Energy Use and Economic Growth in the Southern African Development Community (SADC)

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CONFIDENTIALITY CLAUSE

Date 2019-05-15

TO WHOM IT MAY CONCERN

RE: CONFIDENTIALITY CLAUSE

Due to the strategic importance of this research it would be appreciated if the contents remain confidential and not be circulated for a period of TWO years.

Sincerely,

REBECCA BETH AKINYI ONYANGO

DECLARATION

This research has not been presented before for any degree and is not being considered for any other degree at any other university at the moment.

I declare that this Dissertation contains my own work except where specifically acknowledged.

Student Name and Number

Signed…… [redacted]……………………………………..

Date…………31/03/2021……………………………………….

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Secondly, I thank my dear family for the sacrifice they had to take while waiting for me to complete the research work of this dissertation.

I sincerely thank God for He continuously takes good care of me.

LIST OF ABBREVIATIONS AND ACRONYMS

SADC: Southern African Development Community

WDI: World Development Indicators

REM: Random Effects Model

FEM: Fixed Effects Model

USA: United States of America

TY: Toda-Yamamoto

ARDL: Auto-regressive Distributive Lag model

FDI: Foreign Direct Investment

EI: Environmental Impact

GDP: Gross Domestic Product

EGARCH: Exponential Generalized Autoregressive Conditional heteroscedastic

UK: United Kingdom

OECD: Organization for Economic Co-operation and Development

PQR: Panel Quintile Regression

STR: Smooth Transition Regression

OLS: Ordinary Least Squares

BM: Broad Money

INF: Inflation

GFCF: Gross Fixed Capital Formation

VIF: Vector Inflation Factor

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Energy is a very fundamental resource in the growth of any economy since all activities require energy in any given form. Literature indicates that increase in energy use leads to increase in economic growth. However, such has not been the case in Southern African Development Community (SADC) regional bloc. The main objective of the study is to determine the effect of energy use on economic growth in the SADC member states. The specific research objectives include; establishing the trend of energy use and growth of the economy of member countries of SADC and secondly, to determine the effect of energy use on growth of the economy of the SADC member states. The study sourced full year data for ten SADC member states from the World Development Indicators (WDI) database of the World Bank as well as the official government(s) publications (Statistical Abstracts, Economic Surveys) for these countries for the period 2000 to 2014. The covariates adopted in moderating the relationship include money supply, inflation rates and gross fixed capital formation. The theoretical framework followed the Solow model of long-run economic growth where a panel data modeling technique was employed in estimation of the hypothesized connection. Causality between energy use and economic growth was examined for each of SADC member state. The research found that all countries under study had bi-directional causality between energy use and economic growth except DRC and Tanzania which demonstrated a causality running in a uni-directional way from use of energy to economic growth. Causality in SADC states such as Mozambique, Namibia, South Africa, Zambia and Zimbabwe were not established as the data was missing in some years. The major pre and post estimation diagnostic issues were examined before undertaking an econometric estimation. The significance of the coefficients were tested at 5 percent level. Fixed Effects Model (FEM) was preferred to Random Effects Model (REM) based on Hausman model specification test. The study revealed that for a 1% increase in energy use, growth of economy rose by 19.07 percent (p=0.027) holding other factors constant. This implies that economic growth grows as consumption of energy rises significantly. Money supply and inflation rates were significant covariates. The study suggests to the governments to procure enough amount of energy in a quality-conscious, cost-effective and safe manner without any interruption to achieve sustainable goals of growth and to boost their standards of living. If the SADC economic bloc experiences a lack of energy resources, it will either choose to accept low growth of economy through production with the existing resources of energy or try to increase growth by meeting the uncovered part of demand for energy through imports.

OKUFINGQIWE

Amandla ayisisekelo esibaluleke kakhulu ekukhuleni kwanoma yimuphi umnotho ngoba yonke imisebenzi idinga amandla nganoma iyiphi indlela enikeziwe. Izincwadi zikhomba ukuthi ukwanda kokusetshenziswa kwamandla kuholela ekukhuleni komnotho. Kodwa-ke, lokhu bekungenzeki ebudlelwaneni besifunda seSouthern African Development Community (SADC). Inhloso enkulu yalolu cwaningo kwakuwukuthola umphumela wokusetshenziswa kwamandla ekukhuleni komnotho emazweni ayi-16 eSADC. Izinhloso ezithile zocwaningo zifakiwe; ukusungula inkambiso yokusetshenziswa kwamandla nokukhula komnotho emazweni angamalungu e-SADC futhi okwesibili, ukuthola umphumela wokusetshenziswa kwamandla ekukhuleni komnotho emazweni angamalungu e-SADC. Ucwaningo luthole imininingwane yonyaka ogcwele yamazwe ayishumi angamalungu e-SADC kusuka ku-database ye-World Development Indicators (WDI) yeBhange Lomhlaba kanye nezikhulu zikahulumeni (Statistical Abstracts, Economic Surveys) zala mazwe zesikhathi sika-2000 kuya ku-2014. Ama-covariate amukelwe ekwengameleni ubudlelwano afaka imali ukuphakela, amanani emali kanye nokwakhiwa kwemali engaguquki. Uhlaka lwethiyori lulandele i-Imodeli yeSolow yokukhula komnotho okuqhubeke isikhathi eside, lapho inqubo yokwenza imodeli yedatha yephaneli yayikhona kuqashwe ekulinganisweni koxhumano olucatshangwayo. Ucwaningo phakathi kokusetshenziswa kwamandla Kanye nokukhula komnotho lwenziwe izwe ngalinye eliyilungu le-SADC. Kutholakale ukuthi onke amazwe angaphansi kocwaningo abenenkinga ebhekise kokubi phakathi kokusebenzisa amandla nokukhula komnotho ngaphandle kweDRC neTanzania, okukhombise ukuthi inkinga ethile isebenza ngendlela eqonde ngqo kusuka ekusetshenzisweni kwamandla kuya ekukhuleni komnotho. Izizwe ze-SADC ezifana neMozambique, iNamibia, iNingizimu I-Afrika, iZambia neZimbabwe azange zisungulwe njengoba imininingwane ibingatholakali eminyakeni ethile. Izinkinga ezinkulu zokuxilonga zangaphambi nangemuva kokuhlolwa zahlolwa ngaphambi kokwenza ukulinganiswa kwezomnotho. Ukubaluleka kwama-coefficients kuhlolwe ezingeni lamaphesenti awu-5. Kulinganiswe I-Effects Model (FEM) yayincanyelwa i-Random Effects Model (REM) ngokususelwa kuHausman imodeli yokucaciswa kwemodeli. Ucwaningo luveze ukuthi ukwenyuka ngo-1% ekusetshenzisweni kwamandla, ukukhula komnotho kukhuphuke ngamaphesenti ayi-19.07 ($p = 0.027$) ubambe ezinye izinto njalo. Lokhu kusho ukuthi umnotho uyakhula njengoba ukusetshenziswa kwamandla kukhuphuka kakhulu. Ukunikezwa kwemali namanani entengo babengama-covariate abalulekile. Ucwaningo luphakamisa ukuthi ohulumeni bathole inani elanele le-amandla ngendlela eseqophelweni eliphezulu, engambi eqolo, ephephile ngaphandle kokuphazamisa ukufeza izinhloso ezizinzile zokukhula nokukhuphula amazinga abo okuphila. Uma umfelandawonye wezomnotho weSADC uhlangabezana nokushoda kwezinsizakusebenza zamandla, kungaholela ukukhula okuphansi komnotho ngokukhiqizwa ngezinsizakusebenza ezikhona zamandla noma zokuzama ukukhulisa ngokuhlangana ne-yembula ingxenye yesidingo samandla ngokungenisa ngaphakathi.

CHAPTER ONE

1.0 INTRODUCTION

This introductory chapter provides the background of study, the objectives, research questions and justification of study.

1.1 Background of the Study

The rate of growth of globalization has resulted in integration of countries in various aspects such as economic, political and social as well as stiff competition among countries of the 21st century both developed and developing. The rising competition among countries is as a result of increased economic growth which is linked to massive use of energy (Shahbaz, Mahalik, Shahzad & Hammoudeh, 2019). Energy is an important ingredient for the life of human on earth. It is used in all societal activities, for meal preparation, cloth making, building houses, among other activities (Batool & RoufBhat, 2019). Human beings have required and used energy at a growing rate for their sustenance and well-being.

Energy is therefore a very fundamental resource in the growth of any economy since all activities require energy in any given form (Gomez-Exposito, Conejo, & Canizares, 2018). Economic growth has been postulated to have a direct relationship with energy consumption. According to Alam (2006), energy is the key force being used to drive all activities in any given economy. Consumption of energy goes hand in hand with the national product (Ojinnaka, 2008). Suffice it to say, consumption of energy is a significant indicator of economic growth. It is used in almost all production processes and as a result, foreign earnings have increased due to exportation of energy products. In the process of marketing, production and exploration, many less developed countries have benefited greatly from technology transfer.

However, models have been developed by resource economists to include the role played by various economic resources with the inclusion of energy as the main resource. Availability and use of energy steers growth in an economy and these ideas continue to be segregated in the economics field (Bayar & Gavriletea, 2019). Great criticism has been subjected to the mainstream theory of growth based on a number of circumstances, more especially on the basis of thermodynamics implications for long run economy prospects and economic production. Extensive empirical work has investigated the energy role in the growth process. Main findings are that energy utilized per economic output unit has decreased, but this is to some extent since there is a shift in use of energy from direct utilization of fossil fuels like coal to the utilization of higher quality fuels such as electricity. In case this shift in final energy use consumption is accounted for, energy utilization and the economic activity level remain fairly and tightly coupled. On the same note, time series analysis demonstrate that GDP and energy co-integrate as energy utilization Granger causes GDP when more variables like production inputs and energy prices are incorporated (Shuai & Zhou, 2019).

According to Yoo (2009), the relationship between the growth of economy and consumption of energy has been a discipline for greater research and development. Financial and business economists put more emphasis on the effect of energy prices on growth of economy, but mainstream economic growth theory pays little attention on energy's role in promoting economic growth despite the fact that there are detrimental consequences on the environment as a result of consumption of energy. Moreover, energy plays a big role in growth of economy of developed and countries that are developing.

