ENERGY CONSUMPTION AND MANUFACTURING SECTOR PERFORMANCE IN SUB-SAHARA AFRICA

BY

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ABSTRACT

Although energy consumption contributes immensely to productivity and economic growth, manufacturing sector in Sub-Sahara African (SSA) countries is among the least in terms of energy utilization. The objectives of this study are to investigate the effect of energy consumption on manufacturing performance in SSA within panel of nine SSA countries from 1995 to 2012, to examine the effect of energy consumption on manufacturing performance for SSA within the time series analysis for the period 1980-2012, to examine the effect of energy consumption on manufacturing performance across income group in SSA using panel analysis and to examine causal relationship between energy consumption and manufacturing performance in SSA. For time series analysis, the study employed Autoregressive Distributive Lag (ARDL) method and Granger-causality test. The result proves cointegration and positive effect of energy consumption on manufacturing performance, but no causality relationship between them. For panel analysis, the study utilized Pedroni panel cointegration, Fully Modified Ordinary Least Square (FMOLS) and Granger-causality test. The result of Pedroni panel cointegration proves the evidence of cointegration among the variables. In addition, the long run coefficients suggest that energy consumption, electricity, fossil energy, capital and labour determine the performance of manufacturing sector. Similarly, the results of Granger-causality test discover bidirectional causality for aggregate energy model, no causality for electricity model and unidirectional causality from manufacturing performance to fossil consumption in SSA. Also, evidence of bidirectional among the energy consumption and manufacturing performance is established for the low-income SSA as the unidirectional causality from manufacturing performance to energy consumption was maintained for the middle-income SSA. In the context of policy implication, the study recommends the implementation of subsidy policies that would enhance energy consumption as energy conservation policy may adversely affect manufacturing performance.

Keywords: energy consumption, manufacturing performance, Sub-Sahara Africa

ABSTRAK

Meskipun penggunaan tenaga menyumbang kepada produktiviti dan pertumbuhan ekonomi, namun sektor pembuatan di negara Sub-Sahara Afrika (SSA) adalah kurang menggunakan tenaga. Objektif kajian ini adalah untuk mengkaji kesan penggunaan tenaga ke atas prestasi sektor pembuatan di SSA dengan menggunakan data panel penggunaan tenaga agregat dan tidak agregat bagi sembilan buah negara SSA dari tahun 1995 – 2012, mengkaji kesan penggunaan tenaga ke atas prestasi sektor pembuatan menggunakan data siri masa keseluruhan negara SSA bagi tempoh 1980 – 2012, mengkaji kesan penggunaan tenaga kepada prestasi sektor pembuatan ke atas negara-negara SSAberpendapatan rendah dan sederhana, dan mengkaji hubungan sebab-akibat antara penggunaan tenaga dan prestasi sektor pembuatan di negara-negara SSA. Bagi analisis siri masa, kajian ini menggunakan kaedah Lat Tertabur Autoregresif (ARDL) dan ujian Granger-sebab dan akibat. Keputusan analisis kointegrasimembuktikan wujud kesan positif penggunaan tenaga ke atas prestasi sektor pembuatan tetapi tiada hubungan sebab-akibat antara kedua-duanya. Bagi analisis panel, kajian ini menggunakan Kointegrasi panel Pedroni, *Fully Modified Ordinary Least Square* (FMOLS) dan ujian Granger-sebab dan akibat. Keputusan analisis kointegrasi panel Pedroni membuktikan wujud hubungan jangka panjang antara penggunaan tenaga ke atas prestasi sektor pembuatan. Di samping itu, koefisien jangka panjang yangdianggar menggunakan FMOLS mencadangkan penggunaan tenaga, elektrik, tenaga fosil, modal dan buruh menentukan prestasi sektor pembuatan. Analisis Granger-sebab dan akibatmembuktikan wujudhubungan sebab-akibat dua hala antara penggunaan tenaga agregat dan prestasi sektor pembuatan, tiada hubungan sebab-akibat antara penggunaan elektrik dan prestasi sektor pembuatan serta hubungan sebab-akibat sehala daripada prestasi sektor pembuatan kepada penggunaan tenaga fosil di negara SSA.Selain itu, hubungan sebab-akibat dua hala antara penggunaan tenaga dan prestasi sektor pembuatan wujud di SSA berpendapatan rendah tetapisehaladi SSA berpendapatan sederhana. Dalam kontek perlaksanaan dasar, kajian ini mencadangkan perlaksanaan dasar subsidi tenaga bagi meningkatkan penggunaan tenaga kerana dasar pemuliharaan tenaga menyebabkan kesan sebaliknya ke atas prestasi sektor pembuatan.

Kata kunci: penggunaan tenaga, prestasi pembuatan, Sub-Sahara Afrika

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All praise is to Allah, we seek His help and His forgiveness. We seek refuge with Allah from the evil of our own souls and from our bad deeds. Whomsoever Allah guides will never be led astray, and whomsoever Allah leaves astray, no one can guide. I bear witness that there is no God but Allah and I bear witness that Muhammad is His slave and Messenger.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
ARDL	Autoregressive Distributive Lag
BRIC	Brazil, Russia, India and China
CES	Constant Elasticity of Substitution
CPI	Corruption Perception Index
CUSUM	Cumulative Sum of Recursive Residuals
CUSUMQ	Cumulative Sum of Recursive Residuals Square
ECT	Error Correction Term
EF	Economic Freedom
FMOLS	Fully Modified Ordinary Least Square
GCC	Golf Cooperation Council
GMM	Generalized Method of Moments
IEA	International Energy Agency
IPS	Im, Pesaran and Shim
KLEMS	Capital, Labour, Energy, Material and Services
OECD	Organization of Economic Cooperation and Development
OPEC	Organization of Petroleum Exporting Countries
PP	Phillips-Perron
SSA	Sub-Sahara Africa
T-Y	Toda-Yamamoto
UAE	United Arab Emirate
UNECA	United Nation Economic Commission for Africa
VAR	Vector Autoregressive
VECM	Vector Error Correction Model

CHAPTER ONE
INTRODUCTION

1.1 Introduction

This chapter is made up of eight sections, which introduces the entire research. In such terrain, section 1.2 discussed the background of this study, while section 1.3 consists of the problem statement. Next is section 1.4 that provides the research questions, which are transformed into the objectives of the study in Section 1.5. Section 1.6 provides the significance of the study. Scopes of the study are contained in Section 1.7. Section 1.8 provides the organization of chapters for the entire research and finally Section 1.9 offers the conclusion of the chapter.

1.2 An Overview of Energy Resources and Manufacturing Sector Performance in Sub-Sahara Africa

Sub-Sahara African (SSA) countries have remains backward continent in energy productions and usage. Indeed, even with the enormous deposit of primary energy resources across the region, SSA countries are still among the slightest as far as energy utilisation. Taking the instances of electricity consumption, International Energy Agency, IEA (2014) established that about 620 million people in SSA have no access to electricity, and for those that even do have, the supply is often unreliable, insufficient and among the most costly in the world. Besides this, around 730 million people in the region rely on solid biomass for cooking. This can be justified by the IEA (2014) projection that about one billion individuals will still, in any case, need access to electricity in the world, and SSA will account for about 645 million people of the total by 2030. In Like manner, 2.5 billion individuals will need access to clean cooking facilities, also SSA will account for 881 million people by 2030 as shown in Table 1.1.

Table 1.1
Number of People without Access to Electricity and Clean Cooking Facilities by Region (Million)

	Without access to electricity		Without access to clean cooking facilities	
	2011	2030	2011	2030
Developing countries:	1,257	969	2,642	2,524
Africa	**620**	**645**	**696**	**881**
Sub-Saharan Africa	599	645	695	879
Developing Asia	**615**	**324**	**1,869**	**1,582**
China	3	**0**	446	241
India	306	147	818	730
Latin America	**24**	0	**68**	**53**
Middle East	**19**	**0**	**9**	**8**
World	**1,258**	**969**	**2,642**	**2,524**

Source: International Energy Agency (IEA), 2014

From Table 1.1, as at 2011, about 599 million people have no access to electricity in SSA. In addition, the number is projected at 645 million by 2030. This can be justified by an increase in population. Similarly, about 695 million people in SSA have no access to clean cooking facilities, and the number is projected at 879 million by 2030.

Despite the low level of energy production and consumption, SSA countries are blessed with diverse energy resources, which are disproportionately spread all over the region. The concentration of oil and gas reserves are mostly found in the West, Central, and Southern regions of the continent (IEA, 2014). Additionally, the Southern region of the continent is blessed with the biggest share of coal reserves. Uranium deposits in Africa were one of the largest in the world. Namibia, South

Africa, and the Niger Republic are among the currently leading producers of uranium across the globe (IEA, 2006a). Similarly, the region is exposed to strong sunlight all over the year as well as heavy wind and hydropower potentials (United Nation Economic Commission for Africa, UNECA, 2007; Olumuyiwa, 2008). Figure 1.1 further illustrates energy resources potentials across SSA countries.

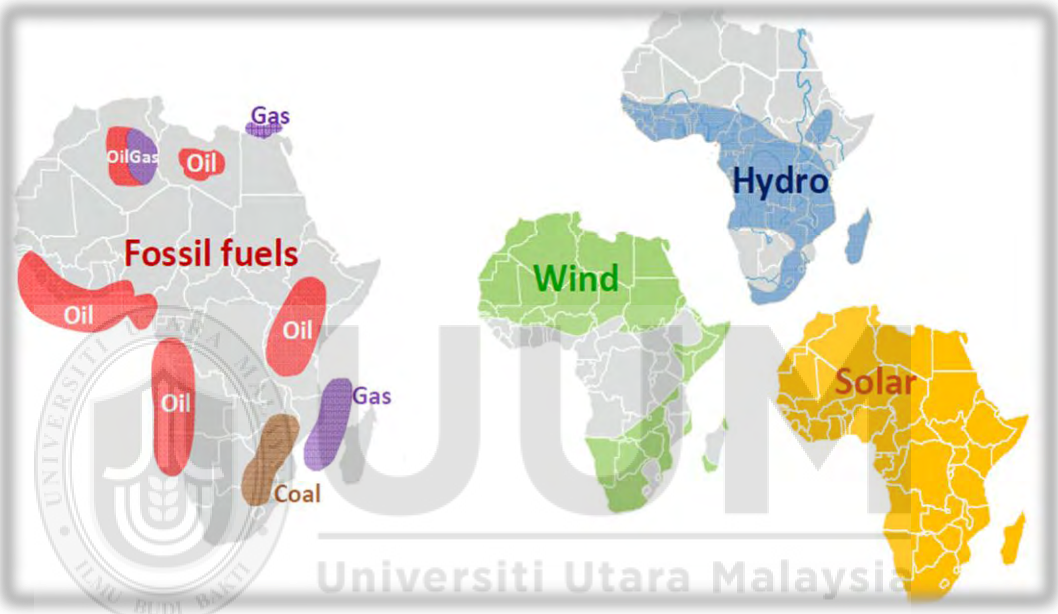

Figure 1.1
Energy Resource Potentials across Sub-Saharan Africa
Source: IEA (2014)

From Figure 1.1, SSA is blessed with energy possibilities, for example, coal which is produced in the southern SSA and with the South Africa as the main producer. While the West, Central and Southern region of the continent produce crude oil mainly in Nigeria, Gabon, and Angola, respectively. Similarly, the hydro potential is spread across the Western and the Southern regions, while the solar potential is spread all over the region.

Meanwhile, the allocation of energy across sectors in SSA reports that the manufacturing sector represents 11 percent of energy consumption, with transportation accounting for nine percent energy consumption. Agriculture, public service, and commercial sectors account for one percent of the energy consumption each while energy consumption for resident occupied 37 percent of the energy used. Other sectors account for the balance of 40 percent energy utilized (IEA, 2005). For clarity purposes, information on sectoral consumption of energy for the SSA is presented in Figure 1.2.

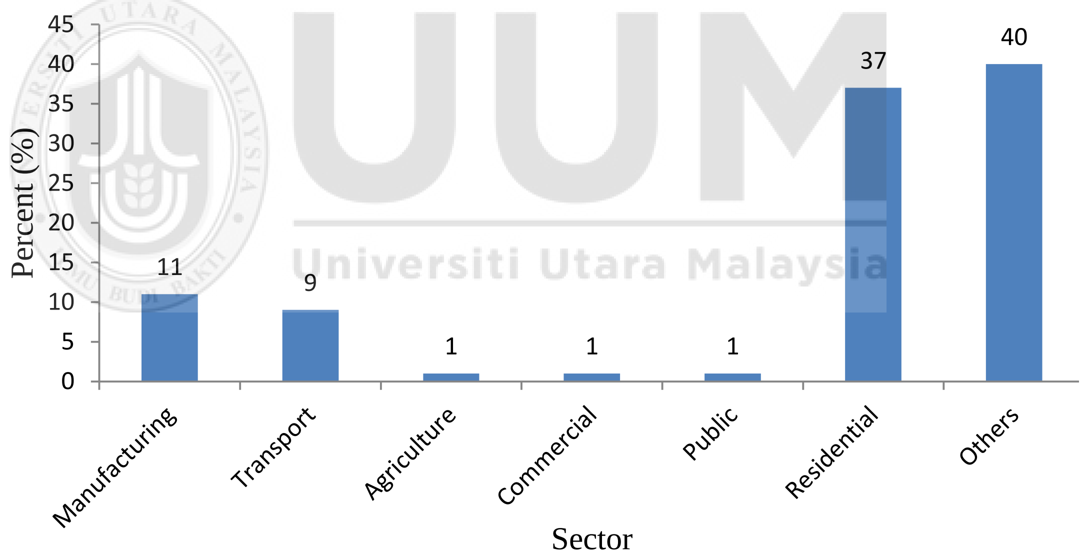

Figure 1.2
Sectoral Energy Consumption in Sub-Saharan Africa
Source: IEA, 2005

There are number of reasons that limits energy use in SSA, among which are: high level of restrictions resultant from poor energy policies, inadequate funding, ineffective energy infrastructures, slow pace of technological expansion, low productivity of energy and low levels of industrialization (Mohammed, Mustafa, & Bashir, 2013).

On the supply side, inadequate investment in infrastructure and the development of facilities that include electricity grids and pipelines, to distribute energy in commercial quantity are among the major factors leading to inadequate energy supply (Mohammed et al., 2013). This situation led to fluctuations in the supply of energy in SSA. Figure 1.3 shows average annual growth rate of energy production in SSA.

