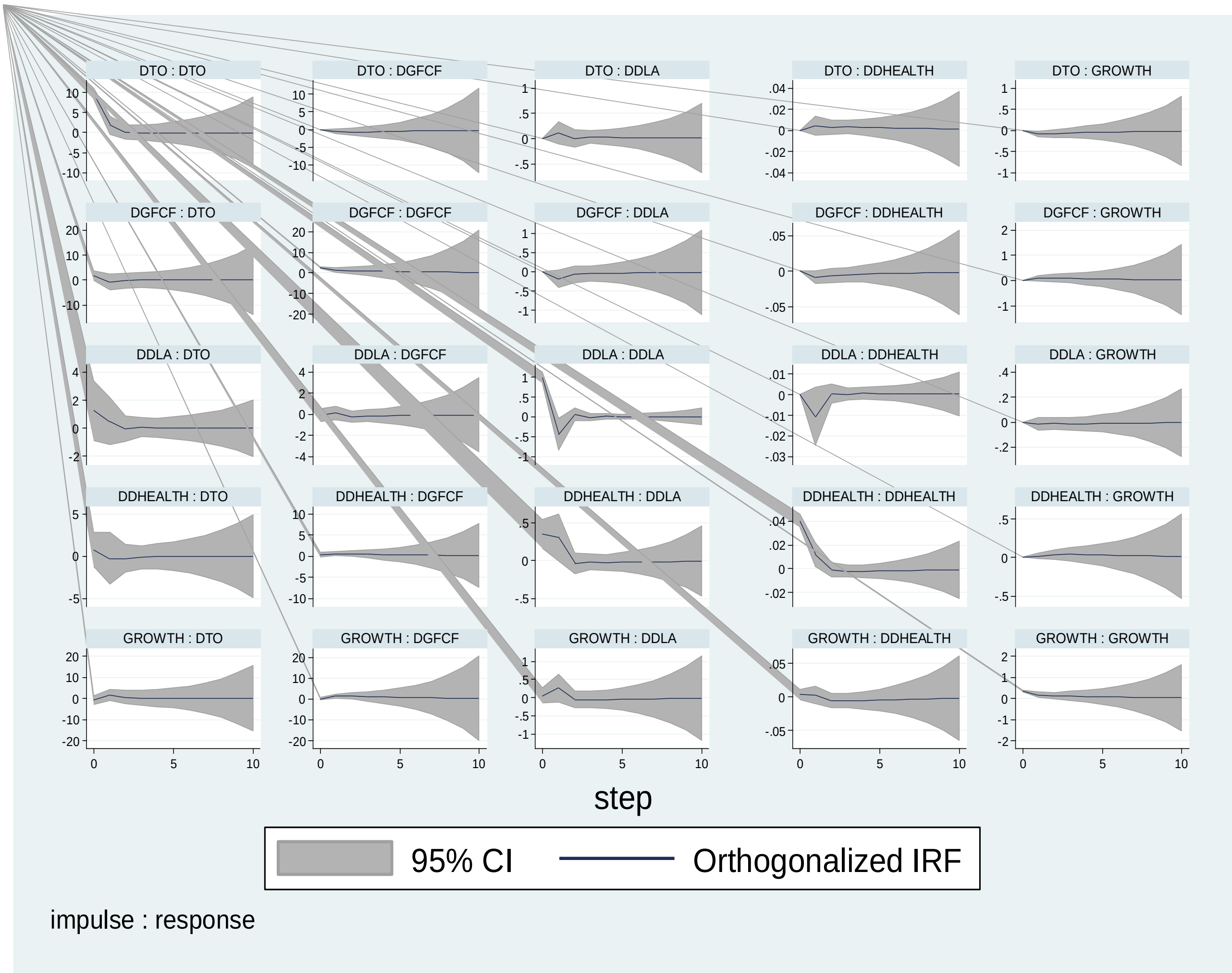
Table 5.6 (b) Health index for middle income Sub-Saharan Africa countries

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.76814	.691283	0.5894	0.5894
Comp2	1.07686	.921852	0.3590	0.9483
Comp3	.155004	.	0.0517	1.0000

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Unexplained
LLE	0.7227	0.0528	0.6892	0
BR	0.6142	0.5065	0.6052	0
PHIV	0.3171	0.8606	0.3985	0

Figure 5.5 (b) Impulse response function for middle income Sub-Saharan African countries



Source: Estimated by researcher.