For instance theories such as causal effect theories, neoclassical growth theory and endogenous growth theory plays a significant role in this study. Theories on causal effect shows the direction of causality and since there is a connection between economic growth and use of energy, the hypothesis of neutrality is rejected since it denies the direct link between consumed levels of energy in a country with the growth of the country's output levels (Armstrong & Kepler, 2018). Neoclassical growth theory shows long run growth of the economy and this explains use of energy in accelerating long run growth of the economy (Abreu, 2021). On the other hand, endogenous growth theory is attributed to use of labor and capital with regard to growth of the economy (Cozzi, 2017). As output is a function of labor and capital, it can be redefined as a function of energy use, broad money, inflation and gross fixed capital formation in this study.

Figure 1.1 shows the trend in economic growth for the Southern African Development Community member states.

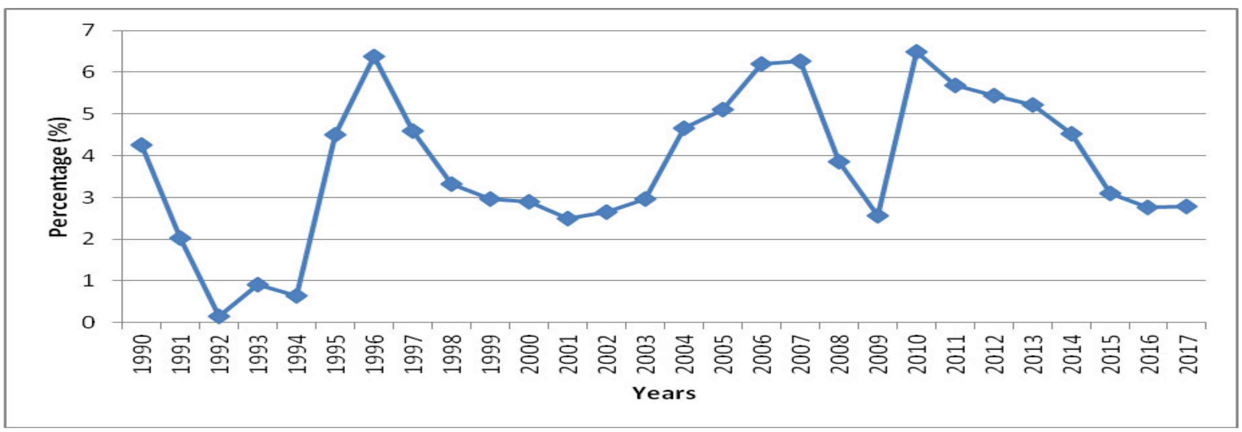

Figure 1.1: Regional Economic Performance (SADC) from 1990 to 2017

Source: World Bank (2019)

Figure 1.1 gives the variation of economic growth for the SADC countries from 1990 to 2017. It is evident that economic growth undergoes various phases that is, increasing and decreasing phases. For instance in 1990, economic growth recorded is 4.26 percent. It decreased to 2.89

percent in 2000 and later increases to 6.48 percent in 2010. The economic growth for the SADC countries again decreases from 6.48 percent in 2010 to 2.78 percent in 2017. Increase in the growth of economy is attributed to increase in government expenditure and recent improvements of investment in the industry sector. Removal of tariffs amongst the member states have also contributed to increase in economic growth since movement of goods across the borders is tax-free hence increasing revenue to the respective countries. On the other hand, a decrease in economic growth is attributed to misuse and embezzlement of funds in most of the member states (Thayer, 2018). The decrease in economic growth is also attributed to drought which has impacted most of the member states thus decreasing yield from agriculture sector.

Unlike other goods of consumption, energy demand is a demand that is derived as it is not valued for itself but for what can be done with it, that is; it is not wanted for its own good but rather for the heat and light which it can offer (Gillingham, Rapson & Wagner, 2016). Consumption of energy is also attached to urbanization as the growth of urbanization normally leads to a different use of land, such as expansion of industries, transportation, infrastructure and the use of domestic related appliances (Bekhet & Othman, 2017; Bilgili, Koçak, Bulut & Kuloğlu, 2017). Bekhet & Othman (2017) concur that the rise in urbanization boosts consumption of energy as the need for goods and services may improve with time. The United States of America (USA) is a country that is highly urbanized and industrialized and has a high energy consumption. Today, for example, the sector of industrialization in the USA uses 22% of the country's energy (Holland, Scott, Flörke, Brown, Ewers, Farmer, & Barrett, 2015). Each industry uses energy, but six industries that are energy-intensive use most of the consumed energy by the sector of industrialization. However, technologies that are advanced allow industries to use less energy to do more. Also, the sector of transportation uses over 28% of the supplied energy to move goods and people from one point to another (Holland, Scott, Flörke, Brown, Ewers, Farmer, & Barrett, 2015).

Energy can be classified into different categories including; primary and secondary energy, commercial energy and non-commercial energy, and lastly renewable and non-renewable energy (Mubeen & Maji, 2018). In the first category, the common primary sources of energy are oil, coal, biomass and natural gas (such as wood). Other primary sources of energy available include nuclear energy from substances that are radioactive, thermal energy stored in the interior of the earth, and potential energy due to the Earth's gravity (Hewitt, & Collier, 2018).

In the second category, commercial energy are sources of energy that are present in the market for a price that is definite (Chandra, Mubeen & Maji, 2018). By far the most significant commercial energy forms are coal, electricity and refined products of petroleum. The sources of energy that are not present in the commercial market for sale are categorized as non-commercial energy. These sources comprise fuels such as cattle dung, firewood and wastes from the agricultural sector, which are gathered traditionally, and not bought at any price and used mostly in households in rural areas. These are also called traditional fuels. It should be noted that Non-commercial energy is always ignored in accounting of energy (Li, Chen & Liu, 2019).

In the third category, inexhaustible energies that are mostly based on biomass and are available in an infinite amount naturally. Since these can be renewed over a short period of time relatively, energy sources that are replenished more rapidly are termed as renewable (Aschilean, Rasoi, Raboaca, Filote & Culcer, 2018). These include fuel wood from forest, petro plants, plant biomass that is; agricultural waste like animal dung, wind energy, solar energy, water energy in the form of hydro-electricity and tidal energy and geothermal energy among others. Non-renewable energy (exhaustible) on the other hand is available in finite amount and develops over a longer time (Neri, Coscieme, Giannetti, & Pulselli, 2018). Due to unlimited use, they are likely to be exhausted one day. These include mineral, coal, nuclear power and natural gas. Coal, natural gases and petroleum are common energy sources being organic (biotic) in this origin. They are also known as fossil fuels.

Efficiency of energy relies both on the kind of fuel used and on the attributes of specific appliances (Gaglia, Dialynas, Argiriou, Kostopoulou, Tsiamitros, Stimoniaris, & Laskos, 2019). In many countries that are developing including SADC states, specifically in rural regions, fuels of traditional, such as fuelwood, agricultural waste and charcoal, incorporate a big portion of household consumption of energy in total. Energy use for the Southern African Development Community states is as given in Figure 1.2.

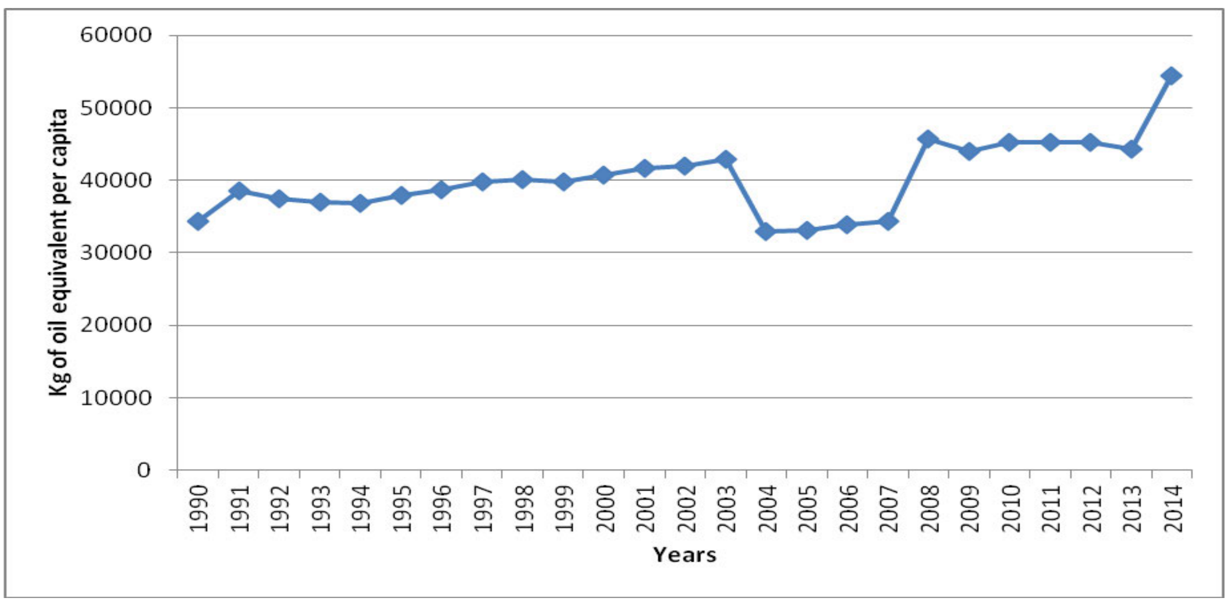

Figure 1.2: Energy Use for the SADC States from 1990 to 2014.

Source: World Bank (2019)

Figure 1.2 gives the variation of energy use for the SADC countries from 1990 to 2014. It is evident that energy use has increased, as in 1990 it was 34373.64 Kg of oil equal in value per capita and by 2000 it rose to 40731.33 Kg of oil equal in value per capita (World Bank, 2019). It again increases to 45309.41 Kg of oil equal in value per capita in 2010 with a further increase to 54448.85 Kg of oil equal in value per capita in 2014. This increase is attributed to increase in development projects which require more energy in most of the member states.

1.2 Statement of the Problem

Energy use is a key resource which enhances economic growth in many economies despite having detrimental consequences to the environment (Magazzino, 2015). Generally, the increase in energy use results to increase in economic growth but this is not the case while considering the Southern African Development Community regional bloc. It is evident that while there is increase in energy use from early 1990s, on the other side there is a decrease in the growth of the economy (Chang, 2016). Even though it increased in 2010, it again decreased in 2017 despite continued increase in energy use.