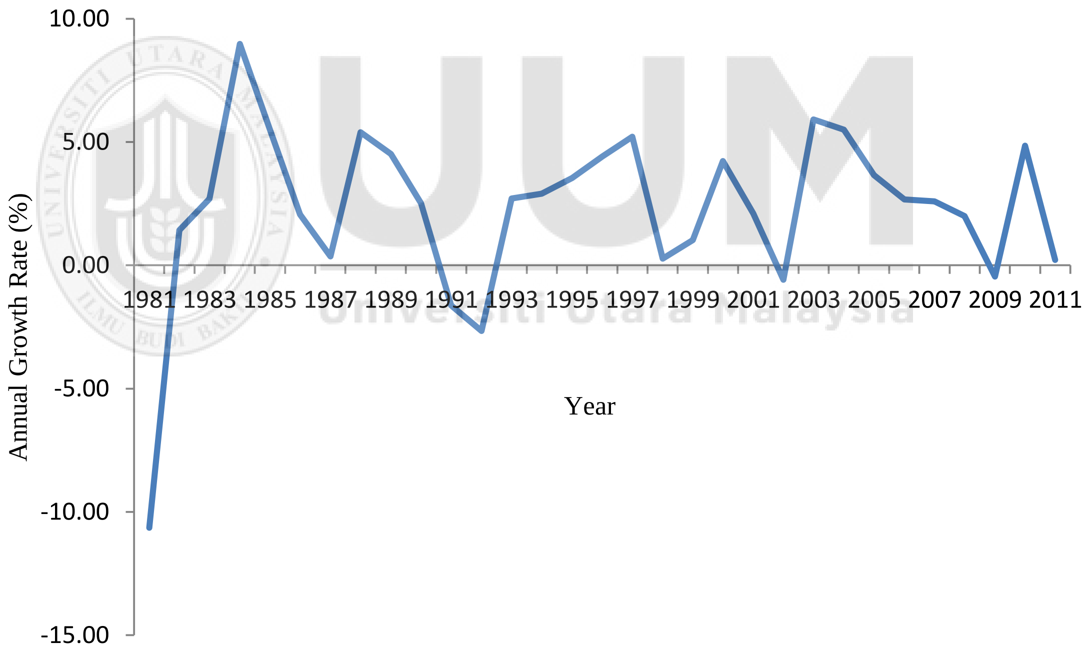

Figure 1.3
Average Annual Growth Rate of Energy Production in SSA Countries, 1980-2012
Source: Author’s Computation

Figure 1.3 explains the general trend of the annual growth rate of energy production in SSA countries during the period 1980 to 2012. From the figure, the growth rate of energy supply has been fluctuating in SSA during the period under study. This cannot be unconnected to inadequate investment in infrastructure to deliver commercial energy efficiently. Similarly, the growth rate in the supply of energy are negative in 1980, 1991 and 2001, an indication of fall in the supply. However, giving the increasing trend in the demand for energy resulting from increase in population and industrial expansions in many economies, negative growth rates of energy supply would translate to fall in the level of consumption arising from scarcity. A shortage in supply of a given commodity would naturally result to increase in the price of the commodity (Acharya, Lochstoer, & Ramadorai, 2013). However, energy is not an exception. Therefore, it can be argued that the unstable supply of energy is associated with fluctuations in the prices of the energy as well as its consumption.

Meanwhile, the growth rate of manufacturing industries in SSA has not match with the world industrial and manufacturing growth rate in the recent two decades. The portion of manufacturing output from SSA countries has remained constant over the period (Lawrence, 2005). Similarly, the portion of export from manufacturing sector in SSA from 1980 to 2000 has remained unchanged around 0.8 percent (Lawrence, 2005). Just as the case of the growth of energy production, manufacturing value added has experienced similar fluctuations in SSA. Figure 1.4 shows an average annual growth rate of manufacturing value added in SSA.

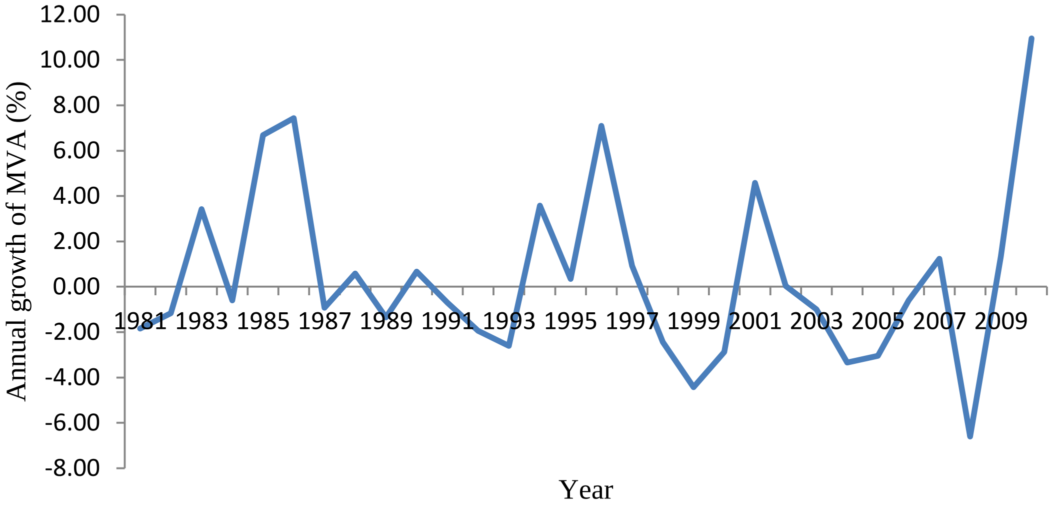

Figure 1.4
Average Annual Growth of Manufacturing Value Added for SSA Countries, 1980-2010

From Figure 1.4, it can be practically observed that manufacturing sector performance in SSA has been experiencing fluctuations over the period and could not be disconnected with the issues relating to the low productivity of energy as evidenced in Figure 1.3. For instance, the lowest energy productivity in SSA was recorded between 1991 and 1992, which transformed into lowest manufacturing performance during the same period in SSA.

Comparing energy consumption and manufacturing sector performance in SSA will further clarify the trend and the link between energy consumption and manufacturing sector performance. Figure 1.5 shows the trend of energy consumption and manufacturing sector performance in selected SSA countries.

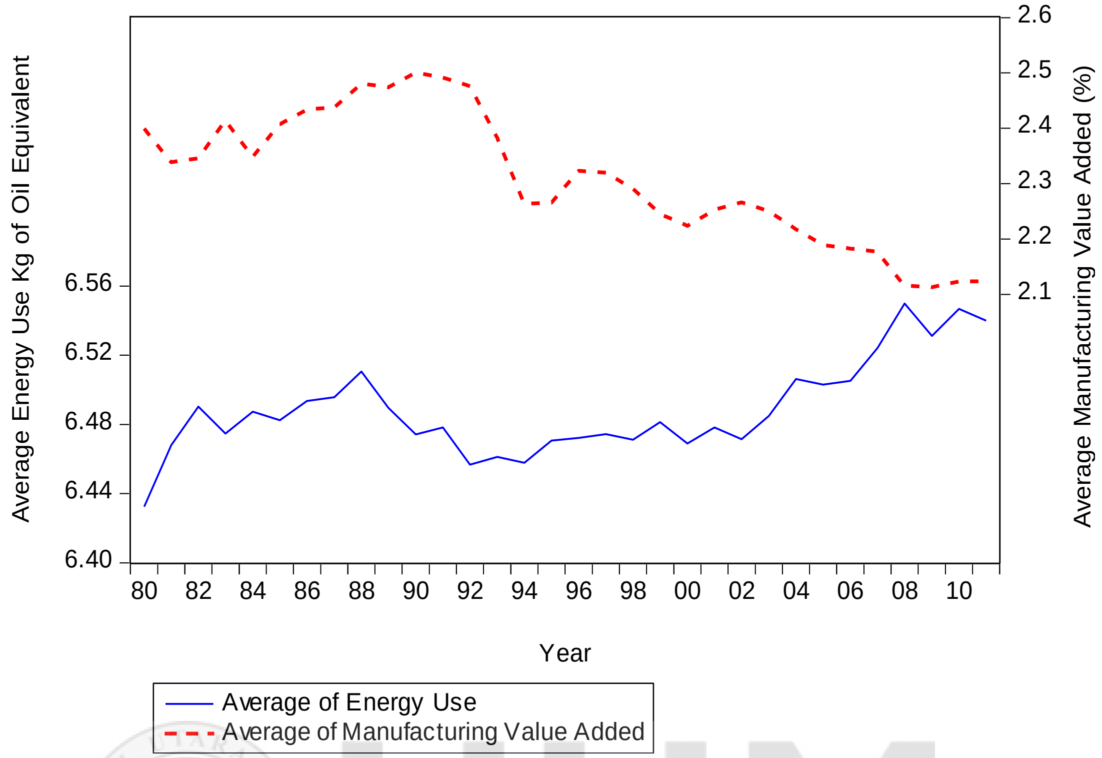

Figure 1.5
Energy Consumption and Manufacturing Sector Performance in the Selected SSA Countries, 1980-2012

In Figure 1.5, it can be observed that the trend of the link connecting manufacturing performance with energy consumption is moving in opposite trend. As it can be observed, while energy consumption is moving in an upward trend, manufacturing value added is moving in a downward trend. Thus, evidence of divergence is revealed in the relationship. It further justified Figure 1.2 for sectoral distribution of energy consumption across the SSA countries where energy consumption by manufacturing sector accounts for only 11 percent of energy consumption. Similarly, this divergence trend may be connected to the low level of industrialization across the SSA region.

In spite of the certainty, Figure 1.5 displayed on the pattern of the relationship between the energy consumption and the manufacturing performance across the sampled SSA Countries. In all actuality, there is a need to demonstrate the relationship between manufacturing performance and energy consumption for the individual country under study. This will further give a clear picture of the connection of energy consumption to manufacturing performance for the sampled SSA Countries. In this way, Figure 1.6 to Figure 1.14 shows the relationship between energy consumption and manufacturing performance in each individual country under study.

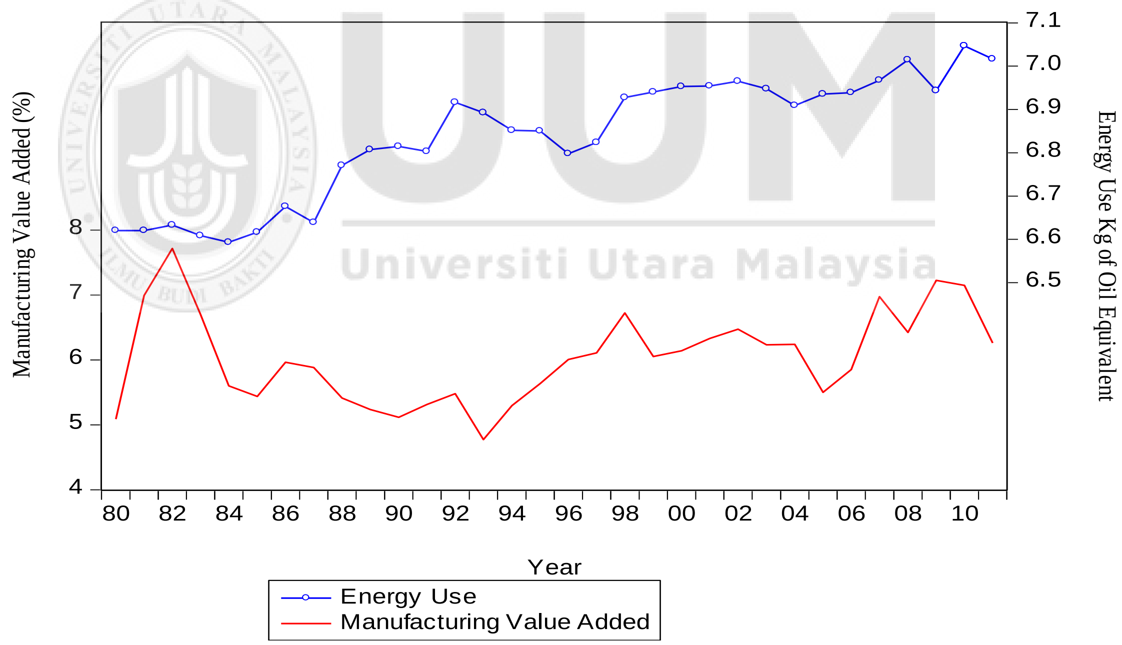

Figure 1.6
Energy Consumption and Manufacturing Sector Performance in Botswana, 1980-2012

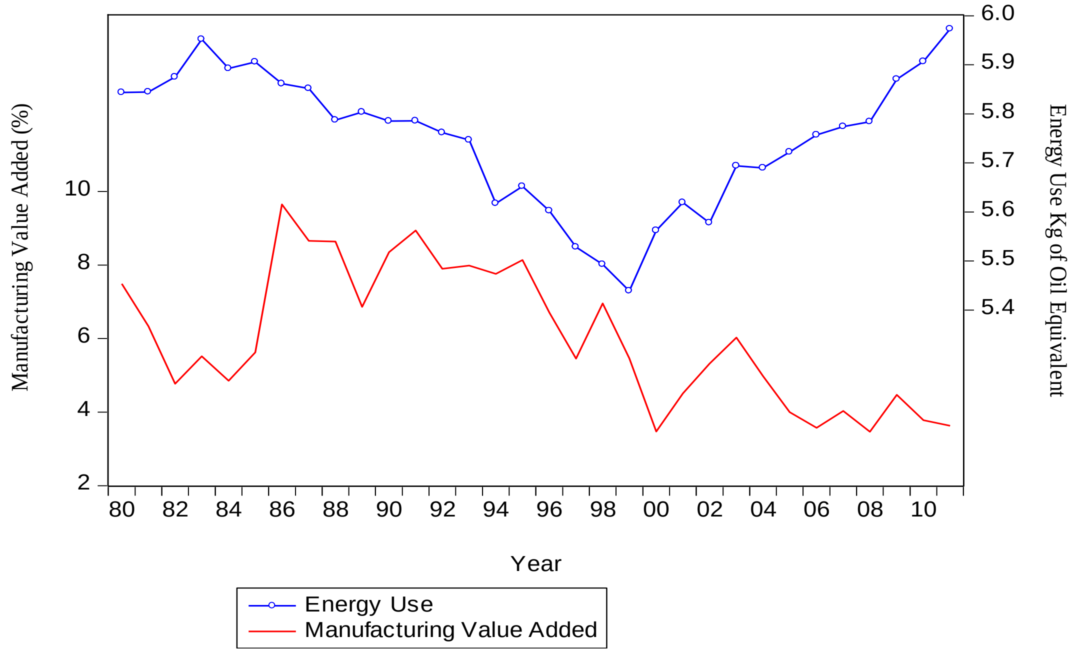

Figure 1.7
Energy Consumption and Manufacturing Sector Performance in Congo Republic, 1980-2012