Table 5.7 (b) Variance of Decomposition of Growth for middle-income Sub-Saharan Africa countries

Forecast-error variance decomposition

Response variable and Forecast horizon	GROWTH	DDHEALTH	DDLA	DGFCF	DTO
	Impulse variable				
GROWTH					
0	0	0	0	0	0
1	1	0	0	0	0
2	.9012938	.0024988	.0014576	.0467011	.0480487
3	.8266849	.0102922	.001859	.089117	.0720468
4	.7833953	.0183672	.0025424	.1130051	.0826899
5	.7577725	.0239727	.0030478	.126595	.088612
6	.7416174	.0276492	.0034022	.1349864	.0923448
7	.7309389	.0300888	.0036397	.1405018	.094831
8	.7236668	.0317501	.003802	.1442531	.096528
9	.7186176	.0329035	.0039147	.1468574	.0977068
10	.7150645	.0337152	.003994	.14869	.0985363
DDHEALTH					
0	0	0	0	0	0
1	.0075988	.9924012	0	0	0
2	.0104191	.8834562	.0573211	.0386849	.0101189
3	.0224599	.8526497	.0554002	.05572	.0137702
4	.0362022	.8273531	.053654	.0648151	.0179756
5	.0473861	.80848	.0525319	.0703366	.0212653
6	.0551782	.79518	.051723	.0741741	.0237446
7	.060683	.7857599	.0511595	.0768828	.0255148
8	.0645943	.7790551	.0507576	.0788138	.0267792
9	.0673962	.7742531	.0504701	.0801961	.0276845
10	.0694117	.770799	.0502634	.0811903	.0283357
DDLA					
0	0	0	0	0	0
1	.0022597	.112842	.8848982	0	0
2	.0465113	.1452931	.777386	.0232426	.0075671
3	.0480968	.144923	.7730854	.0263818	.007513
4	.0496706	.1444558	.7698047	.0279821	.0080868
5	.0514444	.1442672	.7668465	.0288875	.0085545
6	.0526102	.1441006	.764742	.029578	.0089692
7	.0534611	.1439895	.7631983	.0300815	.0092697
8	.0540739	.143909	.7620786	.0304492	.0094893
9	.0545199	.1438511	.7612644	.0307161	.0096484
10	.0548441	.1438091	.7606727	.03091	.0097641
DGFCF					
0	0	0	0	0	0
1	.0031633	.0132099	.0015289	.9820979	0
2	.1827625	.0392239	.0019336	.7468152	.0292649
3	.27051	.0536573	.0049813	.6177244	.0531271
4	.304116	.0586279	.0054745	.5625573	.0692244
5	.3213696	.0617434	.0059122	.5325859	.0783889
6	.3316055	.0637137	.0061542	.5145608	.0839659
7	.3382058	.065021	.0063198	.5029221	.0875314
8	.3426242	.0658996	.0064304	.4951325	.0899133
9	.3456556	.066503	.0065068	.4897883	.0915463
10	.3477707	.0669241	.00656	.4860593	.0926858
DTO					
0	0	0	0	0	0
1	.0056177	.0063643	.015365	.0337859	.938867
2	.0273479	.0065365	.0166128	.0383031	.9111996
3	.029953	.0071357	.0165484	.0390576	.9073053
4	.0300309	.0072955	.0165693	.0390462	.907058
5	.0300598	.0072958	.0165678	.0390837	.9069929
6	.0300931	.0072993	.0165664	.0391142	.906927
7	.0301248	.007305	.0165657	.0391338	.9068705
8	.0301495	.0073097	.0165653	.0391475	.9068281
9	.0301675	.0073131	.016565	.0391573	.9067971
10	.0301807	.0073156	.0165648	.0391645	.9067745

FEVD standard errors and confidence intervals are not saved. Use option **save**.

Table 5.8 (b) Granger causality results for middle-income Sub-Sahara Africa countries

panel VAR-Granger causality Wald test
Ho: Excluded variable does not Granger-cause Equation variable
Ha: Excluded variable Granger-causes Equation variable

Equation \ Excluded	chi2	df	Prob > chi2
GROWTH			
DDHEALTH	0.666	1	0.414
DDLA	0.000	1	1.000
DGFCF	2.825	1	0.093
DTO	5.513	1	0.019
ALL	8.812	4	0.066
DDHEALTH			
GROWTH	0.178	1	0.673
DDLA	2.030	1	0.154
DGFCF	3.308	1	0.069
DTO	0.911	1	0.340
ALL	4.532	4	0.339
DDLA			
GROWTH	1.744	1	0.187
DDHEALTH	5.002	1	0.025
DGFCF	2.232	1	0.135
DTO	0.698	1	0.403
ALL	7.402	4	0.116
DGFCF			
GROWTH	8.342	1	0.004
DDHEALTH	4.721	1	0.030
DDLA	0.620	1	0.431
DTO	2.445	1	0.118
ALL	16.011	4	0.003
DTO			
GROWTH	1.544	1	0.214
DDHEALTH	0.045	1	0.832
DDLA	0.060	1	0.806
DGFCF	0.507	1	0.476
ALL	3.241	4	0.518