Many studies have been done to determine the link between use of energy and growth of the economy in different nations such as Akinlo (2009), Shahbaz, Mihai, Tiwari, (2012), Magazzino (2015), Hirsh et al. (2015), Sama et al. (2016), Shahbaz, Zakaria, Shahzad and Mahalik (2018) and Tariq, Huaping, Haris and Yusheng (2018). These studies apart from having shortcomings, mostly with respect to their techniques of estimation, little if any has a focus on the Southern African Development Community trading bloc. On the same note, some of the studies have shown conflicting results on how energy use affects economic growth. For instance, a study by Akinlo (2009) in Nigeria on consumption of electricity and economic growth show that there is a bi-directional causal association between the growth of the economy and consumption of electricity. Yang, Wu, Schuler, Sebastian, Popat, Yamamoto, & Lu, (2015), also on the growth of the economy and consumption of electricity, explored altered trends on the interconnection between energy consumption and economic growth. A study by Sama, and Tah (2016) in Cameroon established a positive connection between the consumption of energy and gross domestic product. Shahbaz et al. (2018) show a positive connection between the growth of the economy and consumption of electricity. Tariq et al. (2018) establish that increase in the growth of the economy results to an increase in the consumption of energy.

Decreasing tendency of economic growth despite increase in use of energy poses many questions on how energy use influences economic growth of developing countries. Therefore, the reason for this study is to determine the effect of energy use on the growth of economy in the Southern African Development Community member states using appropriate econometric models.

1.3 Research Questions

The questions of the research include:

i. What are the trends of the growth of economy and energy use of the Southern African Development Community member states?

ii. What is the direction of causality between energy use and growth of economy for Southern African Development Community member states?

iii. How is the economic growth of Southern African Development Community member states affected by energy use?

1.4 Research Objectives

The main goal of the study is to determine the impact of energy use on the growth of economy in the Southern African Development Community member states.

The specific research objectives include:

i. Establishing the trend of energy use and economic growth of the Southern African Development Community member states.

ii. To inspect the causality direction between energy use and the growth of economy for Southern African Development Community member states.

iii. Determining the impact of energy use on the growth of economy of the Southern African Development Community member states.

iv. To provide appropriate policy implications to enhance the growth of economy of the region.

1.5 Significance of the Study

The findings of this study are of great importance in different ways:

1.5.1 Governments of the member states

The trend of energy use and economic growth is of great significance to governments of various member states. The member countries will be informed on the use of energy and the trend in economic growth and depending on the relationship, they may either increase or decrease energy use so as to cause a boost in the growth of economy. The extent to which energy use influences the growth of economy of the member states is also of significance as it would be clear to member states if the effect is statistically significant.

1.5.2 Policy Makers of the Member States

The policy makers of the member states may also benefit since they know the extent to which energy use affects economic growth. This forms the basis for forecasting and the level of resource distribution to various sectors of the economy.

1.5.3 Future Researchers

The study also forms the basis for future study. Future researchers may identify the knowledge gap and therefore explore more on the trend of the growth of economy and use of energy as well as the effect of use of energy on economic growth in other regional blocs in Africa.

1.6 Scope of the Study

The study hubs on the Southern African Development Community member states which include; Angola, Botswana, Comoros, Democratic Republic of Congo, Eswatini, Madagascar, Lesotho, Malawi, Mauritius, Namibia, Mozambique, South Africa, Seychelles, United Zambia, Republic of Tanzania and Zimbabwe. The study considered a total number of 15 years from 2000 to 2014. This limitation is due to the availability of data from World Bank database till 2014 for all SADC states.

1.7 Organization of the Study

The current chapter captures the study background and the problem statement. Furthermore, research questions are provided as well as research objectives, scope and significance of the study. Chapter two gives the literature review related to the study and the third chapter presents research methodology, whereas chapter four gives the empirical study findings and chapter five captures the summary, conclusions of the study, policy implications and areas for further study.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

The overall goal of this chapter is to show how significant this study's field, which is how the use of energy and economic growth have been with respect to the amount of research they attracted. Relevant papers on SADC and papers on other regions identifying the gaps left and how this thesis intends to fill those gaps concerning SADC countries are discussed. In addition, the chapter gives a theoretical base upon which this study stands, this is besides the insights on the nature of previous research which are the main guide with regard to selected theories.

2.2 Review of Theoretical Literature

Well-known theoretical frameworks have been applied in the studies of the connection between consumption of energy and growth of the economy. In other studies, the term causality in its various forms dominates. In one form, causality refers to the relationship between events where one set of occurrence, is a direct consequence of another set of events (Bildirici, 2013).

2.2.1 Theories on Causal effect

In this context, the question has been on the direction of causality, if at all a connection exists between use of energy and growth of the economy. Several authors have proposed different hypotheses. These hypotheses according to Bildirici (2013) include: the hypothesis of neutrality, feedback, conservation and growth. **Hypothesis of Neutrality**: The theory denies the existence of a direct link between consumed levels of energy in a country with the growth of the country's output levels. According to Asafu-Adaye (2000) and Jumbe (2004), this hypothesis suggests that the policies targeted at supporting the resources of energy have no outcome on the growth of economy.

Hypothesis of Feedback: The hypothesis claims existing of a bidirectional causality connection between the consumed energy and a country's growth levels of output. The two are complementary such that an increase or a decrease in one of the variables leads to a corresponding increase or decrease in the other variable (Shahbaz and Lean, 2012).

Hypothesis of Conservation: It supposes the energy use and economic growth relationship to only run from the growth of economy to used levels of energy in a country. Consequently, the claim is that, because it is economic growth which increases the level of consumed energy in a country, such economies are scarcely dependent on energy hence can adopt energy conservation policies without negatively affecting output levels. For example, an economy will not be affected by policies as "phasing out energy subsidies" (Mehrera, 2007).

Lastly, the **Hypothesis of Growth**: It counters the preceding hypothesis; it too proposes a one directional cause effect relationship. However, unlike the conservation hypothesis, this hypothesis proposes energy use as one of the determining factors of the growth of economy (Ghosh, 2002; Narayan and Smyth, 2005). The theory therefore sees the economy of a country to be energy dependent to the extent that the level of energy consumed reduction will consequently decrease the country's growth of the economy.

2.2.2 Neoclassical Growth Theory

The Solow growth model (Solow, 1956) is an economic model of long run growth of the economy set within the economics neoclassical framework. The model assumes that theproduction function is increasing in inputs but exhibits constant return to scale, strict essentiality of all the inputs and diminishing marginal product. The model seeks to explain how the long run growth of the economy can be obtained through the use of the three factors of production namely; labour, capital and technology. According to the model, the equilibrium state can be achieved by varying the amount of inputs that enters the production function. The theory underscores the role of technology on economic growth and argues that growth will not be achieved if there is no technological advancement.

The views of the advocates of capital account liberalization as a means of realizing high economic growth can be demonstrated using this neoclassical paradigm. According to the model, energy consumption is beneficial to the SADC countries in three ways. First, it widens investments and output since it enhances capital productivity which can be used to accelerate the catching-up process by way of higher investment. Second, it advances the welfare of citizens in the region by reducing use of other traditional sources of energy like firewood which are associated to ill health. Third, energy use means use of improved technology and thus acceleration of technological innovations leading to increased industrialization which is a booster to economic growth.

2.2.3 Endogenous Growth Theory

Romer (1986) follows the economics of learning by doing attributed to Arrow (1962), where experience and increasing productivity are highly associated. The main intuition of the model is that progress that is technological is the impulsion behind the growth of economy and the aim is to explain the rate of growth that results from technological progress and invention. As opposed to Solow’s model where technological progress grows exogenously, Romer assumes that technological progress grows endogenously and includes the mechanism within his growth model. In this model, ideas increase the knowledge stock (A) and consequently raise the both capital and labour productivity. The model adopts a similar production function to the one advanced by Solow, but assumes A to be an endogenous factor. The outcome is a function of capital, labour, technological change and human capital. According to the model, the population increases constantly at a rate n, and the economy grows only if the technology is growing. The higher the population growth, the higher the progress that is technological and therefore the higher the long run growth of economy. Rebelo (1987) developed a linear function of production where output is a linear function of capital. The function of production is expressed as follows;

$$Y=AK \qquad 2.1$$

Where K is a composite representation of human and physical capital. The AK model does not exhibit decreasing returns to capital and implies a sustained growth of income per capita without any tendency of economy approaching the steady state. A rise in saving rate has a proportional impact to the growth of income per capita on a permanent basis. Rebelo established that technology does not need to exhibit linearity with capital for sustained growth, but sufficiency may be attained by relaxing the Inada conditions at infinity i.e. $Lim_{k\to\infty} f'(k) = b$ and b - σ > discount rate. The production function that satisfies this condition would be expressed in the form;

2.3 Empirical Literature Review

Empirically, results have been as diverse as the theories. Though not delved into, most recent studies employed a nonlinear relationship approach which led to the rising shift by most economists to undertake studies that examine nonlinear associations between economic variables

2.3.1 Causal connection between Consumption of Energy and Economic Growth

In light of the causal effect, it is apparent that a rising number of economists are shifting focus and engaging more into studies that examine nonlinear relationships between economic variables. They postulate that the relationship between the use of energy and variables of economy are likely to be nonlinear inherently including studies by Hamilton (2003), Huang et al. (2008), Chiou-Wei et al. (2008), Aloui and Jammazi (2009), Gabreyohannes (2010), Rahman and Serletis (2010), amid other authors.

Salahuddin and Gow (2019) conducted a study to examine the empirical impacts of 4 variables: growth of economy, consumption of energy, direct investment on foreign and financial development on quality of the environment in Qatar using a dataset of a time series from 1980–2016. Following suitable structural breaks co-integration tests and unit root in multiple, long - and short-run coefficients were determined through the Autoregressive Distributive Lag (ARDL) model application. The Toda-Yamamoto (TY) test of causality was carried out to decide the causal link, if any, between the variables. Estimated outcomes suggest a harmful long-run effect of the consumption of energy on all three quality environmental indicators. Foreign Direct Investment (FDI) has an effect that is negative in the long-run on quality of the environment when it is measured only by Environmental Impact (EI). Development of finance has no crucial effect on any of the signs. Bidirectional causality is noted among three variables: growth of economy, consumption of energy, and development of finance and all three signs of the quality of the environment.