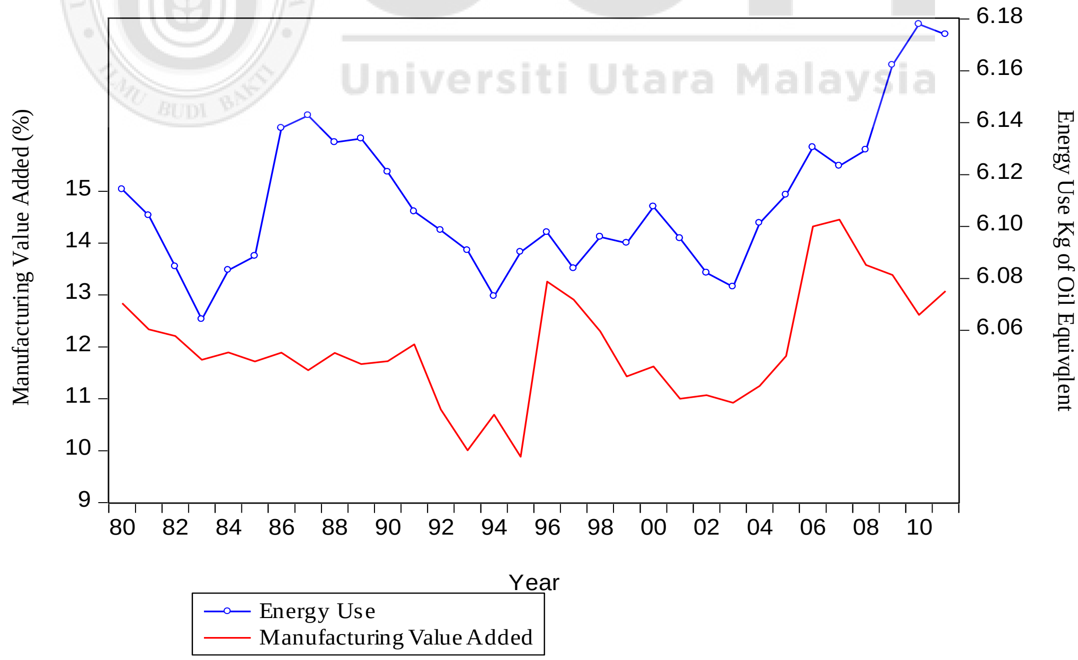

Figure 1.8
Energy Consumption and Manufacturing Sector Performance in Kenya, 1980-2012

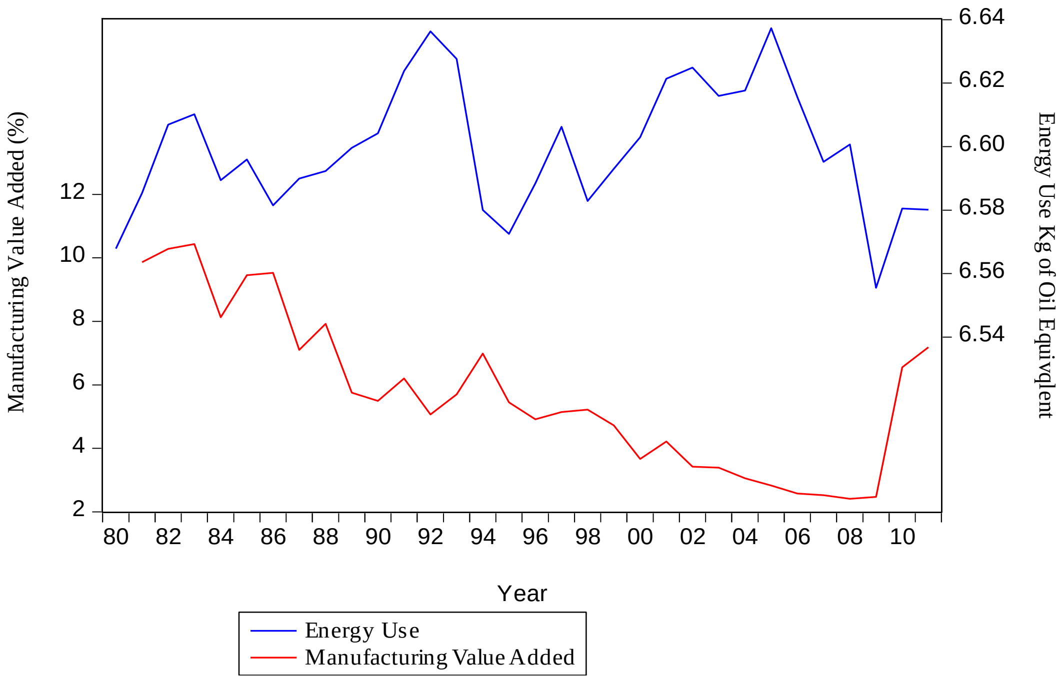

Figure 1.9
Energy Consumption and Manufacturing Sector Performance in Nigeria, 1980-2012

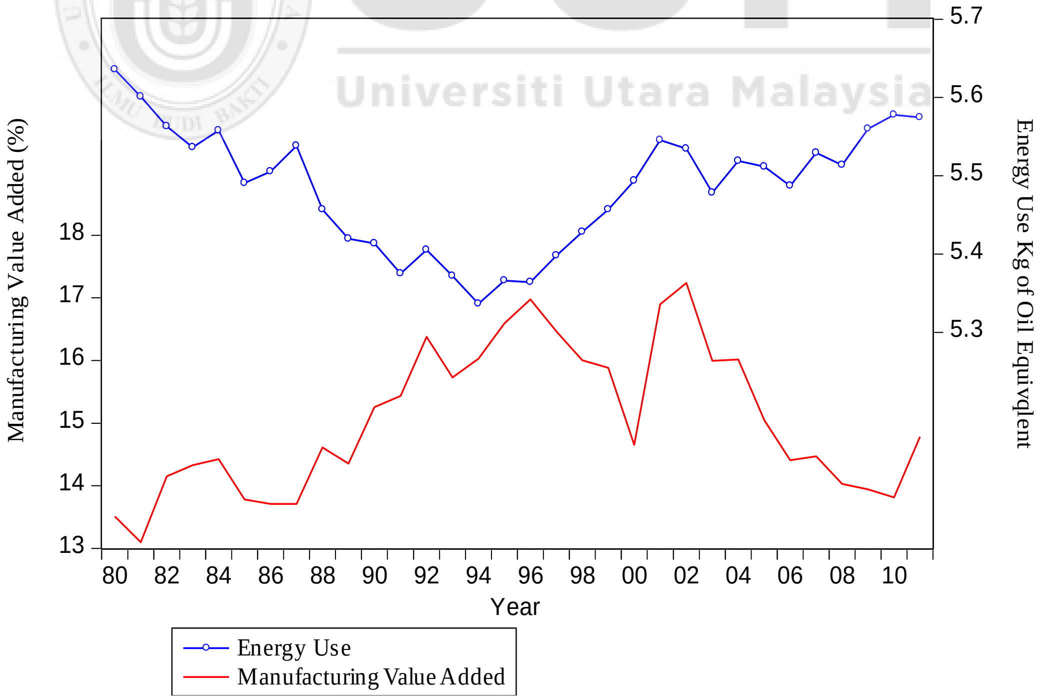

Figure 1.10
Energy Consumption and Manufacturing Sector Performance in Senegal, 1980-2012

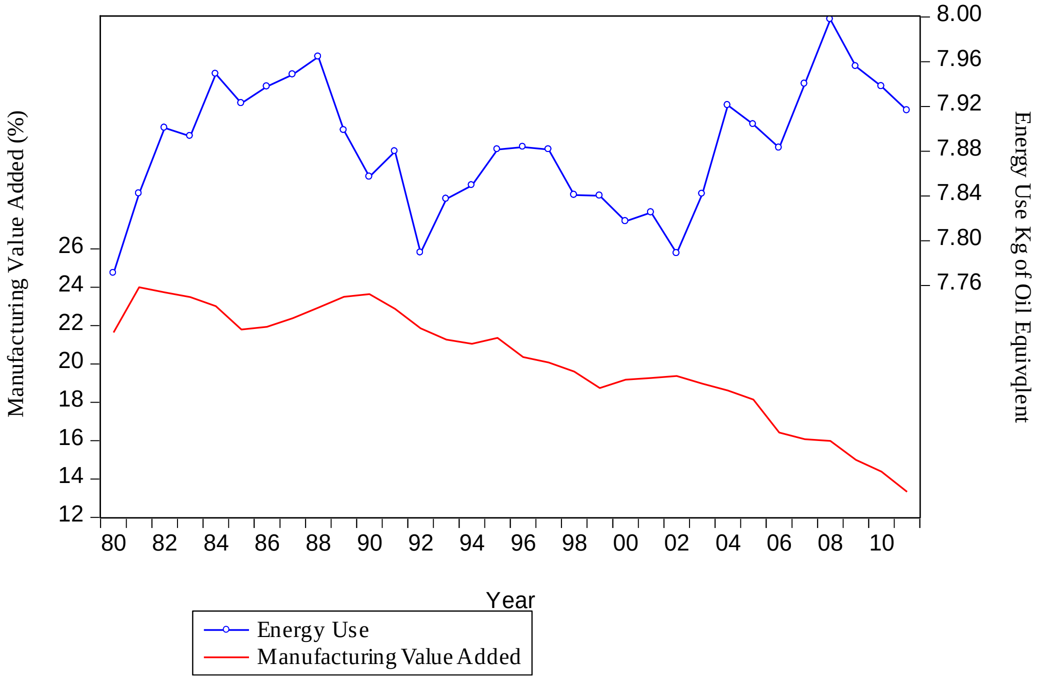

Figure 1.11
Energy Consumption and Manufacturing Sector Performance in South Africa, 1980-2012

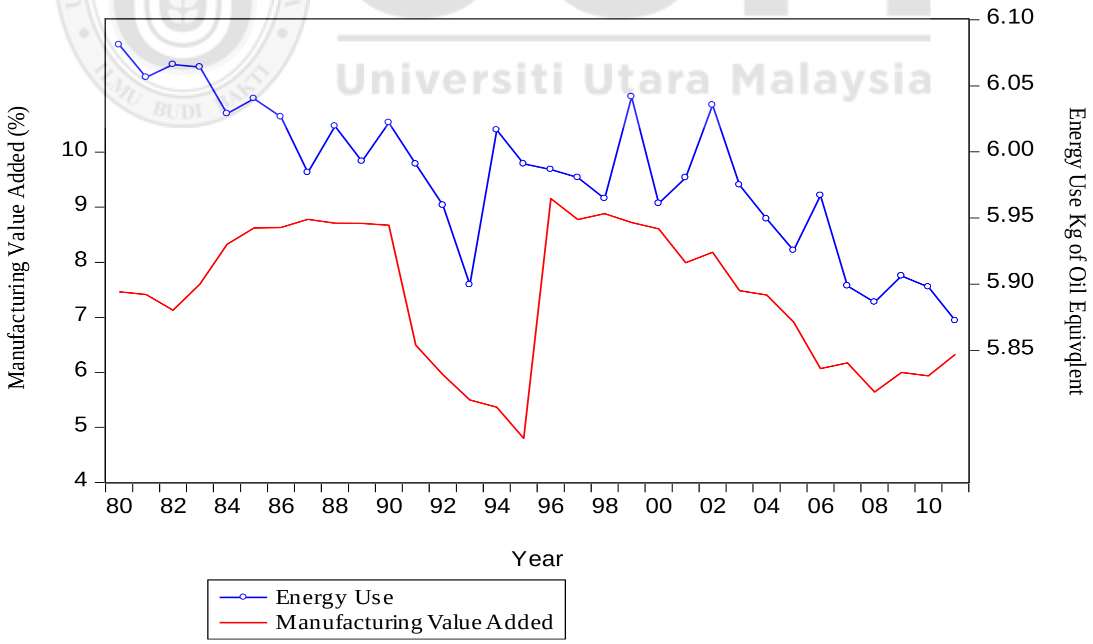

Figure 1.12
Energy Consumption and Manufacturing Sector Performance in Sudan, 1980-2010

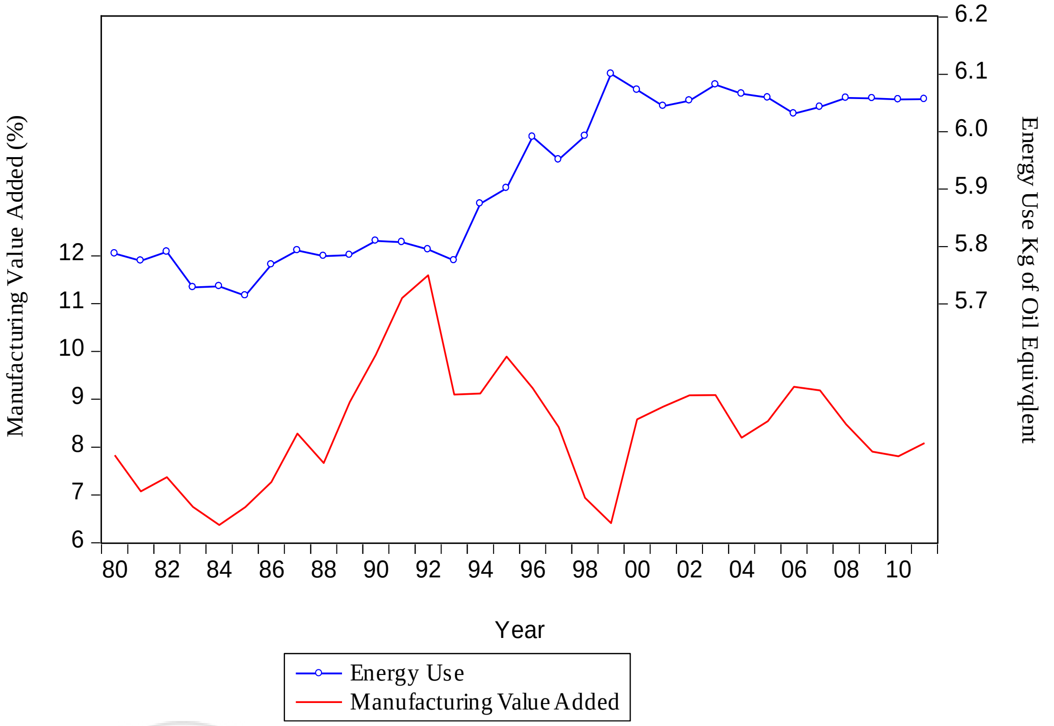

Figure 1.13
Energy Consumption and Manufacturing Sector Performance in Togo, 1980-2012