Table: 5.9 (b) Panel Autoregressive (PVAR) model for middle-income Sub-Saharan Africa countries

```
Panel vector autoregresssion


GMM Estimation

Final GMM Criterion Q(b) =  1.06e-32
Initial weight matrix: Identity
GMM weight matrix:     Robust
                                                    No. of obs      =        91
                                                    No. of panels   =         7
                                                    Ave. no. of T   =    13.000
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
GROWTH						
GROWTH L1.	.4581997	.1671751	2.74	0.006	.1305425	.785857
DDHEALTH L1.	.376673	.4614601	0.82	0.414	-.5277723	1.281118
DDLA L1.	.0000122	.0232811	0.00	1.000	-.045618	.0456424
DGFCF L1.	.0390867	.0232537	1.68	0.093	-.0064896	.0846631
DTO L1.	-.0089971	.003832	-2.35	0.019	-.0165076	-.0014866
DDHEALTH						
GROWTH L1.	.0086211	.0204184	0.42	0.673	-.0313982	.0486404
DDHEALTH L1.	.4132827	.1851298	2.23	0.026	.050435	.7761304
DDLA L1.	-.0118288	.0083019	-1.42	0.154	-.0281001	.0044426
DGFCF L1.	-.0036723	.0020191	-1.82	0.069	-.0076298	.0002851
DTO L1.	.0004633	.0004855	0.95	0.340	-.0004882	.0014148
DDLA						
GROWTH L1.	.7682513	.5816755	1.32	0.187	-.3718117	1.908314
DDHEALTH L1.	12.05331	5.389231	2.24	0.025	1.490609	22.61601
DDLA L1.	-.4680575	.2294728	-2.04	0.041	-.917816	-.0182991
DGFCF L1.	-.0787354	.0527041	-1.49	0.135	-.1820336	.0245629
DTO L1.	.0109694	.0131259	0.84	0.403	-.0147569	.0366957
DGFCF						
GROWTH L1.	3.795641	1.314195	2.89	0.004	1.219866	6.371416
DDHEALTH L1.	9.819032	4.519213	2.17	0.030	.9615371	18.67653
DDLA L1.	.2480042	.3148674	0.79	0.431	-.3691244	.8651329
DGFCF L1.	.5709075	.276927	2.06	0.039	.0281405	1.113675
DTO L1.	-.0605855	.0387431	-1.56	0.118	-.1365207	.0153496
DTO						
GROWTH L1.	5.242877	4.219041	1.24	0.214	-3.026293	13.51205
DDHEALTH L1.	-8.386251	39.5626	-0.21	0.832	-85.92752	69.15502
DDLA L1.	.2043139	.8335905	0.25	0.806	-1.429493	1.838121
DGFCF L1.	-.4597303	.6453721	-0.71	0.476	-1.724636	.8051758
DTO L1.	.194843	.1216513	1.60	0.109	-.0435892	.4332752

Table 5.10 (b) Vector Autoregressive model serial correlation results for middle-income Sub-Saharan Africa countries

LM Test

Null Hypothesis: no serial correlation at lag order h

Date: 07/16/20 Time: 06:32

Sample: 2000 2016

Included observations: 91

Lags	LM-Stat	Prob
1	31.03538	0.1878
2	33.69764	0.1145
3	31.30244	0.1792

Prob from chi-square with 25 df.

Table 5.11 (b) Heteroskedasticity results for middle-income Sub-Saharan Africa countries

VAR Residual Heteroskedasticity Test: No Cross Terms (only levels and squares)
Date: 07/16/20 Time: 06:25
Sample: 2000 2016
Included observations: 91

Joint test:

Chi-sq	Df	Prob.
200.7916	150	0.2436

5.12 (b) Normality results for middle-income Sub-Saharan Africa countries

VAR Residual Normality Test
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 07/15/20 Time: 20:16
Sample: 2000 2016
Included observations:91

Component	Skewness	Chi-sq	Df	Prob.
1	-0.918697	5.97680	1	0.1543
2	0.434192	2.61793	1	0.1678
3	0.156086	0.36091	1	0.5675
4	1.796340	6.78523	1	0.3287
5	-0.683487	5.71796	1	0.5876
Joint		18.2511	5	0.2467

Component	Kurtosis	Chi-sq	Df	Prob.
1	9.238335	14.55968	1	0.8967
2	3.911946	3.153324	1	0.7344
3	3.791523	2.375511	1	0.6987
4	9.241299	2.906999	1	0.7584
5	3.406174	0.625538	1	0.8096
Joint		21.4138	5	0.2314

Component	Jarque-Bera	Df	Prob.
1	203.3354	2	0.6067
2	5.755237	2	0.6899
3	2.726272	2	0.6597
4	194.4956	2	0.7864
5	6.352403	2	0.7746
Joint	412.6649	10	0.0001