Bakirtas, and Akpolat (2018) conducted a study to investigate the causal association between consumption of energy, urbanization and growth of the economy using Dumitrescu-Hurlin Panel

Granger Causality test for the period 1971–2014 in New Emerging-Market Countries (Colombia, India, Indonesia, Kenya, Malaysia, and Mexico). Bivariate and tri-variate panel Granger causality analyses which recognize joint causality effect from two series to another are applied. According to the analysis of bivariate, there is causality of panel Granger from the growth of economy to consumption of energy, and from urbanization to consumption of energy and growth of economy. According to the tri-variate analysis, there is causality of panel Granger from energy consumption and urbanization to economic growth, and from economic growth and urbanization to consumption of energy, and from consumption of energy and growth of economy to urbanization.

Cheng-Lang et al. (2010) analyzed causality between sectoral electricity usage in Taiwan using nonlinear and linear tests of causality and discovered nonlinear causality that is bi-directional among total consumption of electricity and level of output, and nonlinear causality that is unidirectional from the level of output to residential consumption of electricity. Moreover, Lee and Chang (2007) and Huang et al. (2008) assessed the consumption of energy and the growth of the economy causality. In their test, they separated countries into various groups by development level and found disparities in the direction of causality due to variations in level of development. Their outputs show that the causality between consumption of energy and growth of economy is not linear, and depends on level of output.

Another causality study by Chiou-Wei et al. (2008) between use of energy and levels of output for the USA and eight countries in Asia using linear and nonlinear causality tests revealed that the causality direction between use of energy and level of output in the cases of Indonesia, Malaysia, Taiwan and Singapore is changed whenever any likely nonlinearity in the interrelationship among the variables is not controlled for, but allowed for. Nonetheless, both tests of linearity and nonlinear causality indicate the same non-causality or causality direction in the cases of Hong-Kong, Korea, Thailand, Philippines, and the USA.

Furthermore, nonlinear connections between use of energy and growth of economy for 82 nations using threshold regression models were also analyzed by Huang et al. (2008). Using a range of candidates for the reign-switching variable, they confirmed important positive connection between consumption of energy and growth of economy for reigns related with minimum values of threshold. Nevertheless, no important connection or a crucial but negative connection was established among consumption of energy and output for variables of threshold that were optimal than certain levels of threshold. Likewise, Hamilton (2003) assessed nonlinear connection between GDP and oil changes in price, and found clear demonstration of nonlinearity. From his findings, it was discovered that increases in oil price affect GDP much more than decreases in the price of oil. Additionally, studies in the UK, Japan, and France using Markov switching EGARCH models to investigate the relationship between crude shocks of oil and markets of stock were also conducted by Aloui and Jammazi (2009). They determined that the reaction to the real market of stock result volatilities to crude shocks of oil is dependent of regime in all three markets.

Thus, in this dissertation, panel data is used to examine nonlinear causal connection between growth of economy and use of energy for SADC in particular. The causal linkages between consumption of energy and growth of economy are analyzed while controlling for other sources of growth like money supply, government spending, investment and other macroeconomic factors. Herein, it will disaggregate amongst various factors and the length thereof. This dissertation aims to provide a step towards such an understanding.

2.3.2 Impact of Energy Use on Economic Growth

Studies on the relationship between growth of economy and energy are diverse by scope (data period and types of variable analysis), sample countries, econometric methodologies (Soytas and Sari, 2003; Lee, 2006, Balcilar et al. 2010, Ozturk, 2010, Costantini and Martini, 2010). A study by Gozgor, Lau, & Lu (2018) developed a growth model that reflects the measure of economic complexity in efforts to ascertain capabilities for exporting the high value-added (sophisticated) products. Specifically, the study analyzed the impacts of the renewable and the non-renewable use of energy on the GDP in the panel data of 29 Organization for Economic Co-operation and development (OECD) nations between 1990 and 2013. Panel autoregressive distributed lag (ARDL) and the Panel Quintile Regression (PQR) estimation were used. It was established that not only the economic complexity, but also both the non-renewable and the renewable consumption of energy, are indisputably correlated with an optimal rate of growth of economy.

Gabreyohannes (2010) through nonlinear Smooth Transition Regression (STR) modelling approach, examined the consequence of price change on electricity usage, and discovered that changes in prices of electricity influence residential consumption of electricity asymmetrically in Ethiopia. Similarly, Rahman and Serletis (2010), using multivariate STR model, explored oil shocks of price and shocks of monetary effects that are asymmetric on macroeconomic activity for the USA. They established that all the oil prices and oil variability of price had a nonlinear effect on the output.

An empirical investigation was done to analyze the interrelation between use of energy and economic growth in top ten countries that consume energy including; China, Russia, the USA, Japan, Germany, India, Canada, South Korea, Brazil and France (Shahbaz, Zakaria, Shahzad, & Mahalik, 2018). The study used the quantile-on-quantile (QQ) method of Sim and Zhou (2015) to transverse some modulated characteristics of the growth of energy nexus and to capture the connection in its totality. The outputs show an indisputable relation between growth of economy and use of energy, with disparities that are considerable across economic states in each nation.

To investigate the nexus among clean use of energy, economic growth and discharges of Carbon Dioxide (CO_2), Cai, Sam, and Chang, (2018) employed a newly developed bootstrap ARDL bounds test with structural breaks to survey the cointegration and causality for G7 countries. They found absence of cointegration among exact GDP per capita, good use of energy and discharges of CO_2 in Canada, Italy, France, the UK and the USA. However, cointegration was shown to exist in Germany when exact GDP per capita and emissions of CO_2 serve as dependent variables and in Japan when emissions of CO2 is the variable that is dependent. Regarding the outputs of the test of causality, clean consumption of energy was found to cause real GDP per capita for Germany, the USA and Canada and discharges of CO_2 cause clean consumption of energy for Germany.

Another study was undertaken to examine the impacts of renewable use of energy on the economic growth of major countries that consume energy that is renewable in the world (Bhattacharya, Paramati, Ozturk, & Bhattacharya, 2016). Using the Renewable Energy Country Attractiveness Index, the study chose 38 top countries that consume energy that is renewable to describe the operation of growth from 1991 to 2012. With panel techniques of estimation, the results established dependence that is heterogeneity and cross-sectional across the nations. Moreover, the long-run evidence of dynamics between economic growth and traditional and related energy inputs were established. Results from elasticities outcome in long term, show that renewable use of energy has a merit indisputable effect on the outcome of the economy for 57 per cent of the selected nations. For agility, the researchers conducted analyses of time-series of long-run elasticities of output (Bhattacharya, Paramati, Ozturk, & Bhattacharya, 2016).

The significance of the renewable usage of energy for the security of energy across the globe and the environment are inarguable. Inglesi-Lotz (2016) explored the impact of renewable consumption of energy to growth of economy. The study took a panel data approach. Specifically, the study focused on estimating the effect of the renewable use of energy to economic well-being by using techniques of panel data. The findings indicate that the effects of use of renewable energy or its portion to the entire mix of energy to growth of economy is indisputable and significant statistically.

Bretschger (2015) did a study to examine growth, prices of energy, and the channels in between. The study presents stylized cross-country proofs for a negative connection between use of energy and growth of economy. Regarding this motivation, the researcher developed a multi-sectoral framework to derive the growth energy impact from first principles. The structural model is factually estimated for a sample of 37 developed nations with five-year data average since 1975–2009. Approximations of both systems of equations that is simultaneous and separate equations are performed. The factual results indicate a negative energy use impact on investments in formation of knowledge and physical capital. The approximations of simultaneous equations exhibit a dynamic energy use effect: reducing input of energy and increasing the prices of energy induced investments in addition to fostering growth in the long-run. Growth impacts counteract the disputable static effects of lower use of energy.

Raheem and Yusuf (2015) employed a set of data for 12 nations in Africa since 1980-2010. The study considered the likelihood of capturing both the non-linear and linear effect of energy use on growth of economy. According to the linear impact, the study used Ordinary Least Squares (OLS) method, while in the latest procedure, econometric of threshold auto regression of Hansen (1996) was applied for the model of nonlinear. The series of data used in this study was collected from world development indicator database of the World Bank. The Energy use-growth connection in most of the nations studied was disputable, though unimportant. Ramsey RESET Test outcomes indicate that the model of linear agonizes from an error called misspecification.

Taking a sample of 82 nations, Huang et al. (2008) used threshold regression models to model a nonlinear link of the countries' consumed energy levels and their output growth. Taking different candidates for the regime-switching variable, their confirmation was a positive significant connection linking energy employed and growth in national output for lower threshold value regimes. For regimes with threshold values higher than certain levels, the relationship between the variables were either not significant or were negative though significant.

Yet still, in Ethiopia, Gabreyohannes (2010) used a nonlinear Smooth Transition Regression (STR) model to view the consequence of price change on the usage of electricity. The study finding revealed that by increasing electricity prices, electricity consumption within Ethiopian residential areas were influenced asymmetrically. Moreover, Cheng-Lang et al. (2010) used nonlinear and linear models to analyze output level causality with respect to electricity usage in various sectors in Taiwan; he discovered a two way cause-effect connection linking utilized electricity and the nation's output level. At the same time, they found output levels to one-sidedly determine residential electricity usage.

Huang et al. (2008) and Chang and Lee (2007) also investigated the influence, if any, between economic growth and a country's used energy levels. In their test, they grouped their countries differently depending on their development levels. The conclusion was that the direction of influence between growth and energy use also depends on level of development and the direction varied over the constructed groups. Also, they concluded a nonlinear link between energy used and growth of economy showing this to depend on the level of output. Moon and Soon (1996) established growth of economy and consumption of energy to form a U-shaped relationship. That is, at the initial stage, a country's growth of economy rises as more is spent on energy until a point where it begins falling with increased energy use.