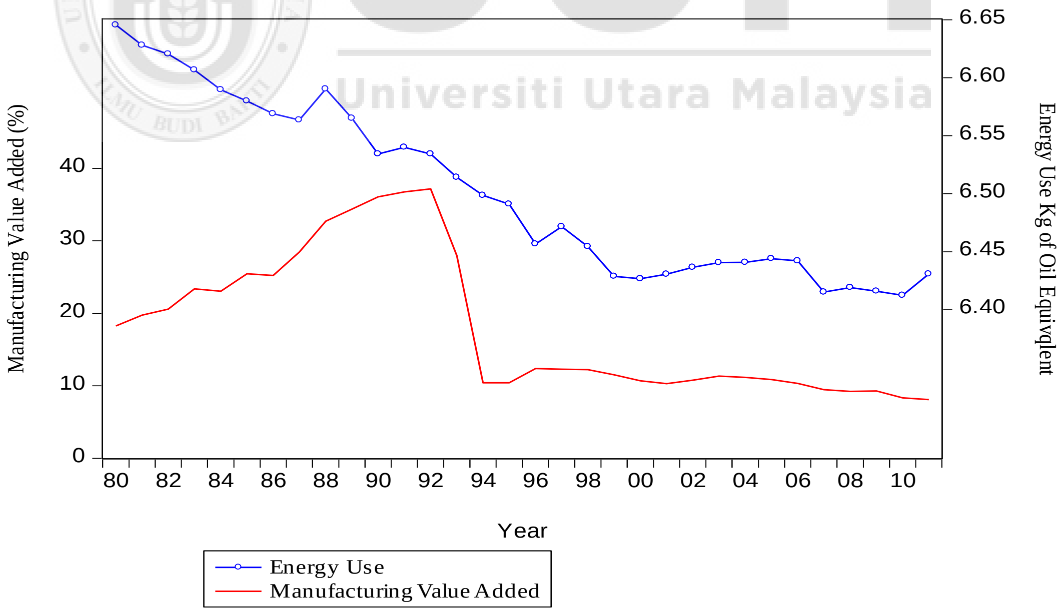

Figure 1.14
Energy Consumption and Manufacturing Sector Performance in Zimbabwe, 1980-2012

Figure 1.6 to Figure 1.14 showcase the trend of energy use and manufacturing performance for each sampled individual SSA Country. It is observed from the figures that different trending has been maintained. For instance, evidence of converging trend was reported for Kenya during the whole period under review in Figure 1.8. A similar trend was the case for Sudan and Togo in Figure 1.12 and Figure 1.13, respectively, especially from 1990 to 2010. Notwithstanding, Figure 1.9 uncovered an alternate case for Nigeria amid the whole time frame under study, as the relationship between energy use and manufacturing performance was entirely diverging. This was additionally the case for Senegal and South Africa as presented in Figure 1.10 and Figure 1.11, respectively. For the Congo Republic, manufacturing sector performance has been increasing while energy use was decreasing between 1980 and 1994. In addition, from 1998 to 2010, manufacturing sector performance was decreasing as energy use was increasing as evidenced in Figure 1.7. For the last group, Figure 1.6 shows no trend between manufacturing performance and energy use as evidenced for the Botswana.

For the disaggregated energy consumption, Figure 1.15 and Figure 1.16 show the trend between manufacturing performance and fossil energy consumption, and manufacturing performance and electricity consumption, respectively.

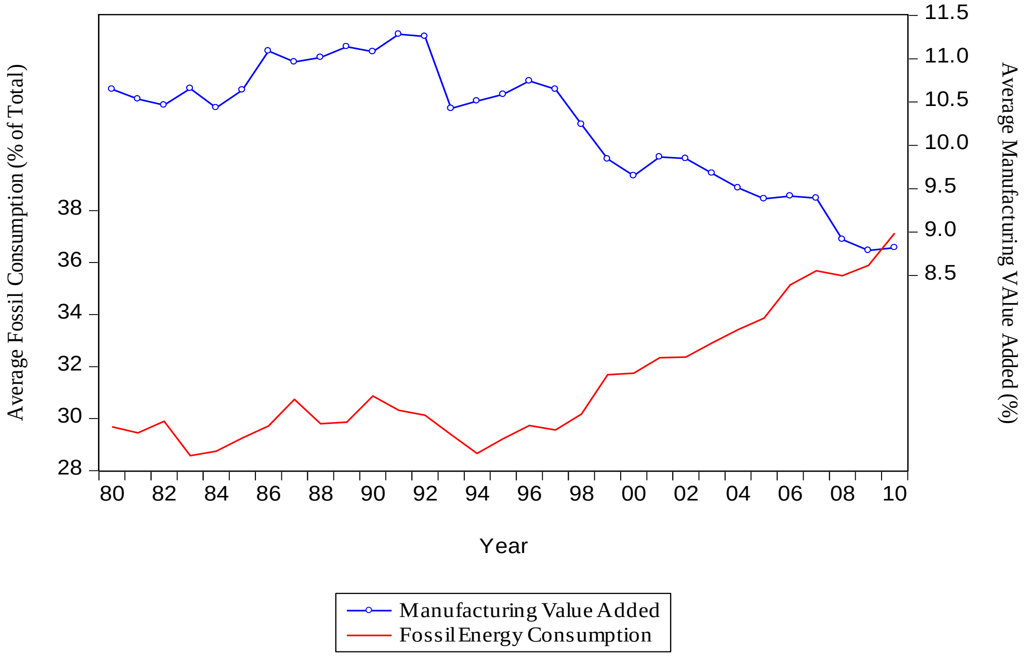

Figure 1.15
Fossil Energy Consumption and Manufacturing Sector Performance in Sampled SSA Countries, 1980-2012

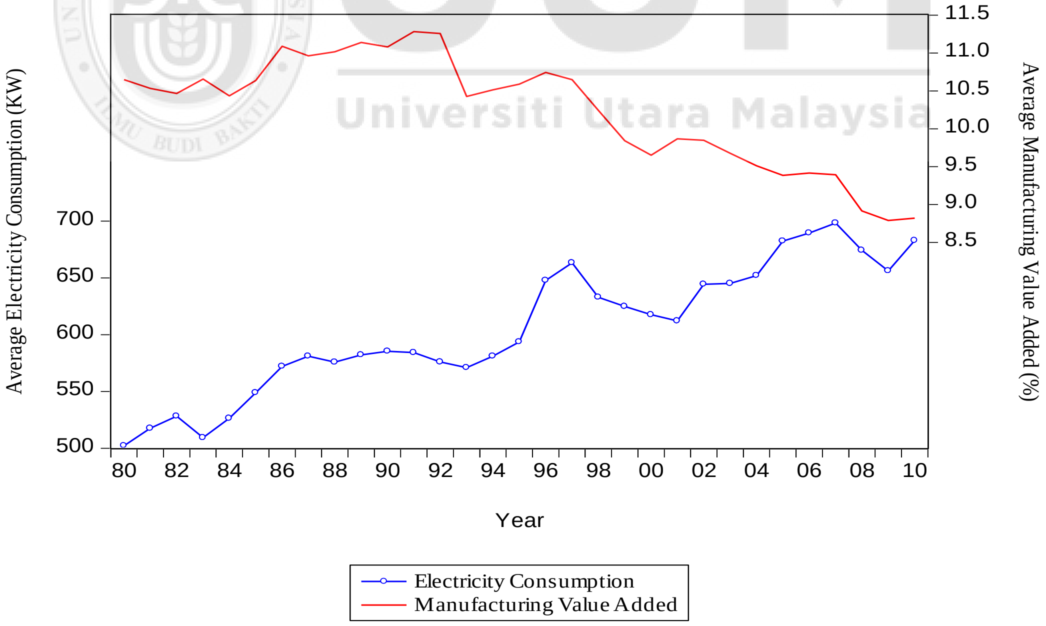

Figure 1.16
Electricity Consumption and Manufacturing Sector Performance in the sampled SSA countries, 1980-2012

Figure 1.15 and Figure 1.16 show the relationship among disaggregated energy, which includes Fossil energy and electricity with manufacturing sector performance for the sampled SSA countries. It can be noticed that the trend between both fossil energy consumption and electricity consumption, and manufacturing performance are moving in the opposite trend. Meaning that while both fossil energy consumption and electricity consumption are moving in an upward trend, manufacturing value added is moving in a downward trend. Consequently, evidence of divergence was revealed in the relationship. This relationship shows a similar trend for the aggregate energy consumption as shown in Figure 1.5.

1.3 Problem Statement

In modern economies, production coupled with many other forms of consumption (such as household, firms and government consumptions) employs energy usage as one of the fundamental factor input. It gives the idea that energy usage is among the main sources of industrialization and economic growth. In this manner, both industrialization and economic growth may encourage the use of more energy.

Unlike in the traditional neoclassical growth model where energy in the production process is thought to be neutral; which have situated energy inputs to remain as an intermediate factor of production. Whereas labour and capital stand as the fundamental factors of production which facilitate the biophysical economist views on energy as the essential factor of production. In such views, therefore, production will deeply rely on energy input which would drastically affect output performance as a result of energy consumption changes (Cleveland, Costanza, Hall, & Kaufman, 1984). Furthermore, (Beaudreau, 2005b). In such perspectives, it denounces the traditional growth model for considering energy input as a less important factor of production by stressing that from the engineering point of view, production is impossible without engaging energy. Therefore, this justifies considering energy as a vital input and, as a result, energy has been considered as part of the production inputs.

For this purpose, at the beginning of the 20th century, scholars such as Soddy (1922), Scott (1933) and Rautenstrauch (1939) have raised issues and concerns on why energy is not included in the production analysis. In an attempt to tackle these issues, some scholars such as Berndt and Wood (1979) and Kümmel, Lindenberger, and Eichhorn (2000) take account of energy in the standard neoclassical two-sector model. Recently, attempts have been made to emphasize the significance of energy consumption in the process of production. As a result, many studies have attempted to include energy as an extra factor input in extension to capital and labour. This can be seen in the work of Stern (2000) for the United States (US), Oh and Lee (2004a) for Korea, Ghali and El-Sakka (2004) for Canada, Beaudreau (2005a) for the US, Soytas and Sari (2006) for G-7 economies[1], Soytas and Sari (2007) for Turkey, Narayan and Smyth (2008) for G-7 countries, Lee and Chang (2008) for Asian

[1] G-7 countries are group of industrialized countries, which includes Us, Canada, France, German, Italy, Japan and UK.

economies, Wolde-Rufael (2009) for African countries, Iyke (2015) for Nigeria and, Solarin and Ozturk (2016) for 12 OPEC[2] members.

On the theoretical argument of the role of energy, empirical evidences revealed that there has been disagreement on the position of energy on the growth rate of GDP. Since from the exertion of Kraft and Kraft (1978), there has been a rapid increase in the literature to investigate empirically, in both developing and developed economies, on the link connecting energy with the growth rate of GDP by utilizing co-integration and Granger causality models (Lee & Chang, 2008; Chontanawat, Hunt, & Pierse, 2008). More recently, studies in this area generally use a multivariate models (Zamani, 2007; Narayan, Smyth, & Prasad, 2007; Stern & Enflo, 2013; Odhiambo, 2014; Bastola & Sapkota, 2015; Alper & Oguz, 2016; Danmaraya & Hassan, 2016). Yet, consensus has not been reached on the position of energy to economic growth.

According to IEA (2014), SSA is rich in energy potentials, accounting for almost 30 percent of global oil discoveries over the last five years. The region also, has vast untapped potentials of solar and hydro, as justified by Figure 1.1. However, despite the rich energy resources, the continent still remain backward as far as energy productions and consumptions are concerned. Taking the instance of electricity, IEA (2014) reveals that about 620 million individuals in SSA have no electricity access,

[2] OPEC countries include Algeria, Angola, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, UAE and Venezuela.

and for those that do have, its supply is mostly insufficient, unreliable and among the most expensive in the world.

Coming down to the sectoral distribution of energy consumption in SSA, IEA (2005) reports that manufacturing sector accommodates 11 percent of energy utilization in Africa. With transportation accounting for nine percent, while energy consumption in residents' accounts for 37 percent of energy utilization. Looking at the share of manufacturing industry, agricultural and commercial sectors as far as energy consumption in SSA is concerned. It can be observed that the sectors are among the least in terms of energy utilization. This translates to a serious problem as far as productivity and, by extension, economic growth are concerned. Owing to the inevitable fact that the sectors contribute immensely to the increase in productivity, but having least energy utilization. This further confirms the reasons that limit energy use in SSA, among which are: low level of income per-capita coupled with low industrialization level (as evidently shown in Figure 1.2). This has been subsequently followed by the small rates of ownership of electric tools as well as the operation of automobiles and electric appliances (such as refrigerators & freezers).

Furthermore, energy consumption in SSA was low because of lack of proper investment in energy infrastructure. This has led to fluctuations in the supply of energy in SSA. In addition, looking at the trend from Figure 1.3, it can be seen that, at some points in time, the growth rate in the supply of energy are negative, an indication of fall in the supply. In any case, giving the growing demand for energy resulting from an increase in population and industrial expansions in many economies, negative growth rates of energy supply would mean a fall in the level of consumption arising from scarcity. Thus, a fluctuation in the supply of energy is related to energy consumption in SSA countries and as a result, manufacturing sector's energy consumption could be affected. This may further affect the performance of manufacturing sector.

Similarly, over the last three decades, SSA countries' manufacturing growth has been inconsistent as it was shown in Figure 1.4. This could be linked with low energy consumption because of low energy productivity as shown in Figure 1.3. This further justifies the association between energy and manufacturing sector performance, as low energy productivity can be associated with low growth rate of the manufacturing sector in SSA. Thus, it can be concluded that economic growth will be seriously harmed in SSA.

In the same way, divergence trend in the relationship among both aggregate energy consumption, fossil energy, electricity consumption and manufacturing productivity in SSA countries was shown in Figure 1.5, Figure 1.15 and Figure 1.16, respectively where both aggregate energy consumption, fossil energy consumption and electricity consumption are moving upward and manufacturing performance was moving in the opposite direction. This raised the issue whether energy consumption can stimulate economic growth in general and manufacturing performance in particular. As most of the previous literature have suggested the proof of positive link that has connected the growth rate of GDP and energy consumption. Thus, the need to investigate disaggregated component of GDP to come up with findings that are more robust cannot be overemphasize.