Literature also established the effect of other macroeconomic factors on economic growth. For example, a study by Seetanah and Khadaroo (2002) focused on economic growth and applied panel data of 39 Sub-Sahara African Countries for the period 1980 to 2000. The study used static and dynamic panel data to approximate the FDI effect on growth of economy for the data on trade openness, annual inflation, Human Capital and real GDP. The study found that FDI, and Human capital impacts positively on the GDP of African countries. Also, Ocharo *et. al.* (2014) carried out a study which aimed to approximate the connection between private capital inflows, remittances and growth of economy in Kenya. The study applied time series data that covered the period 1970 to 2010 and used the Ordinary Least Square (OLS) method to estimate the connection. Economic growth was regressed on human capital, Macroeconomic stability, financial development, trade openness, government expenditure and remittances. The study found a causality that is unidirectional from FDI as ratio of GDP to growth of economy and concluded that government should continue to seek high economic growth rate to attract the capital flows.

2.4 Summary of the Literature Reviewed

This section has reviewed both theories that pertain to economic growth and energy use. Theoretically, the two have a direct and indirect relationship. Demand for energy is crucial as it affects the economy which in turn affects the lives of people (i.e. their income, health, happiness), and their capability to meet basic needs such as the need for education, infrastructure and among others. According to Ozturk (2010), there exists widespread analysis in the documentation about the causal connection between utilization of energy and growth of economy yet no agreement is forthcoming. For instance, Oh and Lee (2004), Stern (2000), Ho and Siu (2007), Wolde-Rufael (2004), along with others, postulate that only use of energy leads to economic growth. Yet, on the contrary, Zamani (2007), Mehrara (2007), Ang (2008), Zhang and Cheng (2009) uphold the conservation hypothesis by maintaining that causality ranges from output to consumption of energy. Glasure (2002), Lee (2005, 2006), Erdal et al. (2008) and Belloumi (2009) reported a causality that is bi-directional between the use of energy and its capacity of output. On the other hand, Huang et al. (2008), Halicioglu (2009) and Payne (2009) discovered no causality between growth of economy and consumption of energy. Yet still, Sari and Soytas (2003), Lee (2006), Francis et al. (2007), Akinlo (2008) and Chiou-Wei et al. (2008) discovered mixed findings for different groups of nations.

Most studies have clearly concentrated at exploring the causality, or cointegration among the two variables. Both negative and positive effects of use of energy are pronounced (Bakirtas, & Akpolat, 2018; Gozgor, Lau, & Lu, 2018; Shahbaz, Zakaria, Shahzad, & Mahalik, 2018). A number of model exercises of comparison exist where various models are run on standardized hypotheses to better synthesize sensitivities and give answers factual questions through models' ensembles. These analyses that are based on the model omit a couple of the factors that may yield in lower economic benefits or economic cost, as they typically model only the emissions reduction costs not the benefits, and in many instances have only limited productivity representation enhancing effects.

Further, some studies acquiescently concur to the fact that most of the linear models employed in energy use-growth relationship suffer from misspecification error. Thus, in this dissertation, panel data is analyzed under a non-linear model to inspect the effect of energy use on economic growth in the selected SADC countries. To strengthen the model, other variables that are central in many economic models as established in the literature were included as controls, these included: broad money, inflation rates as well as gross fixed capital formation. These control variables are used to moderate the model employed since growth of economy does not only rely on use of energy but other macroeconomic factors.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This section explains the research methodology and model specification used to examine the correlation between energy use and growth of economy in the Southern African Development Community (SADC). The theoretical framework is outlined followed by model specification and an explanation of the variables used in the econometric regression. Lastly, the estimation procedures, the diagnostic tests employed to test the agility of the findings and the type as well as the sources of data for estimation is discussed.

3.2 Theoretical Framework

The role of energy consumption as growth of economy factor is well established in economic growth models mainly explored in the energy field of economics. The energy sector has been shown to be an important contributor in resolving not only economic but also social problems in developing countries such as poverty (Ghali and El-Sakka, 2004, Beaudreau, 2005). This is with regard to the sector's ability to enhance a country's productivity, in turn resulting in better economic growth and development, through better supply of clean and reliable energy sources (Nkomo, 2007; Poveda and Martinez, 2011).

Many economic growth models attribute economic growth to be influenced by a myriad of factors. The Solow model of long-run economic growth fancies that the labor and capital can be substituted in the functions of production thus causing versatility in the whole process of production (Solow, 1956). It is argued that in the long run, the rate of growth of economy is decided by enlarging the force of labor and progress technologically. Thus the production function is represented as shown with a constant return to scale.

$$Y = F(K, L) = AK^{\alpha}L^{\beta} \qquad 3.1$$

Where **Y** represents Gross Domestic Product **(GDP)**; **A** represents the level of technology, **K** stands for capital and **L** signifies the Labor.

However, recent functions have been modified to accommodate other factors deemed as determinants of economic growth such as government expenditure and population growth which boosts aggregate consumption. It is further postulated that growth in human capital and investments are crucial to the growth of economy. Technology which is immense in energy production also aids development by reducing cost and time and making processes more efficient and cheaper.

3.3 Specification of the Model

The study acquired and remolded a model used by Esen & Bayrak (2017) and included variables used by Odhiambo (2009) as well as Ozturk, Aslan and Kalyoncu (2010) based on the Solow growth model. The model of econometric analysis is based on panel model of dynamics as used by Ozturk, Aslan and Kalyoncu (2010) with all the elements of cross sectional and time series. The functional model to be approximated as presented below;

$$GDP_{it} = \beta_0 + \beta_1 EnergyUse_{it} + \beta_2 BroadMoney_{it} + \beta_3 Inflation_{it} + \beta_4 GrossfixedCapitalFormation_{it} + \varepsilon_{it} \qquad 3.2$$

Where; $\boldsymbol{\beta_0}$, $\boldsymbol{\beta_1}$, $\boldsymbol{\beta_2}$, $\boldsymbol{\beta_3}$, and $\boldsymbol{\beta_4}$, are parameters, and ε= random residual. It is expected that economic growth will be positively influenced by energy use, broad money, gross fixed capital formation based on existing empirical literature, except inflation rate which is expected to have a negative effect. This priori hypothesis is however not cast in stone since there are other myriad factors that are significant and perhaps not adequately taken care of in the model. Just before carrying the factual analysis, the natural logarithm of all variables to decrease in heteroscedasticity. On the same note, from the theoretical framework, Output is a function of capital and labor only. In this study the model was specified by replacing capital and labor with energy use, broad money, inflation and gross capital formation. Output given as Y was replaced with Gross Domestic Product (GDP).

3.4 Variables Definition and Measurements

Economic Growth: This is the dependent variable of the model. It is measured through the Gross Domestic Product (**GDP**) which is the sum of goods and services produced in a country. According to the World bank (2015), Economic Growth which is denoted as GDP per capita (US$), refers to the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. Data are in U.S. dollars.

Energy Use: Energy use refers to consumption of primary energy prior to transformation to other fuel end-users, which is the same as the native production plus imports and stock changes, minus supplied fuels and exports to aircraft and ships engaged in over-seas transport. It is measured as kilogram (kg) of oil equivalent per capita.

Broad Money (BM): Broad money is the country's supply of money which is the entirety of assets that citizens and enterprises can use to make payments or to hold as short-term investments such as currency, funds in bank accounts and anything of value resembling money.

It comprises of things like securities in short-term and deposits in short-duration other than shares. This is a proxy for financial sector and market development and is represented by the ratio that is percent of broad money (M2) to GDP.

Inflation Rate (INF): Inflation refers to the rate of increase in general price levels in the economy. An increase in inflation within optimum thresholds is anticipated to lead to increased private investment (Rahman *et al.*, 2015), conversely it can also result in decreased private investments (Greene& Villanueva, 1991). It is measured in percentage.

Gross Fixed Capital Formation (GFCF): We expect it to have a positive sign as an increase in productive investment will increase the productive capacity of the economy.

3.5 Estimation Techniques

The study applies a technique of panel data of estimation because of its many merits over both data sets of cross-section and time-series. The method has higher the degrees of freedom and less Multicollinearity resulting to estimates that are faster, (Hsiao, 2014) and offers higher malleability in modeling dissimilarities in behaviour across the nations which ensures the ability to control heterogeneity that is unnoticed.

The panel data analysis method has two main approaches, namely; the Fixed Effects Model (FEM) which assumes omitted effects particular to cross sectional units are the same over time and the Random Effects Model (REM) which assumes the omitted effects are random variables.

In order to choose between the random effects and fixed effects, a Hausman test is conducted. It tests whether the unique residuals are related with the regressors; the null hypothesis is that they are not (Greene, 2008). If the null hypothesis cannot be rejected, then random effect is preferred because it is a more efficient estimator.

3.6 Diagnostic tests

The study undertook several diagnostic tests to enhance and to validate the estimation results.

The pre estimation tests carried out included stationarity. The particularized model was approximated using Statistics and Data (STATA) and the objects of the study are explored via tests that are systematic. Other post estimation tests include; Multicollinearity through VIF analysis, normality, homoscedasticity and autocorrelation analysis.

3.6.1 Multicollinearity

According to Hair et al. (1998), multicollinearity occurs when the explained variables used in the regression model are highly correlated giving rise to biased estimates. The study applied Vector Inflation Factor (VIF) for the multicollinearity and its tolerance defined as 1/VIF. Presence of multicollenearity was concluded for VIF value greater than 10 and absence of multicollinearity for VIF value of less than 10.

3.6.2 Normality test

To check for normality, the Shapiro Wilk test was applied to determine if the null hypothesis error term is normally distributed. The hypothesis to be tested was specified as follows;

H0: There is a normal distribution of data

H1: There is no normal distribution of data

A large p value implies that the errors are normally distributed and data come from a normal distribution (Wakyereza, 2017).

3.6.3 Test for Auto-correlation

The presence of autocorrelation was tested through the Wooldridge Test for Serial correlation. The absence of autocorrelation is rejected when probability values are less than 5% critical value. It computes lag order ρ based on an auxiliary regression of the errors of the estimated OLS line and the hypothesis is specified as follows;

H0: No autocorrelation among residues

H1: There is autocorrelation among residues

The null hypothesis is rejected if the probability values of the test are greater than 5% denoting absence of autocorrelation among the residuals.

3.6.4 Heteroskedasticity Test

The study applied test of constant variance to investigate the presence of heteroscedasticity. Clustered standard errors and the F statistic and the associated p value are examined. The null hypothesis of absence of constant variance would be accepted if the probability values are less than 5%. (Wakyereza, 2017).

3.6.5 Testing for Unit Roots

A more formal analysis of panel data analysis involves deciding the order of series integration under investigation. To explore the absence or presence of a unit root in the energy consumption and GDP per capita the study uses fisher unit root tests. Panel unit root testing arose from time series unit root testing. The major dissimilarity to time series testing of unit roots is that we have to consider asymptotic behavior of the time-series dimension T and the cross-sectional dimension N. The channel through which N and T come together to infinity is crucial if one wishes to determine the never crossing estimators' behavior and tests used for non-stationary panels.

The Fisher-type test uses p-values from unit root tests for each cross-section i. The test's formula is as shown below:

$$P = -2\sum_{i=1}^{N} ln\ p_i \qquad 3.3$$

The test is asymptotically chi-square distributed with 2N degrees of freedom (T_i tends to infinite for finite N). A big advantage is that the test can handle panels that are unbalanced. Furthermore, the lag lengths of the individual augmented Dickey-Fuller tests are allowed to differ. A hitch of the test is that the p-values have to be obtained by Monte Carlo simulations. However, the test is easily executed in Stata.

3.6.6 Validity and Reliability Tests

Morris and Burkett (2011) spell out that in quantitative research, evaluation criteria include validity and other factors. Validity findings from a sample that is random, equal groups in the case of experimental study, use of instruments that are reliable and valid, and the assurance that any conflict of interest has been diminished (Morris and Burkett, 2011).

The validity of the theory and methodology, as outlined above, predicated on the vast extant literature on the topic and the studies within the discourse which employ a similar methodology, is coupled with consistency that stems from the use of a large, well developed and nationally representative dataset. Panel datasets normally have more degrees of freedom and more sample variability than cross-sectional data which may hence improve the econometric estimates' efficiency (Hsiao et al., 2005).

Reliability is another evaluation criterion in quantitative research and is mainly bothered with an adequate size of a sample so that inferences can be made with clarity and exactness. Reliability is defined as the clarity or exactness of the instrument of measurement (Kerlinger, 1964). The World bank panel dataset is a large scale nationally representative longitudinal survey drawn from each country and because of the sequential observations for a period of time, this creates reliability and validity as there is greater capacity for capturing the complexity of the relationship of the variables in question than a single cross-section.

Theoretically, the study builds on a strong and burgeoning economics literature which has emerged on the association between the growth of economy and energy use. Several papers within this broad economics of energy literature have, in a similar vein to this proposed study, estimated the correlation of various socio-economic factors the growth of economy and use of energy by running regressions on cross-sectional and longitudinal panel data. Indeed, in a SADC context, there have been a number of studies which have not specifically used data from the World Bank panel dataset to estimate the relationship among these variables. This study would, thus, merely extend this well-established literature, by exploring a yet examined relationship, at least in the SADC context, that between the growth of economy and use of energy by employing panel data techniques.

3.7 Granger Causality Test

As established in the literature, the determinant direction among energy use and growth of economy is not well founded. The study tested for the direction of causality of use of energy and GDP per capita using Pedroni (1999) approach as outline below:

$$\Delta \ln GDP_{it} = \Phi_{1i} + \sum \Phi_{11ip} \Delta \ln GDP_{it-p} + \sum \Phi_{12ip} \Delta \ln EC_{it-p} + \psi_{1i} ECT_{t-1} \qquad 3.4$$

$$\Delta \ln EC_{it} = \Phi_{2i} + \sum \Phi_{21ip} \Delta \ln EC_{it-p} + \sum \Phi_{22ip} \Delta \ln GDP_{it-p} + \psi_{2i} ECT_{t-1} \qquad 3.5$$

To estimate equation (1) and (2) Pesaran *et al.* (1999) pooled mean group estimator (PMGE) is used with the causality test being based on $H_0 \equiv \Phi_{12ip} \equiv 0$ and $H_0 \equiv \Phi_{22ip} \equiv 0$ for all *i* and k. To establish how many lags to include in the estimation of the pooled mean estimator Akaike information criterion is used. Significant p values (less than 0.05) imply the existent of causal effect.

3.8 Data Source

This study inspects the connection between use of energy and economic growth (GDP) in 16 SADC countries. Due to such reason, yearly records of data were needed from the WDI database of the World Bank as well as the official government(s) publications (Statistical Abstracts, Economic Surveys) for these nations for the period 2000 to 2014. The goal is to acquire the maximum size of the sample when deciding the periods within the analysis scope and economies. Dataset used was mainly sourced from the countries that are members of SADC that is; Angola, Botswana, Comoros, Congo Dem. Rep, Eswatini, Lesotho, Madagascar, Mauritius, Malawi, Mozambique, Namibia, Seychelles, Tanzania, South Africa, Zimbabwe and Zambia.

CHAPTER FOUR

4.0 DATA ANALYSIS, INTERPRETATION AND DISCUSSIONS

4.1 Introduction

This section details results analyzed from the consolidated secondary data collected from various sources as indicated in the previous chapter for the years between 2000 and 2014. Since the data has taken panel dimension, we are able to tell from the SADC; the various effects of energy use despite its dynamism, on economic growth. An all-inclusive fundamental and technical analysis using fixed effects model handled investigates, using varied specific parameters; to identify how energy use influence the growth of economy in the Southern African Development Community (SADC). The findings are presented as descriptive in the form of tables and graphs and organized in relation to the core targets/goals of the study.

4.2 Technical Analysis

4.2.1 Descriptive Statistics

The study considered the following descriptive statistics; mean, standard deviation, minimum and maximum. The mean is the average value, standard deviation is a measure of dispersion that shows how the variables are scattered around their means, and the minimum is the least value while maximum is the highest value of that particular indicator under consideration. The study excluded countries such as Comoros, Eswatini, Lesotho and Seychelles as they did not have complete data for energy use in some years except for the years between 2004 and 2007. Further, Madagascar and Malawi were excluded as they did not have any data on energy use.

The variables under study include; economic growth, energy use, broad money, inflation and

Gross fixed capital formation (the average investment rate) as the GDP percentage. According to the findings in table 4.1, GDP per capita US$ and the rate of population have the means of 3155.03 per capita US$ and the standard deviations for between and within being 2733.75 and 2804.76, respectively. The lowest and highest value for economic growth are 256.54 per capita US$ and 9163.64 per capita US$ respectively.

Table 4.1: Summary Statistics

Variable		Mean	Std. Dev.	Min	Max	Observations
GDP	overall	3155.03	2733.753	256.5394	9163.64	N = 150
	between		2804.762	319.8994	7147.045	n = 10
	within		588.1083	1568.219	5171.625	T = 15
Energy	overall	834.4044	648.8406	295.4088	2913.13	N = 148
	between		673.6315	320.1931	2621.685	n = 10
	within		68.45817	552.4824	1125.849	T = 14.8
BM	overall	40.99788	28.06469	2.857408	151.5489	N = 141
	between		26.7242	7.158927	94.29492	n = 10
	within		11.24209	5.403474	130.2419	T = 14.1
INF	overall	21.10912	64.49921	-.6920301	513.9068	N = 122
	between		24.99661	2.330409	68.52267	n = 9
	within		59.76625	-46.60533	466.4933	T-bar = 13.5556
GFCF	overall	21.75523	8.123923	2.000441	43.05135	N = 140
	between		6.450298	9.207594	29.71044	n = 10
	within		5.248665	11.90235	44.24087	T-bar = 14

On the other hand, energy use had an average of 834.40 Kg of oil equal per capita whereas the lowest and highest values are 295.41 Kg of oil equal per capita and 2913.13 Kg of oil equal per capita respectively. The other macroeconomic variables, that is broad money, inflation rate and gross fixed capital formation had the following means; 41 percent, 21.1 percent, and 21.8 percent respectively.

4.2.2 Trend Analysis

In the first objective, the pattern in terms of the parameters fluctuations' nature was explored in the various nations under research. The research acquired diverse graphical showings which depict the trend of the variables of interest over all the periods of time across the panels.