Similarly, at individual country analysis, the relationship between energy use and manufacturing performance has yielded a conflicting and contracting evidence. Whereas in some countries under study, evidence of convergence was reveal in the relationship, the reverse is the case for other countries as evidence of divergence was shown in the relationship. Similarly, some countries demonstrate no any relationship between energy use and performance. Taking Kenya, Sudan, Senegal and Zimbabwe, for instance, the trend of the relationship have shown the evidence of convergence where the rise in energy use matched with the rise in manufacturing performance. The reverse is the case for Congo Republic, Nigeria, South Africa and Togo. Looking at Figure 1.6 to Figure 1.14, it can be clearly deduced that there is disagreement on the association between manufacturing sector performance and energy use and hence, the need to examine the exact link between energy and manufacturing performance in SSA countries for a better policy making cannot be over emphasize.

Moreover, UNECA (2007) established that energy consumption growth has for long been associated directly to welfare improvement and economic growth. Every production and several consumption activities involve energy consumption as a vital factor. This is owing to the fact that energy strengthens the productivity of capital, labour, and other production inputs. It is one of the means to industrialization, urbanization, and economic growth; in proper sequence, industrialization, urbanization, and economic growth promote more energy consumption (Paul & Bhattacharya, 2004). Therefore, in countries where energy accessibility is inadequate or in a situation where energy is economically unaffordable for the majority of the society, economic development is critically harmed, and growth is restricted (UNECA, 2007).

1.4 Research Questions

Following the above problem statement, the following questions will act as a guide, and in the course of the study, it is expected that answers will be provided to the following question:

i. What is the extent of the relationship between energy consumption and manufacturing sector performance using the aggregate and the disaggregate energy consumptions in SSA?
ii. Is there any link between aggregate energy consumption and manufacturing sector performance in SSA?
iii. In what way does the connection between aggregate energy consumption and manufacturing sector performance differ across income group in the sampled SSA?

iv. What is the direction of the causality between aggregate and disaggregate energy consumptions, and manufacturing sector performance in SSA?

1.5 Objectives of the Study

The general target of this study is to investigate energy consumption among the SSA countries on one hand and its relationship with manufacturing sector performance on the other hand. To actualize this general objective, the following specific objectives are pursued:

i. to investigate the effect of energy consumption on manufacturing sector performance using the aggregate and the disaggregate energy consumptions among the selected SSA countries.

ii. to examine the link between aggregate energy consumption and manufacturing sector performance in the whole SSA countries.

iii. to evaluate the interrelation between aggregate energy consumption and manufacturing sector performance across different income group in the sampled SSA.

iv. to examine the direction of causalities between aggregate and disaggregate energy consumptions, and manufacturing sector performance among selected SSA.

1.6 Significance of the Study

This study principally focuses on the issue of energy consumption and manufacturing sector performance among the SSA countries. In this way, the present study would undertake an empirical investigation on the link between the performance of manufacturing sector and energy consumption within SSA region. In such manner, the research is expected to make a significant contribution in the following ways:

This study is anticipated to make significant contribution to the existing literature on energy consumption-growth nexus. As economic growth and energy consumption relationship is clearly interpreted by contradicting and conflicting findings on similar studies.

Similarly, even though there are many researches on issues surrounding economic growth and energy consumption, it comes into sight that there is paucity of literature on SSA, especially using the disaggregated energy data. This research therefore, will be of significant by disaggregating energy data to come up with a more robust recommendation for policymaking.

Furthermore, most of the studies on energy-growth nexus are concern about aggregate GDP and there is the need to look into the manufacturing sector performance in isolation. Therefore, this study will investigate the link connecting energy consumption with performance of manufacturing sector, as increase in aggregate performance of the manufacturing firms' generally will result to rise in economic growth.

Finally, the findings of this study would additionally put forward a number of openings for the SSA to diagnose policies that would strike a balance between consumption and conservation of energy in sustaining and speeding up the growth of the economy in general and manufacturing performance in particular. In addition, the research would also provide some recommendations for the SSA region, depending on the outcome of the study.

1.7 Scope of the Study

The study covers a panel of nine out of the 48 SSA, namely: Botswana, Sudan, Kenya, Nigeria, Senegal, South Africa, Congo Republic, Togo, and Zimbabwe. The decision of selecting these nations is legitimized by the way that they are from the same district and the accessibility of the data among the SSA countries. For that reason, the research makes use of data from the panel of nine SSA countries from 1995-2012 as well as the time series data from 1980–2012. The time period selected is influenced by the availability of data of each of the variables. The study used data on total energy consumption (kWh), Fossil fuel energy consumption (percentage of total), electric power consumption (kWh), and manufacturing value added (constant 2005 USD), Labour force participation rate, percentage of total population ages 15-64 years, economic freedom, corruption perception index, inflation rate and gross capital formation (constant 2005 USD). Figure 1.17 and Figure 1.18 present the map of countries in SSA Region and map showing low-income and middle-income countries in Africa based on the World Bank classification from which the countries are selected, respectively. The countries selected in low-income SSA include Congo Republic, Sudan, Togo and Zimbabwe, while the middle-income countries include Kenya, Nigeria, Senegal, South Africa and Sudan.

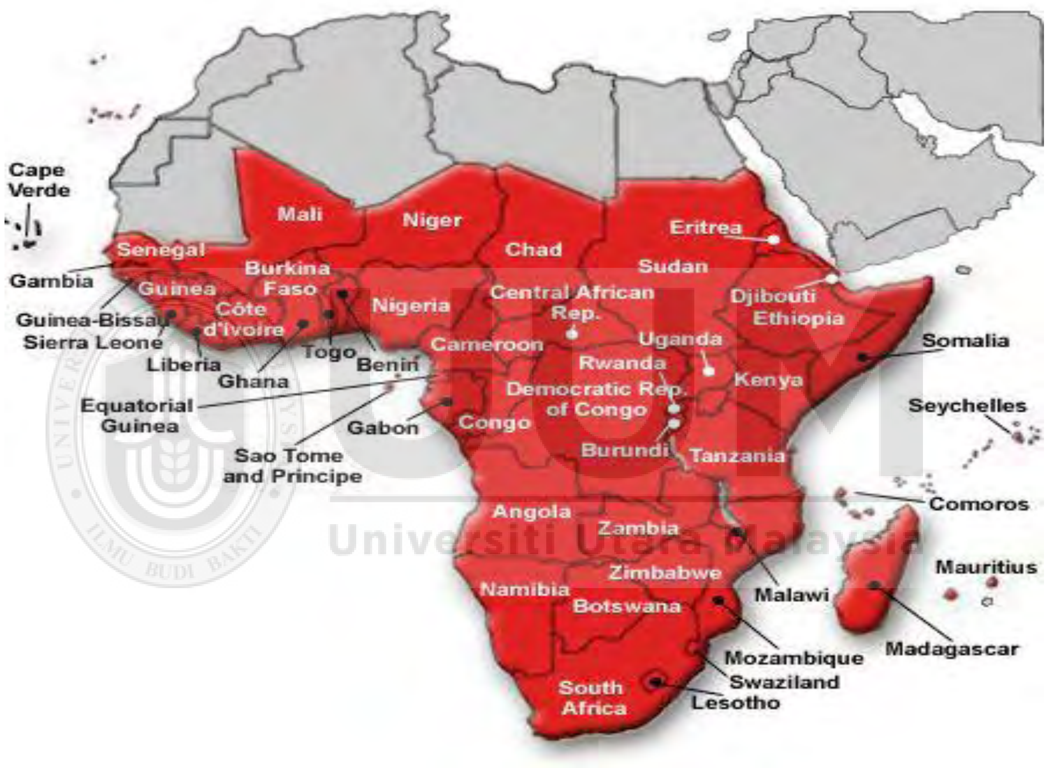

Figure 1.17
Countries in SSA Region

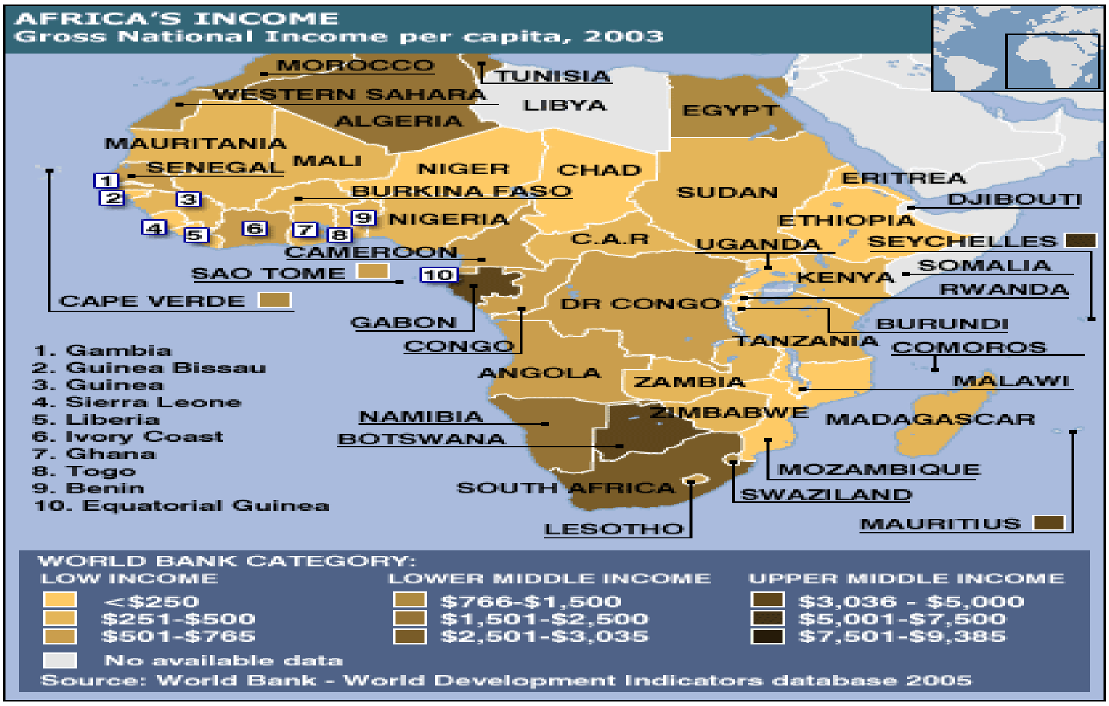

Figure 1.18
Map Showing Low-Income and Middle-Income Countries in Africa

1.8 Organization of Chapters

This research is made up of five chapters. This chapter is the first and the introductory chapter. It contains the overview of energy resources and manufacturing sector in SSA, problem statement, research questions, research objectives and the significance of the study. Other components of this chapter cover the scope of the research as well as the organization of chapters and finally, the conclusion of the chapter. Chapter Two accommodates a review of the literature on issues relating to the study as well as the theoretical review. Chapter Three contains the theoretical framework and the research methodology for this study, as Chapter Four discusses the result findings. Finally, Chapter Five summarizes and concluded the study.

1.9 Conclusion

As an introductory chapter, this chapter demonstrates an understanding of the whole research. It covers the overview of energy resources and manufacturing sector in SSA. Under this, issues' concerning energy consumption, productivity, and GDP growth among SSA, in general, was discussed. Furthermore, the sub-section emphasizes the importance attached to energy consumption in the production process and output performance. Following the overview, the chapter presents a problem statement where the problems on energy and manufacturing performance were raised. Taking after the problem statement, research questions are drawn in another sub-section and later translated into objectives in the next sub-section. The significance appended to this study is given in a different sub-section, and finally, the last two sub-sections of the chapter handle scope the study and organization of chapters, respectively.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

The objective of this chapter is to examines the association between output, growth and energy in the literature. Section 2.2 provides the theoretical review of economic growth. The section has been categorized into two, which include Neoclassical perspective and the Mainstream perspective that relegated energy as a factor of production, to a dismal position, and the Endogenous theory and Biophysical theory which accords a more central role to energy in the production process. Following this, the review of the position of energy in production and growth is contained in Section 2.3 where the interaction between economic growth and energy consumption is surveyed. Similarly, the relationship between output and energy consumption is contained in Section 3.4 as Section 3.5 displayed the gap in the literature. Finally, Section 2.6 concludes the chapter.

2.2 Energy and Production

Historical facts have shown the importance of energy as an important building block to economic growth. The first instance that stimulated the industrial revolution is the 18th century Britain, which adapted the use of coal as an alternative fuel due to the scarcity of charcoal. Coal fired (capital) equipments, which lead to an increase in productivity just as the steam engine is replaced by horse-powered pumps. The resulting general fall in prices, (including coal itself) led to increasing demand for all goods. Again, during the 19th century in Western Pennsylvania, the discovery of petroleum stimulated the development of the internal combustion engine. Likewise, falling costs boosted the demand for both energy and other goods. Clearly, since the 18th century, fossil-fuel and electric power driven capital machinery have been both substitute and booster of human and animal labour (Ayres, 2001).

The role of energy in stimulating output has yielded rising interest by researchers succeeding the work of Schurr (1982, 1984), that assumed electrification significantly strengthens the growth of labour and multifactor productivity in the U.S. economy in the early 20th century. The theories reviewed in this section include: neo-classical theory of growth, the mainstream perspectives, the endogenous growth theory and the biophysical perspectives.

2.2.1 The Neoclassical Growth Theory

The neoclassical theory of growth was developed primarily to explain economic growth and is therefore set mainly in the context of an industrial economy (Barro, 1996). In such an economy, the two main factors of production are capital, K and labour, L. The theory is therefore primarily concerned with the way growth of output, Y is influenced by the growth of L which was assumed to be given exogenous, and the growth of K due to investment (Sundrum, 1992).

The neoclassical growth theory can be represented by Solow model, which explain the long-run growth of neoclassical framework. The model focuses on the total production function in addition to the link connecting investment and the economic growth rate. The fundamental assumption of Solow model is that there is a closed economy producing one single (composite) good using both L and K (Agenor, 2004). The production function therefore, attributes K and L inputs which are needed to produce Y using a Cobb-Douglas production function of $Y=F(K,L) = K^{\alpha}L^{1-\alpha}$. Constant return to scale is described in the production function, meaning that output will change in proportion to change in input.