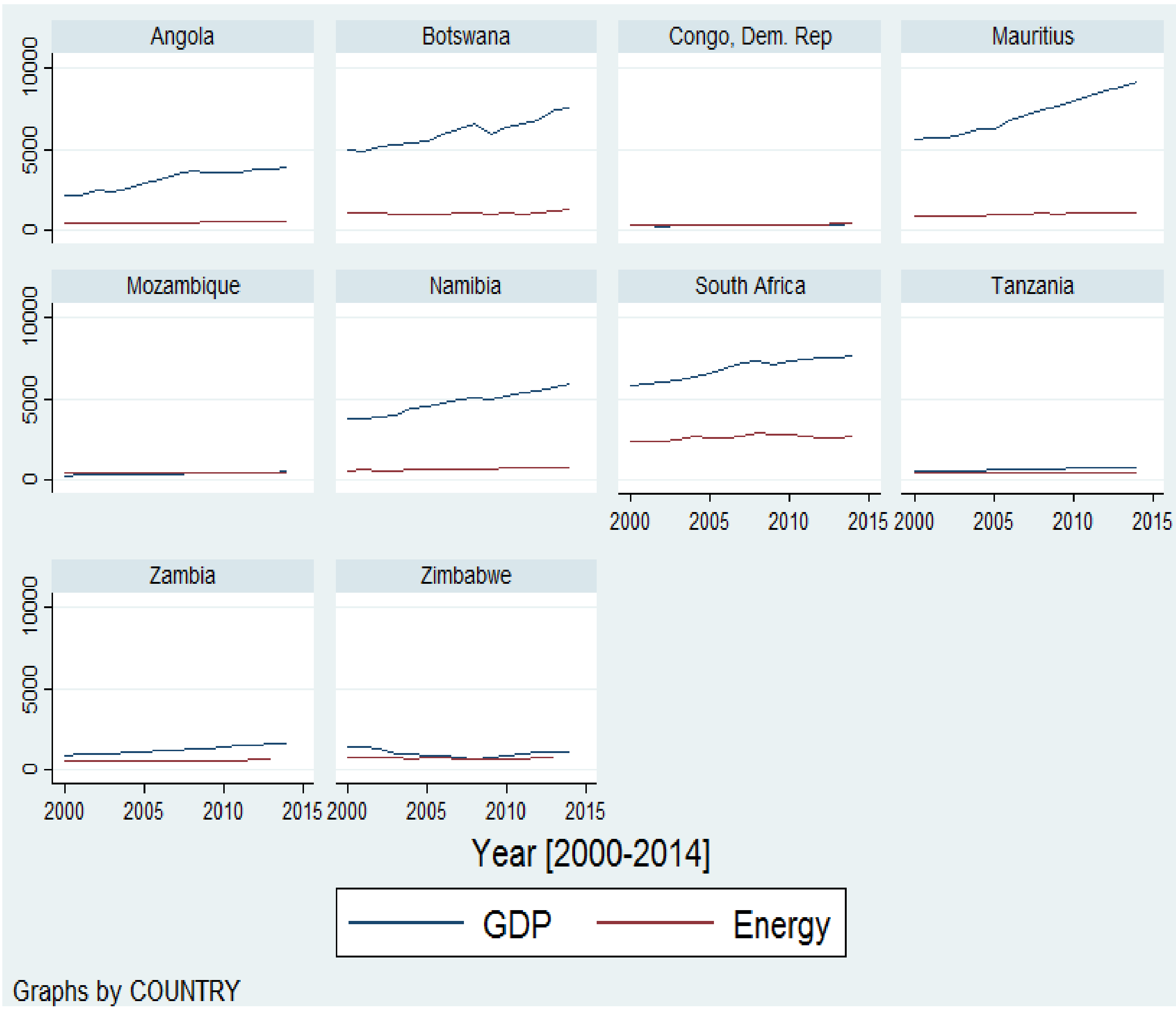

Figure 4.1: Trends in Growth of the Economy and Energy Use

The trends illustrated in figure 4.1, show more fluctuations in Zimbabwe which were biased whereas other states showed some consistency in terms of growth or stagnation of the two.

Angola, Botswana, Mauritius, Namibia and South Africa demonstrated a fairly constant rise in Energy use along with the Economic growth. However, all countries except South Africa had small consumption levels of energy with Angola, DRC, Mozambique, Namibia, Tanzania and Zambia recording low levels.

Further, it could be observed that some countries in the SADC region had the same trends in economic growth and use of energy, for example Mozambique, DRC, Tanzania, Zimbabwe and Zambia.

4.3 Causal relationships between Energy Use and Economic Growth

In this case, the study specifically was interested in determining whether one time series predicts another. That is whether energy uses both in short-run and long-run causes growth of economy or the other way round. The results in the second column of coefficients with energy use excluded in the equation shows energy use, in all countries, being significant in causing economic growth. Their p values were significant at 5 percent levels. However, the causal relationship in some nations such as Mozambique, South Africa, Namibia, Zimbabwe and Zambia was not established as the data was missing in some years. It can therefore be implied that energy use causes economic growth. The findings are as shown in figure 4.2.

Table 4.2: Granger Causality/ Wald tests

Country	Equation (Economic Growth)	Excluded (Energy Use)	Equation (Energy Use)	Excluded (Economic Growth)
Angola	**7.7477** (0.021)		**76.591** (0.000)	
Botswana	**7.6476** (0.022)		**7.3063** (0.026)	
Congo, Dem. Rep. (DRC)	**453.89** (0.000)		**.16662** (0.920)	
Mauritius	**2860.4** (0.000)		**179.73** (0.000)	
Mozambique	-		-	
Namibia	-		-	
South Africa	-		-	
Tanzania	**22.399** (0.000)		**5.1407** (0.077)	
Zambia	-		-	
Zimbabwe	-		-	

NB: Bold values are chi square while Values in parenthesis are the p values.

On whether economic growth causes energy use, the findings confirmed the same in all countries with significant p values except DRC which had p value (p=0.920) and Tanzania (p=0.077) exceeding 0.5 level. Thus a unidirectional causality was reported in these two countries of SADC. The study concludes that all countries except DRC, Tanzania and those with missing or inadequate data demonstrated a causality that is bi-directional between energy use and economic growth. From the literature, Bakirtas, and Akpolat (2018) supported the study's findings while exploring the causal correlation between use of energy, urbanization and growth of economy using the Dumitrescu-Hurlin Panel Granger Causality test in New Emerging-Market Nations (India, Colombia, Indonesia, Malaysia, Kenya and Mexico). They found out that there is panel Granger causality from growth of economy to use of energy. Additionally, a study by Cheng-Lang *et al.* (2010) which analyzed causality among sectoral electricity usages in Taiwan supported this study finding. They found out that there was a nonlinear causality that was bi-directional among total consumption of electricity and the level of output, and nonlinear causality that was unidirectional from the level of output to residential consumption of electricity.

4.4 Econometric estimation of Energy Use and Economic Growth in SADC States

4.4.1 Introduction

Energy consumption has been quite been emphasized in both empirical and theoretical literatures. It is proposed that energy use forms the basis of economic growth (Inglesi-Lotz, 2016). Therefore, this objective intends to point the exact extent to which energy use may encourage general growth of the economy in SADC nations. Through descriptive statistics, it was observed how variations across panels and between the coefficients illuminate that disposition. In this goal, the study's aim was to explore how the said variable as well as the covariates with their nature of stochastic relates with growth of economy in those nations.

Following the adoption and modification of a model used by Bhattacharya, Paramati, Ozturk, and Bhattacharya (2016) which included variables utilized by Gozgor, Lau and Lu (2018) based on the Solow growth model, the analysis model of econometric is based on the panel model of dynamic with both components of time series and cross sectional. This was used to demonstrate the significance and its implication on economic growth. The conceived model was estimated by random effects with pre-approximation of unit roots, cointegration and Hausman specification test.

4.4.2 Unit Root Test

To avoid approximate change with time due to non-stationarity, unit root tests were employed to investigate or to detect non stationarity in all the study variables which in turn leads to spurious estimates. The Fisher-type unit-root test was applied for each variable under research. This type of unit root analysis is based on augmented Dickey-Fuller tests. If variables were discovered to be non- stationary, first differencing or successful lagging was applied until the bias is eliminated. This reduced the number of periods. The null hypothesis in this case was that the variable under consideration was non-stationary or has unit root and in our case, it was stated as;

H_0: Panels contain unit roots

H_1: Panels are stationary.

Table 4.3 below shows the Fisher unit-root test and it was revealed that all variables except broad money and inflation rate had the p values>0.05 which led to a failure to reject the null hypothesis (that the variables had unit root). Hence, the first dissimilarity for non-stationary variables were carried out in an effort to correct for non-stationarity.

Table 4.3: Unit Root Tests

Variables	Inverse chi-squared	P value at lag(0)	Inverse chi-squared after 1st differencing	P value at lag (0) after 1st differencing
GDP	4.0777	0.9999	87.7073	0.0000
Energy Use	7.8054	0.9931	166.7394	0.0000
Broad Money#	53.9808	0.0001	-	-
Inflation Rate#	119.0659	0.0000	-	-
Gross Fixed Capital Formation	14.2885	0.8156	76.8108	0.0000
#Stationary at levels				

Source: Author's Computation

4.4.3 Fixed Effects Versus Random Effects model

In selection of model, random and fixed effects were compared in which the previous fancies that the real size of effect is constant in all 10 nations and the effect of summary is approximate of this normal size of effect while the latter fancies that the true size of effects varies from one nation to another and that the nations under study show a random sample of effects size that could have been observed and thus the effect of summary is our approximate of the effects' mean. Further, Borenstein (2009) proposes that under fixed effects, there is a hypothesis that all the dispersion in observed effect is due to an error in sampling while under random effects, there is room that part of the dispersion noticed may demonstrate actual dissimilarities in effect size across nations.

In order to decide on the best fitting model, the study opted for the Hausman specification test where the fixed effects model specification was compared to the random effects model. The null hypothesis was that the dissimilarities in coefficients are not step-by-step. Consequently, on conducting the test, it was shown that P-value of 0.000 meant that the effects at the individual level are best modeled using the fixed effects method. The findings are as shown in table 4.4.

Table 4.4: Hausman Specification test

	Coefficients (b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Energy				
D1.	.8143843	.857644	-.0432597	.
BM	-3.253457	1.617542	-4.870999	1.959505
INF	-.3245748	-.1915677	-.1330071	.0369262
GFCF				
D1.	-3.852998	-5.055491	1.202493	.

```
                b = consistent under Ho and Ha; obtained from xtreg
  B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho:  difference in coefficients not systematic

              chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                      =       40.59
            Prob>chi2 =      0.0000
            (V_b-V_B is not positive definite)
```

D1: First Differences

In this study, the Hausman test opted fixed effects model instead of random effects model which do not allow approximation effects of the mean of the effects of distribution and instead estimates one true effect. Despite the fact that every represented nation in the study gives varied information concerning a different size of effect, they all emanated from one economic bloc and thus the researcher had to make sure that all these sizes of effects are shown in the summary estimate.

4.5 Regression Results for Fixed Effects Model

The acquisition of fixed model effects was based on various nations under one economic bloc with similar economic dynamics as well as conditions for boosting regional economic status. After undertaking numerous pre estimation diagnostic tests and model selection, the fixed effects variant is valid for interpretation. Table 4.5 indicates the results of the regression.

Table 4.5: Final Model - Fixed-Effects within regression

```
Fixed-effects (within) regression               Number of obs      =        98
Group variable: Code                            Number of groups   =         8

R-sq:                                           Obs per group:
     within  = 0.1535                                         min =         3
     between = 0.0528                                         avg =      12.3
     overall = 0.0093                                         max =        14

                                                F(4,86)            =      3.90
corr(u_i, Xb)  = -0.8885                        Prob > F           =    0.0059
```

D.lnEconomicGrowth	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnEnergyUse						
D1.	.1907485	.0847586	2.25	0.027	.022254	.359243
lnBroadMoney	-.0345988	.0127257	-2.72	0.008	-.0598967	-.009301
lnInflation	-.0144897	.0049402	-2.93	0.004	-.0243105	-.0046689
lnGrossFixedCapFormation						
D1.	.0046294	.0182944	0.25	0.801	-.0317387	.0409974
_cons	.1787603	.050539	3.54	0.001	.0782921	.2792286
sigma_u	.02926208					
sigma_e	.0277418					
rho	.52665069	(fraction of variance due to u_i)				

```
F test that all u_i=0: F(7, 86) = 2.23                   Prob > F = 0.0394
```

Source: Author's Computation

The growth of economy explaining variations in total in the SADC states were less than 10 percent. Additionally, 5.3 percent of the variations explain growth of economy in between the panels while 15.3 percent of the variations describe the GDP within the panels. The whole OLS fit is important. It implies the data used fit the model well. This is because the overall P value is 0.0059<0.05. The residuals' standard deviation within groups and variance attributable to the differences across the panels were 0.0293 (sigma) and the residuals' standard deviation between groups is 0.0277 (sigma_e). The proportion of variance as a result of differences across the panels was 52.6 percent. Thus there was no relationship between the repressor and the residuals. The fixed effects model, due to time series component, makes assumptions on normal distribution of the stochastic random error term, constant variance of error terms across observations, linearity, no serial autocorrelation of the error terms and no perfect correlation between any pair of independent variables and stationarity. However, linearity was not tested since the model adopted was nonlinear. Therefore, other post estimation diagnostic tests were undertaken so as to validate the yielded estimates.

4.5.1 Multicollinearity Test

Multicollinearity is deemed to be present when there is perfect linear connection between the variables under study. The inflation factors of variance were applied to decide if any pair of explanatory variables was optimally collinear and the magnitude and size of the determined pairs of variables. This bias arises when one or more pairs of independent variables are perfectly correlated to each other. Therefore, the Variance Inflation Factors (VIF) were examined. The findings are as represented in table 4.6.

Table 4.6: VIF

Variable	VIF	1/VIF
lnBroadMoney	4.12	0.242692
lnInflation	3.92	0.254949
lnEnergyUse		
D1.	1.22	0.821956
lnGrossFix~n		
D1.	1.08	0.923527
Mean VIF	2.59	

Source: Author's calculations

The VIF test measured how much variance of an estimated coefficient increased due to collinearity. For VIF values>10 and 1/VIF values<0.10, multicollinearity is considered to be available. The findings show that all variables had low correlation implying absence of multicollinearity in the suggested model. It should be noted that first differencing eliminates or lowers multicollinearity which may lead to spurious regression.

4.5.2 Normality Test

To continue with approximation of the linear model, the study applied the Shapiro Wilk test for normal data or distribution of the stochastic random error terms. Table 4.7 below revealed that at 5% significance level, overall residuals of the variables were not normally distributed.

Table 4.7: Test for Normality

Variable	Obs	W	V	z	Prob>z
Residuals	99	0.92039	6.518	4.156	0.00002

The results indicate the p-value of the residuals of 0.0002 which is less than 0.05 implying that the null hypothesis of the residuals' normality is rejected. Therefore, data was not normally distributed and thus the research opted to employ a non-linear model.

4.5.3 Homoscedasticity

The study explored the presence of constant variance of the error terms across all the observations in the panels. One can regress residual squares (from RE or FE depending on the estimation) and its square using the clustered standard errors and read the F statistic and the associated p value. The p value was found to be significant. This implies that heteroscedasticity is absent. The findings are as represented in table 4.8.

Table 4.8: Test for Constant Variance

```
Linear regression                               Number of obs     =         98
                                                F(2, 7)           =      89.44
                                                Prob > F          =     0.0000
                                                R-squared         =     0.2537
                                                Root MSE          =     .00189

                                    (Std. Err. adjusted for 8 clusters in Code)
```

uhatsq	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
xb	-.0485832	.027854	-1.74	0.125	-.1144474	.0172809
c.xb#c.xb	.8613978	.2498436	3.45	0.011	.2706117	1.452184
_cons	.0014808	.0004939	3.00	0.020	.000313	.0026487

```
r; t=0.08 13:25:53

. testparm c.xb##c.xb

 ( 1)  xb = 0
 ( 2)  c.xb#c.xb = 0

       F(  2,     7) =   89.44
            Prob > F =    0.0000
```

4.5.4 Autocorrelation

If there is a suspected or proved correlation between random error terms of the subsequent time periods, then there is high likelihood of the existence of serial correlation. If present, the bias leads to spurious estimates of economic growth. The finding in table 4.9 shows absence of autocorrelation implying that adjacent observations were not correlated. Therefore, the fixed effects regression did not underestimate the coefficients of the standard errors.

Table 4.9: Wooldridge Test for Serial correlation

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,       7) =     78.725
           Prob > F =      0.0000
```

It is observed that the null hypothesis of no serial correlation is strongly disputed. Also, the output from the first regression difference includes standard errors that account for clustering within the panels. If there is serial correlation in the idiosyncratic residual, clustering at the panel level produces compatible approximates of the standard errors, and as highlighted by Baltagi (2001) other estimators produces estimates that are more efficient.

4.6 Discussion of the Findings from Fixed Effects Model

Upon designating the fixed effects model, the results are ready for discussion. The study traversed crucial factors as shown in Table 4.5 whereby it was highlighted that if all other factors including energy use were kept constant, economic growth will be significantly higher by 17.87 percent (p=0.001). From the variable of interest, the study also established that for a one percent rise in energy use, economic growth increased by 19.07 percent (p=0.027) holding other factors constant. This means that growth of economy grows as use of energy rises. Thus there is an indisputable and important connection between energy use and growth of economy. This outcome correlates with the results obtained by Gozgor, Lau, and Lu (2018) that analyzed the impacts of the non-renewable and the renewable use of energy on economic growth in the panel data of 29 OECD nations. It was confirmed that non-renewable and renewable consumption of energy is positively affiliated with a higher rate of the growth of economy.

Other covariates that were significant were broad money and inflation. Gross fixed capital formation was not significant. The former two had a disputable and significant effect on growth of economy. Specifically the study revealed that for a 1% increase in broad money, growth of economy rose by 3.56 percent (p=0.008) holding other factors constant. However, economic theory postulates that as broad money increases, so as the economic growth. This outcome agrees with the study by Chude and Chude (2016) which was undertaken in Nigeria.

It was also revealed that for a 1 percent increase in inflation, growth of economy rose by 1.45 percent (p=0.004) holding other factors constant. High inflation rates leads to the increase in the overall price levels in the country. As one of the macroeconomic factor, it was revealed to significantly influence the economic growth in SADC countries. This study therefore agrees with Kryeziu, N., and Durguti (2019)'s study which undertaken in the Eurozone region.

Lastly, gross fixed capital formation was revealed to have an important and positive connection with growth of economy rate among the countries in SADC. This study agrees with Onyinye, Idenyi and Ifeyinwa (2017) which was carried out in Nigeria even though in this case the effect was not significant. As gross fixed capital formation increases by a unit, economic growth rate rose by 0.46 percent (p=0.801) holding other factors constant. Gross fixed capital formation triggers investments thus paving the way for high economic activities in any economy. The study findings indicate the reverse of the economic theory.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the study variables' findings. Conclusions are thereafter made with a key focus on the established connection between the use of energy and economic growth in the states of SADC. Later, relevant policy recommendations and areas of further research are suggested.

5.2 Summary of the study findings

Upon reviewing diverse literature, it was inferred that the measurements and in specific, state governance, is connected with how government bodies are structured, what procedures they apply in ruling and what outputs they are capable accomplishing for the country's economy and the citizens they rule. Apart from the fact that better governance forms part of the main fiscal framework of prudence, proper resource utilization in the public domain and an accountable program, the study focused in exploring the relationship of various governance indices and the regional (SADC) economic performance.

Study variables involved were the GDP, energy use, broad money, Inflation rate and Gross fixed capital formation (the average investment rate) as a percentage of GDP. The study used fixed effects model in estimation and significance tested at 5 percent level. It was shown that the growth of economy was importantly influenced by energy use, broad money and inflation rate. Gross fixed capital formation was not statistically significant despite having the right sign (positive). Apart from energy use which shows a crucial and positive connection with the growth of economy, broad money and inflation rates were revealed to significantly reduce economic growth in SADC states.

In conclusion, factors which need attention by the governments of the respective states and the region as a whole include energy use, broad money and inflation rate which show a significant effect on the growth of economy of the region.

5.3 Conclusions of the findings

Production mechanization and the rise of mass (serial) methods of production after the industrial revolution in the late 18^{th} century led to an increase in energy demand. This later on, made the process of production and states' capacity to become maximally dependent on energy-based inputs and energy. Although energy is not the only input that decides the production level and economic development of a nation or region, this study has confirmed that it is optimally significant for the growth of the economy. It is only by ways of consuming a particular energy amount that nations can obtain a particular level of the growth of economy.

5.4 Policy Recommendations

In the current world, energy is not only seen to be an input of production but it is also viewed as a commodity at a strategic point that makes part of the basis for international connections and shapes the politics and economy of the world. The situations under which procurement of energy and the challenges faced during the process of procurement directly impact competition at both the international and national levels; these situations also shape the structures of production in nations and comprise one of the core signs of basic variables of economics.

Countries' demands for energy are optimizing each day, based on their economies' growth and their changing socio-economic structures. Their failure to increase generation of energy apart from their optimizing consumption of energy leads to a crucial challenge called a deficit in energy. Based on the study finding, continuous increase in energy consumption equally results to increase in growth of the economy. Hence, the governments require procuring of enough energy amounts in a quality-conscious, cost-effective, safe way without any disruption to obtain sustainable goals of growth and boosting their standards of living. If the SADC economic bloc experiences inappropriate resources of energy, that is unsustainable resources, it will either opt to accept low growth of the economy by production with the in place resources of energy or attempt to maximize growth by attaining the uncovered part of demand for energy through imports.

Money supply and inflation rates should be considered as they also contribute to the decline in economic growth. More attention is required by the government in order to control the sectors to which financial resources may have a replicative effect in these countries and at the same time control the rates of inflation so as not to constrain the economies. This can be achieved through re-examining the fiscal policies which regulates money supply in the respective economies.

5.5 Areas for further study

The study was conducted to investigate the role of energy use on economic growth in SADC states. There is need therefore to undertake a similar study investigating whether energy use supports economic growth of net importer states in developing countries. Therefore, there is need for similar studies utilizing other covariates apart from broad money, inflation rates and GFCF and incorporate others like human capital, rule of law and political stability levels among others in relation to economic growth.

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