The Solow model further demonstrates capital accumulation in an economy which is specified by $K=sY-dK$. According to this, the difference between gross investment, sY and depreciation, dK represent the change in the capital stock K. The model furthermore, believes constant part of rental earnings and wages are saved by workers. Since the economy is assume to be closed, investment is used to raise capital and savings is equals investment. Depreciation happens every period no matter how much output is produced.

2.2.2 Mainstream Theoretical Perspectives

The differentiation between primary inputs and the intermediate inputs has assumed a considerable role on how mainstream growth theory view the role of energy in production that regard capital, labour and land as essential inputs along with materials and energy as intermediates inputs. This indicates that return to different factors of production is finally accumulated to the three important inputs, which are assumed to be labour, capital and land (Stern & Cleveland, 2004). The conclusion of the neoclassical assumption of where productivity of a factor input should is equal to its cost share in production is that only the important inputs, *L* and *K* are given all the central attention, while energy is according a discouraging and indirect function (Stern & Cleveland, 2004). Growth theories at all times contrarily explained technical progress as the most important cause of labour productivity.

However, technical progress is among the dominant energy utilizing mechanism of development (Jorgenson, 1984). This leads a number of works to include energy into the conventional capital and labour, either in a Constant Elasticity of Substitution (CES) or in a Cobb-Douglas production framework. The first approach was first taken by Berndt and Wood (1975), who also included services along with material in a production function referred to as *KLEMS* (where, *K* represents stock of capital, *L* represent labour, *E* stands for energy, while *M* is material input & *S* is the services employed). Following this work, others have tried to investigate the substitution and complementarities possibilities that were previously ignored. These works like the mainstream foundation, still constraint the output elasticity of each input to be in proportion to its share cost.

By indication, energy prices have no important effect on real output (Gallop & Jorgenson, 1980). Hannon and Joyce (1981) describe similar situation for the US by combining capital and energy. Afterward, Jorgenson (1984) employed a transcendental logarithmic production function with electric energy where he described energy prices have an extreme strong inverse consequence on the output in

US and Japan throughout the energy crisis era in 1970s. Later, it was disproved by many economists, in view of the fact that decrease in prices of energy in 1980s did not enhance growth (Ayres, 2001).

2.2.3 Endogenous Growth Theory

In an effort to clarify technological change endogenously, Romer (1986) and Lucas (1988) come up with the endogenous model. The model based its argument on three principles. The first principle was on improvement in the process of mixing raw materials through technological change, which prevails at the center of economic growth. Their model therefore, looks like the Solow (1956) model with technological change. The second principle was that technological change emerges in extensive fraction from deliberate moves made by people that react to market motivation. In this manner, the model considers technology endogenously determined, as opposed by neoclassical growth theory in which technology is exogenously determined. Similarly, in the third principle, the main basic belief was that training for running raw materials are naturally not quite the same as other goods. This is because when new training cost is acqiured; the training may be used and re-used over with no extra cost. Therefore, mounting fresh and improved training is the same as incuring a fixed cost. This is one of the features of technology.

Endogenous model assumes four basic inputs: capital *(K)*, labour *(L)*, human capital *(H)*, and technology *(A)*. Capital is calculated as the units of consumption goods while *L* is considered by number of people. In addition, *H* is an individual calculation of collective result of events similar to on-the-job training and formal education. The model considers a close economy with $Y = F(K, N, A)$ where Y represents total output, N is the effective labour input consisting of labour inputs and human capital inputs, K denotes the capital, while A stands for the state of technology which accommodate energy.

2.2.4 Biophysical Theoretical Perspectives

The Biophysical (ecological) school has advanced a divergent approach to theory of production in reaction to the mainstream formulation. The fundamental feature of the biophysical school is the rejection of the assumption of factor productivity must be equivalent to factor shares. This perspective reflects on the work of Georgescu-Roegen (1977). Biophysical models contend that energy is the central factor of production. In the biophysical perspective, the need of labour, capital or exogenous technical progress is not necessary in describing the right appropriate of past output data, not just in the US, but also in other economies (Cleveland *et al.* 1984; Constanza, 1991; Cleveland, 1992; Kaufmann, 1992). From this point of view, it assumed a strong link connecting energy along with economic growth exist, with small or no responsibility for labour or capital. Although, Ayres (2001) comments a straightforward connection involving energy consumption and growth do not essentially indicate causality. This fact could as well imply that energy use is the result and not the cause of economic growth. The address to this concern is explored in the non-theoretical approaches.

More recently, Beaudreau (1995) have tried to explain two more production functions by dropping the assumption of equal opportunity for all factors of production. He suggested a production function with two factor inputs, which are physical work *W(t)*, having direct relationship to consumption of energy and Supervision *S(t),* which is attributed to managerial or organizational activities. For that purpose, he takes electricity generation as proxy for physical work and, indirect production labour as proxy for supervision. Using a Cobb-Douglas with electricity, capital and labour, he revealed electricity productivity to be positive and significant for US, West Germany and Japan.

The suggestion of Georgescu-Roegen (1970, 1977, 1979) and Kummel *et al.* (2000) to starts from a capital, labour and electricity *(KLE)* type of general production function, satisfying the conditions for constant returns to scale. The possibility of such production function is the Linear Exponential family of functions: $q = q_0 k^{\alpha} l^{\beta} e^{\gamma} \exp^{\left(a_1\frac{k}{l}+a_2\frac{l}{k}+b_1\frac{l}{e}+b_2\frac{e}{l}+c_1\frac{e}{k}+c_2\frac{k}{e}\right)}$ where *k, l, e* denote capital, labour and energy, *a, b,* and *c* are technology related parameters and α+β =1-γ are productivity parameters. Kummel *et al.* (2000) use a two-parameter effective specification in an industrial production for US, Germany and Japan. They found energy productivity to be positive and significant in these countries. These estimates were considered to match the experimental output with exceptional accuracy (Ayres, 2001). This brought about the conclusion that the contribution of energy to production is credited to other factors in the past.

In conclusion, the four theories discussed above provide a clear picture of the relationship between capital, labour, energy consumption and productivity. While the neoclassical growth theory and the mainstream theoretical perspective viewed the role of energy in production as neutral, the endogenous and biophysical theories viewed energy as an important factor in production process and therefore assumed a more central role in production.

2.3 Empirical Review of Energy Consumption and Economic Growth

The empirical exploration of the relationship connecting economic growth with energy consumption is a well-studied topic starting with the investigation of Kraft and Kraft (1978). The subsequent studies are associated with Masih and Masih (1996), Yu and Choi (1985) and Soytas and Sari (2003), which generated contradicting results in both developed and developing societies. Despite the fact that many studies used a bivariate framework, recent studies claimed that utilizing a multivariate framework in investigating the relationship is more suitable, considering the fact that Granger-causality could be responsive to omitted variables bias. Stern (1993, 2000), Ghali and El-Sakka (2004) and Asafu-Adjaye (2000) are examples studies that used multivariate framework.

Despite the vast studies administered on this relationship, there has been disagreement among scholars on the presence and the causality direction between economic growth and energy consumption. Although selected studies, for instance, Wolde-Rufael (2006), Lee (2005), Yuan, Kang, Zhao and Hu (2008), Lee and Chang

(2008), Wolde-Rufael (2009), Pao and Tsai (2010), Al-mulali and Sab (2012), Ouedraogo, Levermore and Parkinson (2012), Shahbhaz, Mutascu and Azim (2013), Yildirim, Sukruoglu and Aslan (2014), Al-mulali and Ozturk (2014), and Alshehry and Belloumi (2015) argued that consumption of energy Granger-causes GDP growth, another group, for example, Narayan and Smyth (2005), Wolde-Rufael (2006), Akinlo (2008), Wolde-Rufael (2009), Mozumder and Marathe (2007), Odhiambo (2010), Ouedraogo *et al.* (2012), Stern and Enflo (2013), Odhiambo (2014) and Kasman and Duman (2015) and Alper and Oguz (2016) suggested that it is the growth of GDP that Granger-causes energy consumption in numerous nations.

In the same way, the third group of research such as Wolde-Rufael (2006), Akinlo (2008), Ziramba (2009), Tsani (2010), Fuinhas and Marques (2012), Solarin and Shahbaz (2013), Rahman *et al.* (2015) and Ahmed and Azam (2016) maintained that GDP growth and energy consumption causes one another. Thus, feedback relationship between GDP growth and energy consumption is said to exist. In the last view, scholars like Wolde-Rufael (2006), Yuan *et al.* (2008), Huang, Hwang and Yang (2008), Ziramba (2009), Wolde-Rufael (2009), Acaravci and Ozturk (2010), Ozturk and Acaravci (2011), Almulali and Ozturk (2014) and Narayan (2016) asserted that there exist no causality among economic growth and energy consumption. These are otherwise referred to as the Neutrality group.

The absence of general agreement concerning this relationship could be linked with diverse pattern and sources of energy consumption for many economies. Thus, diverse pattern and sources of energy could contain different effects on the output of a nation. Similarly, scholars have different pattern and methodology employed in the analysis. Although, some scholars utilized the time series analysis such as: Oh and Lee (2004b), Ho and Siu (2007), Tang (2008), Bertleet and Grounder (2010), Fuinhas and Marques (2012), Mohammad *et al.* (2013), Islam, Shahbaz, Ahmed and Alam (2013), Tang and Shahbaz (2013) , Solarin and Shahbaz (2013), Bastola and Sapkota (2015) and Tang, Tan and Ozturk (2016) to examine the connection between real output and energy consumption, other studies which include Lee (2005), Mehrara (2007), Narayan and Smyth (2008), Akinlo (2008), Huang *et al.* (2008), Apergis and Payne (2009), Odhiambo (2010), Ozturk (2010), Sadorsky (2012), Ouedraogo (2013), Smiech and Papiez (2014), Kasman and Duman (2015), Ozturk and Al-mulali (2015) and Alper and Ogur (2016) utilized panel data technique in studying the relationship connecting real output with energy consumption.

Arising from the above, this study reviewed literature by methodology. It started by reviewing studies that employed the time series approach with different techniques of data analysis such as VAR, VECM, ARDL, etc with their major findings. Following the time series approach, the study also reviewed literature that utilized the panel data such as: Panel VECM, Panel ARDL, GMM, etc in their analysis of energy consumption and economic growth.

2.3.1 Analysis Using Time Series

Within the time series analysis, several methodologies have been employed to investigate real output and energy consumption. Studies by Soytas and Sari (2003), Mozumder and Marathe (2007), Ho and Siu (2007), Akinlo (2008), Yuan *et al.*(2008), Belloumi (2009), Odhiambo (2009a), Warr, Eisenmenger, Krausmann and Schandl (2010), Bertleet and Grounder (2010), Islam *et al.* (2013), Iyke (2015) and Alshehry and Belloumi (2015) are examples of researches that utilized the Vector Error Correction Model (VECM) in their analyses of the link concerning real output and energy consumption. Taking the work of Soytas and Sari (2003), VECM was employed to re-examine the energy with GDP relationship for G-7 economies. Similarly, Odhiambo (2009) utilized the VECM for South Africa to discover the association connecting electricity consumption with real output. In addition, by employing VECM, Islam *et al.* (2013) investigated economic development and energy consumption connection for Malaysia within a multivariate framework using the VECM. Moreover, Iyke (2015) examined electricity consumption-growth nexus for Nigeria by using the VECM approach.

In the same way, scholars such as Kraft and Kraft (1978), Yang (2000), Jumbe (2004), Bowden and Payne (2009), Payne (2009), Ziramba (2009), Payne (2011a), Stern and Enflo (2013), Tang and Tan (2013), Rahman, *at al*. (2015) and Tang Tan and Ozturk (2016) utilized the Granger causality test as part of the analysis of the linkage connecting energy consumption with real output. For example, Ziramba (2009), evaluated the link among disaggregate energy use and output from industrial sector for South Africa by applying the causality test. Furthermore, Granger causality test was utilized by Stern and Enflo (2013) to analyzed the causality amongst energy and output in Sweden. In addition, Rahman *et al.* (2015) studied sectoral productivity and energy consumption in Malaysia by employing the Granger causality test.

Likewise, some scholars, such as Narayan and Singh (2007), Sari, Ewing and Soytas (2008), Tang (2008), Odhiambo (2009b), Ouedraogo (2010), Mohammed *et al.* (2013), Amusa and Leshoro (2013), Shahbaz *et al.* (2013), Solarin and Shahbhaz (2013), Bloch, Rafiq and Salim (2015) , Bastola and Sapkota (2015) and Danmaraya and Hassan (2016) used the Autoregressive Distributed Lag (ARDL)-Bounds testing technique proposed by Pesaran, Shin and Smith (2001). Detailing into the work of Narayan and Smyth (2005), ARDL-Bounds test was employed for Australia in examining employment, real income and electricity consumption. Additionally, Acarvci and Ozturk (2010) analyzed economic growth,$C0_2$ emissions and energy consumption in Turkey by utilizing the ARDL-Bounds test. Likewise, ARDL-Bounds test was employed for Pakistan to study sectoral relationship between electricity consumption and output Mohammed *et al.* (2013). Similarly, Bloch *et al.* (2015) used ARDL-Bounds testing procedure for China to studied coal, oil and electricity consumption with economic growth.

Furthermore, the link connecting energy consumption with real output has been investigated within time series analysis by employing the Toda-Yamamoto causality testing approach (Wolde-Rufael, 2004, Fatai, Oxley & Scrimgeour, 2004, Zhang & Cheng, 2009 Tsani, 2010, Dagher & Yacoubian, 2012). Considering the studies of Fatai *et al.* (2004), for India, Thailand, Indonesia, New Zealand and Australia, causality between GDP growth and energy consumption was investigated within the time series analysis by employing the Toda-Yamamoto causality testing approach. In the same regard, Zhang and Cheng (2009) employed the Toda-Yamamoto technique in investigating the presence and direction of causality between economic growth carbon emissions and energy consumption in China. Likewise, maintaining similar approach, Dagher and Yacoubian (2012) take the case of Lebanon in studying the linkage of energy use to growth.

Akinlo (2008) employed both the VECM along with Co-feature analysis to study the association among electricity and growth in Nigeria. Similarly, Wavelet analysis and Granger causality were used in the work of Aslan *et al.* (2014) to look into the association involving energy with economic growth for the US. Furthermore, Dergiades, Martinopoulos and Tsoulfidis (2013) employed a parametric and non-parametric causality test within time series to explore the interection that connect energy consumption to output for Greece. Finally, Wesseh and Zoumara (2012) utilized the Boostrapped causality tests in their analysis of energy consumption and real output in Liberia.

Major Findings in Time Series Approach

Utilizing VECM within the time series data analysis, contradicting results have been suggested in the analysis of the interrelationship that connects energy with the growth of GDP. Some scholars argued in favour of a unidirectional causal relationship among economic growth and energy consumption, others maintained a bidirectional causal link among energy and the growth of GDP, while some others revealed no causal relationship among the variables. Mozumderr and Marathe (2007) Akinlo (2008) and Islam *et al.* (2013) are examples of studies that used VECM and maintained the occurrence of a one way causalitymoving from real output to energy. The study of Islam *et al.* (2013) for Malaysia, suggested that it is GDP that determined the consumption of energy in the short and the long run by employing VECM approach. Thus, a one way causality was established running from GDP to consumption of energy.

On the contrary, Ho and Siu (2007), Soytas and Sari (2007), Belloumi (2009), and Warr *et al.* (2010) found causality moving from aggregate energy, electricity energy consumption and oil energy to GDP and manufacturing value added. Taking the instance of Ho and Siu (2007) in Hong Kong, economic growth and electricity was investigated by using the VECM approach. Their findings established causality existing from electricity to growth. Similarly, in exploring the interconnection among energy utilization and economic growth for China, Yuan *et al.* (2008) used VECM and maintained causality moving from consumption of electricity to economic growth. Likewise, employing the VECM for Tunisia, there exists causal connection moving from energy to economic growth Belloumi (2009).

Furthermore, Ghali and El-Sakka (2004), Odhiambo (2009) and Tang and Shahbaz (2013) still utilized VECM and provided a proof of feedback among energy and real output. Thus, energy and GDP growth Granger- causes one another. Detailing into the study of Ghali and El-Sakka (2004), growth of output and energy use was investigated for Canada using the VECM. The variable showed causality moving in both directions in the short-run. Therefore, feedback is said to exist among the variables. Again, Odhiambo (2009) utilized the VECM for South Africa in investigating the causal link connecting electricity consumption with economic growth. The result described distinct feedback causal relationship for electricity consumption and economic growth. Finally, Tang and Shahbaz (2013) explored economic growth along with electricity consumption and energy prices in Malaysia by using the VECM. There result found that economic growth and consumption of electricity to Granger-cause one another.

Under the same methodology, a contrary view of neutrality hypothesis was reported. Yuan *et al.* (2008) used the VECM and disclosed no causality for coal, aggregate energy and economic growth. Similarly, Oh and Lee (2004b) employed the VECM for Korea and suggested no causality is connecting energy and GDP.

Identifying the numerous advantages of the ARDL-Bounds testing approach over the previous methods, evidence of cointegration between real output and energy consumption have been reported within the time series data analysis (Sari, *et al.* 2008; Ziramba, 2009; Odhiambo, 2009; Ouedraogo, 2010; Bertleet and Grounder, 2010; Odhiambo, 2010 & Shahbaz *et al.* 2013). For example, in South Africa, Ziramba (2009) tried to look into the association connecting output and the consumption of disaggregate energy from industrial sector by a way of cointegration utilizing the Bounds test. The findings of the study implied that output from industrial sector is a long-run influencing variable for the consumption of electricity. Additionally, by employing ARDL-Bounds test in Burkina Faso, Ouedraogo (2010) explored the economic growth-electricity relationship and revealed a proof of cointegration among electricity, economic growth and capital utilizing economic growth and electricity as dependent variables. In the same method, Shahbaz *et al.* (2013) demonstrated that consumption of energy have encouraging effect on economic growth in China. On the contrary, Tang (2008) used the ARDL-Bound test and found a contradicting result of no cointegration between growth and energy.

On the causal link, the studies of Narayan and Singh (2007), Odhiambo (2009a), Shahbhaz *et al.* (2013) and Muhammed *et al.* (2013) utilize the ARDL-Bounds testing procedure and reveals the presence of causality moving from the consumption of energy to growth. Considering the study of Narayan and Singh (2007) for Fiji Islands, causality moving from electricity to GDP was found, which implied that Fiji Island is an energy dependent country. Beside, Odhiambo (2009a) explored the causality among energy consumption and growth of GDP for Tanzania by utilizing the ARDL-Bounds testing approach and provided a causal flow from aggregate energy to economic growth. Equally important, Mohammed *et al.* (2013) focused on nexus connecting economic growth and energy in Pakistan by engaging the Bounds test and declared a unidirectional association moving from the consumption of energy to economic growth.

Furthermore, confirmation of a proof of causality running from economic growth to energy utilization was established in the literature by employing the ARDL method. The study of Narayan and Smyth (2005) for Australia revealed confirmation of causality from income to electricity usage. Likewise, Amusa and Leshoro (2013) provided the proof of causality keep moving from economic growth to electricity utilization in Botswana. Contrary to this view, Solarin and Shahbhaz (2013) studied the causal link connecting economic growth with electricity utilization in Angola by utilizing the ARDL-Bounds test and maintained bidirectional causality among the variables. Finally, no causality was shown between total energy utilization and economic growth in the study of Turkey employing the Bound test approach (Acaravci & Ozturk, 2010).

In addition, a similar time series data was analyzed using the threshold cointegration to looked at the existence of long run association between real output and energy consumption. Ho and Siu (2008) maintained a long rum relationship among energy and real output for Taiwan as Akinlo (2008), Wesseh and Zoumara (2012), and

Yildirim *et al.* (2014) used Co-feature analysis and VECM, Boostrapped causality and Wavelet analysis, respectively. Their findings maintained the energy lead growth hypothesis. Similarly, using maximum entropy and Bootstrapped approach in Pakistan, Ahmed, Raiz, Khan and Bibi (2015) maintained feedback causal link among energy consumption and economic growth.

The existence and direction of Granger causality among energy use and economic growth has been examined using the Toda and Yamamoto Granger causality within a time series data analysis. This relationship varies among different studies. Wolde-Rufael (2004), Fatai and Scrimgeour (2004), Tsani (2010), Payne (2011a), Tang and Tan (2013) and Rahman *et al.* (2015) provided proof of unidirectional causal link moving from aggregate energy and disaggregate energy utilization to economic growth. The study of Fatai and Scrimgeour (2004) established a causal link from energy to income for India and Indonesia by employing the Toda-Yamamoto causality technique. In the same way, Payne (2011a) take the case of US from 1949 to 2007 to study the causal association linking economic growth with biomass energy by employing the Toda-Yamamoto tests and maintained causality moving from biomass to economic growth.

Also, Rahman *et al.* (2015) utilized aggregate growth in productivity as well as industrial and manufacturing growth in productivity for Malaysia using the Toda-Yamamoto Granger causality test and found Malaysia to be energy reliant at both aggregated and disaggregated levels. Contrary to these studies, a proof of one way causality moving from economic growth to natural gas was maintained (Payne, 2011b), and from GDP to energy consumption (Zheng & Cheng, 2009).

Again, using the modified Granger causality test suggested by Toda-Yamamoto, energy and economic growth was found Granger-causing one another. Thus, a feedback association exist among energy consumption and real output (Bowden and Payne, 2009; Ziramba, 2009; Tsani, 2010; Ou, Xiaoyu & Zhang. 2011; Dagher & Yacumbian, 2012). On the study of Ziramba (2009) for South Africa, a feedback hypothesis was established among oil consumption and industrial output. Similar to this, Dagher & Yacumbian (2012) study for Lebanon suggested a strong proof of a feedback connection among economic growth and consumption of energy.

Utilizing similar method above, Bowden and Payne (2009), Ziramba (2009) and Tang and Tan (2013) maintained the neutrality hypothesis which signifies presence of no causal association among energy consumption and economic growth. On the account of Bowden and Payne (2009), causality was examined for the US through the Toda-Yamamoto approach, their findings revealed absence of Granger-causality for total energy, transportation energy consumption and economic growth. Also, Jafari, Othman and Nor (2012) established no causality among energy consumption and economic growth.

2.3.2 Analysis Using Panel Data

Just as in time series analysis, many studies utilized the panel data approach in looking at the interconnection involving consumption of energy and real output. For example, Glasure and Lee (1998), Masih and Masih (1997), Lee (2005), Mehrara (2007), Mahadevan and Asafu-Adjaye (2007), Chen and Chen (2007), Apergis and Payne (2009), Narayan and Prasad (2008), Lee and Chang(2008), Apergis and Payne (2010), Ozturk and Acaravci (2010), Sadorsky (2012) and Kasman *et al.* (2015) used panel cointegration and ECM to investigate the association among energy consumption and growth of real output. Taking the studies of Lee (2005), the causal link between economic growth and energy consumption was re-examined within the panel data approach for 18 developing countries by using panel cointegration, and panel-based ECM. Furthermore, Narayan and Smyth (2009) utilized the panel cointegration for a panel of Middle Eastern countries to explore the causality that link economic growth, export and energy consumption.

Similarly, by utilizing another method of analysis, Huang *et al.* (2008), Al-Iriani (2006), Lee and Chang (2007) and Ciarreta and Zarraga (2010) employed the Generalized Method of Moments (GMM) in their study of the relationship between real output and energy consumption. With respect to GMM approach, Al-Iriani (2006) re-visited energy-growth nexus for a panel of Gulf Cooperation Council (GCC) countries. Still, Ciarreta and Zarraga (2010) applied GMM method in examining the causal relationship that connects economic growth to consumption of electricity for 12 countries in Europe by utilizing data from 1970 to 2007.

Moreover, Soytas and Sari (2003), Wolde-Rufael (2006), Squalli (2007), Akinlo (2008), Odhiambo (2010), Ozturk and Acaravci (2011), Fuinhas and Marques (2012), and Odhiambo (2014) investigated the interrelation of energy use and growth using panel ARDL in their panel data analysis. Considering the study of Squalli (2007), panel ARDL was used for OPEC countries to investigate economic growth and electricity relationship. In the same aspect, Fuinhas and Marques (2012) utilized the panel ARDL for Italy, Greece, Portugal, Spain and Turkey in examining the association connecting energy consumption to economic growth. Also, ARDL-Bounds approach was also employed by Odhiambo (2014) for two lower middle income nations that include Ghana and Cote d'Ivoire as well as two upper-middle income nations that include Brazil and Uruguay.

Finally, within the panel data analysis, energy and GDP was investigated utilizing the panel cointegration and Granger causality tests in the works of Yu and Choi (1985), Murray and Nan (1996), Lee (2005), Odhiambo (2009b), Wolde-Rufael (2009), Pao and Tsai (2010), Apergis and Payne (2010), Fawowe (2012), Al-mulali and Sab (2012), Ouedraogo (2013) and, Ahmed and Azam (2016). Considering the study of Fawowe (2012), energy and real GDP was examined within the panel context for SSA countries by utilizing the panel cointegration and panel causality approach. Additionally, Ouedrago (2013) used a panel of Economic Community of West African States (ECOWAS) to explain the association between energy consumption and economic growth by using the panel cointegration and panel causality methods. Similarly, Ahmed and Azam (2016) utilized Granger causality for 119 countries including (30 high income OECD, 13 high income non-OECD, 65 middle-income countries and 11 low-income countries) in investigating the consumption of energy and economic growth nexus.

Major Findings in Panel Data Analysis

In the same way, panel data analysis has provided contradicting results just as the time series data analysis maintained. Employing panel cointegration and causality test in a panel data context, conflicting results was revealed in the investigation of the connection of economic growth and consumption of energy. Some scholars argued in favor of a unidirectional causal link among energy and economic growth, others maintained a feedback link connecting energy and economic growth, while some other studies revealed no causal relationship among the variables. Studies by Lee (2005), Wolde-Rufael (2009), Pao and Tsai (2010), Apergis and Payne (2010), Al-mulali and Sab (2012), Ouedraogo (2013) and Ahmed and Azam (2016) proved the occurrence of causality moving from economic growth to energy use by utilizing a panel cointegration and causality test. In their study, Pao and Tsai (2010) examined the causal link connecting energy usage and output for a panel of BRIC countries. The result proved causality from output to energy use. Again, Al-mulali and Sab (2012) studied energy consumption, private sector investment, domestic credit and $C0_2$ emission in SSA countries and asserted that causality keep running from the private sector investment and domestic credit to aggregate energy consumption.

Also, Ouedraogo (2013) investigate the ECOWAS countries within the panel context and proposed proof of causality moving from economic growth to energy.

Contrary to the above findings, Yu and Choi (1985), Al-Iriani (2006), Al-mulali and Sab (2012) and, Ahmed and Azam (2016) proved one way causality moving from total energy usage to economic growth. Taking the instance of Ahmed and Azam (2016), energy usage Granger causes economic growth for 40 countries including (six high income OECD, six high income non-OECD, 27 middle-income & one low-income) countries. On the same study, bidirectional causality was maintained for 18 countries including (five high income OECD, two high income non-OECD, 10 middle-income & one low-income) countries as no causality was revealed for 36 countries including (15 high income OECD, two high income non-OECD, 14 middle-income & five low-income) countries. Likewise, a feedback relationship using panel cointegration exists among energy consumption with GDP (Odhiambo, 2009b) and finally, the neutrality hypothesis exist using panel cointegration and causality test (Murray & Nan, 1996; Wolde-Rufael, 2009).

In addition, panel ECM shows proof of causality moving from consumption of energy to economic growth (Masih & Masih, 1997; Asafu-Adjaye, 2000; Mahadevan & Asafu-Adjaye, 2007). Contrary to this view, evidence of feedback relationship was asserted in the works of Glasure and Lee (1997). Similarly, Masih and Masih (1997) disclosed no causality existing between energy consumption and real output. Also, employing panel Boostrapped causality test, there exist one way causality moving from energy use to growth of GDP (Narayan & Prasad, 2008).

Likewise, within the panel data context, panel ARDL- Bounds technique demonstrated the confirmation of cointegration for GDP along with consumption of energy and proved evidence of a causal link moving from energy to economic growth (Wolde-Rufael, 2006 & Odhiambo, 2014). Similarly, Al-mulali and Ozturk (2014) established causality moving from fossil electricity fuel to growth of GDP in Oman and Qatar.

Contrary result was maintained by Odhiambo (2010) as the causal link keep running from GDP to energy consumption. Despite these results maintained unidirectional causality, evidence of bidirectional causality was maintained using the panel ARDL-Bounds test (Fuinhas & Marques, 2012; Akinlo, 2008b; Al-mulali & Ozturk, 2014; Alper & Oguz, 2016). Taking the study of Al-mulali and Ozturk (2016), feedback hypothesis was maintained for Bahrain and united Arab Emirate (UAE). Neutrality view was provided for Soytas and Sari (2003), Ozturk and Acaravci (2011), and Alper and Ogus (2016). In the EU countries, Alper and Oguz (2016) revealed no causality connecting economic growth with energy consumption for Hungary, Poland, Cyprus, Estonia, and Slovenia.

2.4 Empirical Review of Energy Consumption and Output from Manufacturing and Industrial Sectors

Although, most of the previous studies used GDP in studying the connection of energy use to economic growth, GDP may not be correctly measured because of the dimension of uncounted economy (Karanfil, 2008). Scholars like Jumbe (2004), in Malawi that evaluated energy with income, have differentiated between GDP as a whole and agricultural GDP as well as non- agricultural GDP. Some other studies utilized manufacturing and industrial output as an alternative to GDP. Thus, there is the need to investigate the relation from the manufacturing sector as it contributes immensely to GDP. Just as in the case of the energy-GDP nexus, mixed evidence was discovered on energy consumption and output. These findings have also yield four hypothesis which include: the conservation, feedback, growth as well as the neutrality hypothesis (Payne, 2009).

Utilizing Johansen-Jusalius cointegration and Granger causality test in Pakistan, a mixing result was revealed for sectoral output and energy consumption. As both industrial and service sector Granger causes energy consumption, evidence of feedback between energy consumption and agricultural output was maintained (Liew, Alwi, Verbanov, Manan & Klemes 2012). Again, ARDL-Bounds test was used for the US to study the association connecting disaggregated energy consumption and industrial production. Sari *et al.* (2008) provided the evidence of long-run connection among fossil fuel, coal, hydroelectricity, solar, natural gas and industrial production.

Additionally, proof of bidirectional causation from electricity consumption and total energy use to manufacturing output existed for Taiwan and Turkey using the VAR and VECM method (Chang, Fang & Wen, 2001; Sari & Soytas, 2007). Furthermore, Ewin, Sari and Soytas (2007) examined the association between disaggregated energy use and industrial output by means of the generalized variance decomposition approach for the US and revealed that coal, gas and fossil energy have a long-run association with industrial output.

Moreover, some studies utilized the Toda-Yamamoto Granger causality test to investigate energy-output relationship (Payne, 2009; Ziramba, 2009). Taking the case of South Africa, Ziramba (2009) revealed a bi-directional link for oil consumption and industrial productivity while the neutrality view was maintained for coal and electricity consumption and industrial productivity. Similarly, Payne (2009) compared renewable energy and output with non-renewable energy and output for the US and found no causality in the relationship.

Finally, a mixing result was found in the work of Rahman *et al.* (2015) for Malaysia on the relationship between total and sectoral productivity and energy consumption (aggregate & disaggregate). Although, the result has shown evidence of feedback between electricity and industrial productivity; electricity and manufacturing productivity; mineral and industrial productivity; mineral and manufacturing productivity; emission and manufacturing productivity; coal and manufacturing productivity; and, total energy and manufacturing productivity, a case of a unidirectional causality was found from electricity to manufacturing productivity along with energy consumption to manufacturing productivity, while one way causality from manufacturing productivity to fossil consumption; industrial productivity to fossil consumption; industrial productivity to emission and manufacturing productivity to total energy consumption was found.

For clarity purpose, Table 2.1, Table 2.2, Table 2.3, and Table 2.4 displayed a summary of some selected studies on Energy-Led Growth Hypothesis, Growth-Led Energy Hypothesis, Feedback Hypothesis and Neutrality Hypothesis, respectively.

Table 2.1
Selected Studies on the Energy-Led Growth Hypothesis

Year	Author(s)	Countries	Period	Methodology	Conclusion(s)
2016	Tang, Tan and Ozturk	Vietnam	1971-2011	Panel cointegration and ECM	ENG→Y
2016	Solarin and Ozturk	12 OPEC member country	1980-2012	Panel Granger causality	ENG→Y (Kuwait, Iran, Libya, Nigeria and Saudi Arabia)
2016	Alper and Oguz	EU member countries	1990-2009	ARDL Bound Testing Approach and Asymmetric causality	ENG→Y (Bulgaria)
2016	Ahmed and Azam	119 countries		Granger causality	ENG→Y [40 countries including (six high income OECD, six high income non-OECD, 27 middle income and 11 low-income) countries]
2015	Alshehry and Belloumi	Saudi Arabia		Johansen cointegration and VECM	ENG→Y
2015	Iyke	Nigeria	1971-2011	VECM	ELC→Y
2014	Al-mulali and Ozturk	Six ECC countries	1980-2012	ARDl-Bound testing approach and Toda-Yamamoto Test	ELC→Y (Oman and Qatar)
2014	Yildirim, Sukruoglu and Aslan	USA	1973q1-2012q4	Wavelet Analysis and Granger causality test	ENG→Y
2014	Odhiambo	Brazil, Uruguay, Ghana and Cote D' Ivoire	1972-2006	ARDL-Bound testing Approach	ENG→Y (Brazil and Uruguay)
2013	Shahbhaz, Mutascu and Azim	China	1971-2011	ARDL-Bound testing Approach and VECM causality test	ENG→Y
2013	Muhammad et al.	Pakistan	1972-2002	ARDL-Bound testing Approach and VECM causality test	ENG→Y
2013	Tang and Tan	Malaysia	1970-2009	Granger causality	ELC→Y
2012	Al-mulali and Sab	30 SSA countries	1980-2005	Panel cointegration and causality test	ENG→Y
2011	Payne	USA	1949-2007	Toda-Yamamoto causality test	ENG(Biomas)→Y
2010	Apergis and Payne	Nine South American countries	1980-2005	Panel cointegration and ECM	ENG→Y

Table 2.1 (Continued)

Year	Author(s)	Countries	Period	Methodology	Conclusion(s)
2010	Pao and Tsai	Brazil, Russia, India and China	1965-2009	Granger causality	ENG→Y
2009	Wolde-Rufael	17 African countries	1971-2004	Granger causality	ENG→Y (Algeria, Benin, South Africa)
2009	Soytas and Sari	Turkey	1960-2000	VAR and Granger causality test	ENG→Y
2009	Belloumi	Tunisia	1971-2004	VECM	ENG→Y (short run)
2009a	Odhiambo	Tanzania	1971-2006	ARDL-Bounds Testing Approach	ENG→Y
2008	Narayan and Prasad	30 OECD countries	Different sample period	Bootstrapped causality Test	ELC→Y (Australia, Iceland, Italy, Slovakia, Czech Rep., Portugal, UK and Korea
2008	Yuan, Kang, Zhao and Hu	China	1965-2005	Johansen cointegration and VECM	ELC→Y
2008	Lee and Chang	16 Asian countries	1971-2002	Granger causality	ENG→Y (long run)
2007	Narayan and Singh	Fiji Island	197102992	ARDL-Bounds Testing Approach	ELC→Y (long run)
2007	Ho and Siu	Hong Kong	1966-2002	VECM	ELC→Y
2007	Mahadevan and Asafi-Adjaye	20 Net energy exporting and importing countries	1971-2002	Panel ECM	ENG→Y (Argentina, Nigeria, Kuwait, Indonesia, Malaysia, Saudi Arabia and Venezuela)
2006	Al-iriani	Six GCC countries	1971-2002	Panel cointegration and causality test	ENG→Y
2006	Wolde-Rufael	17 African countries	1971-2001	ARDL-Bounds Testing Approach	ENG→Y (Benin, Congo DR, Tunisia)
2004	Wolde-Rufael	Shanghai	1952-1999	Toda-Yamamoto Test	ENG→Y
2004	Fatai et al.	India, Indonesia, Thailand and Philippine	1960-1999	Toda-Yamamoto Test	ENG→Y (India and Indonesia)
2000	Asafu-Adjaye	India, Indonesia, Thailand and Philippine	Different sample period	VECM	ENG→Y (India and Indonesia)

Notes: ENG, ELC and Y represents energy consumption, electricity consumption and economic growth

Table 2.2
Selected Studies on the Growth -Led Energy Hypothesis

Year	Author(s)	Countries	Period	Methodology	Conclusion(s)
2016	Solarin and Ozturk	12 OPEC member countries	1980-2012	Panel Granger causality test	Y→ENG (Algeria, Iran, UAE and Venezuela)
2016	Ahmed and Azam	119 countries		Granger causality	Y→ENG [25 countries including (four high income OECD, two high income non-OECD, 10 middle income and 1 low-income) countries]
2016	Solarin and Ozturk	12 OPEC member country	1980-2012	Panel Granger causality	ENG↔Y (Ecuador)
2015	Bastola and Sapkola	Nepal	1980-2011	Johansen cointegration, ARDL and Granger causality test	Y→ENG
2015	Ahmed, Raiz, Khan and Bibi	Pakistan	1971-2011	Maximum Entropy Bootstrapped Approach	Y→ENG
2015	Kasman and Duman	New EU member candidate	1992-2010	Panel causality	Y→ENG
2014	Odhiambo	Ghana, Cote D'Ivoire, Brazil and Uruguay	1972-2006	ARDL-Bounds Testing Approach	Y→ENG (Ghana, Cote D'Ivoire)
2013	Ouedraogo	15 ECOWAS countries	1980-2008	Panel cointegration and Granger causality	Y→ENG (short run)
2013	Stern and Enflo	Sweden	1850-2000	Granger causality	Y→ENG
2013	Islam et al.	Malaysia		VECM	Y→ENG
2013	Amusa and Leshoro	Botswana	1981-2010	ARDL-Bound Testing Approach	Cointegration
2011	Payne	US	1949-2006	Toda-Yamamoto test	Y→ENG (natural gas)
2010	Odiahmbo	Congo DR, Kenya and South Africa	1972-2006	ARDL-Bound Testing Approach	Y→ENG (Congo DR)
2010	Pao and Tsai	Brazil, Russia, India and China	1965-2009	Granger causality	Y→ENG
2009	Wolde-Rufael	17 African countries	1971-2004	Granger causality	Y→ENG (Egypt, Cote D'Ivore, Morocco, Sudan, Tunisia and Zambia

Table 2.2 (Contined)

Year	Author(s)	Countries	Period	Methodology	Conclusion(s)
2009	Zhang and Cheng	China	1960-2007	Toda-Yamamoto Test and Generalized Impulse response	Y→ENG
2008a	Akinlo	Nigeria	1980-2006	VECM	Y→ELC
2007	Mozumder and Marathe	Bangladesh	1971-1999	Coitegration and VECM	Y→ELC
2006	Wolde-Rufael	17 African countries	1971-2001	ARDL-Bounds Testing Approach	Y→ELC (Cameroon, Nigeria, Ghana, Senegal, Zambia and Zimbabwe
2005	Narayan and Smyth	Australia	1966-1999	ARDL, VEC Zivot-Andrew structural break	Y→ENG

Notes: ENG, ELC and Y represents energy consumption, electricity consumption and economic growth

Table 2.3
Selected Studies on the Energy- Growth Feedback Hypothesis

Year	Author(s)	Countries	Period	Methodology	Conclusion(s)
2016	Solarin and Ozturk	12 OPEC member country	1980-2012	Panel Granger causality	ENG↔Y (Ecuador)
2016	Ahmed and Azam	119 countries		Granger causality	ENG↔Y [18 countries including (five high income OECD, two high income non-OECD, 10 middle income and 1 low-income) countries]
2015	Rahman *et al*.	Malaysia	1971-2012	Toda-Yamamoto causality Test	ENG↔Y
2015	Al-mulali and Ozturk	14 Middle-East and North America	1996-2012	FMOLS, DOLS and Granger causality	ENG↔Y
2015	Ahmed, Raiz, Khan and Bibi	Pakistan	1971-2011	Maximum Entropy Boostrapped Approach	ENG↔Y
2015	Jammazi and Aloui	Six GCC countries	1980-2013	Wavelet Window Cross Correlation	ENG↔Y

Table 2.3 (Continued)

Year	Author(s)	Countries	Period	Methodology	Conclusion(s)
2013	Tang and Tan	Malaysia	1970-2009	ARDL-Bound Test and Granger causality	ELC↔Y
2013	Solarin and Shahbahz	Angola	1971-2001	ARDL-Bound Test and VECM causality test	ENG↔Y
2012	Fuinhas and Marques	Portugal, Italy, Spain, Greece and Turkey	1965-2009	ARDL-Bounds testing approach	ENG↔Y
2012	Dagher and Yacumbian	Lebanon	1980-2009	Toda-Yamamoto and ECM causality	ENG↔Y
2010	Tsai	Greece	1960-2006	Toda-Yamamoto Test	ENG↔Y (Disaggregate level)
2009	Ziramba	South Africa	1980-2005	Toda-Yamamoto Test	ENG↔Y(industrial production)
2009	Odhiambo	South Africa	1971-2006	Granger causality test	ELC↔Y
2008a	Akinlo	11 SSA countries		ARDL-Bound Testing Approach	ENG↔Y (Ghana, Ghambia and Senegal)
2006	Wolde-Rufael	17 African countries	1971-2001	ARDL-Bounds Testing Approach	ELC↔Y (Egypt, Gambia and Morocco)
2004	Ghali and El-Sakka	Canada	1961-1997	VECM	ENG↔Y

Notes: ENG, ELC and Y represents energy consumption, electricity consumption & economic growth

Table 2.4
Selected Studies on the Neutrality Hypothesis

Year	Author(s)	Countries	Period	Methodology	Conclusion(s)
2016	Solarin and Ozturk	12 OPEC member country	1980-2012	Panel Granger causality	ENG≠Y (Angola and Qatar)
2016	Alper and Oguz	EU member countries	1990-2009	ARDL Bound Testing Approach and Asymmetric causality	ENG≠Y (Cyprus, Estonia, Hungary, Poland and Slovania)
2016	Ahmed and Azam	119 countries		Granger causality	ENG≠Y [36 countries including (15 high income OECD, two high income non-OECD, 14 middle income and five low-income) countries]
2016	Narayan	135 countries		Predictable regression model	ENG≠Y
2014	Al-mulali and Ozturk	Six ECC countries	1980-2012	ARDl-Bound testing approach and Toda-Yamamoto Test	ENG≠Y (Kuwait and Saudi Arabia)
2012	Jafari, Othman and Nor	Indonesia	1971-2007	Toda-Yamamoto Test	ENG≠Y
2011	Ozturk and Acaravci	11 middle East and North African countries	1971-2006	ARDL-Bounds Testing Approach	ELC≠Y
2010	Acaravci and Ozturk	Turkey	1968-2005	Granger causality	ENG≠Y
2009	Bowden and Payne	US	1949-2006	Toda-Yamamoto Test	ENG(transport)≠Y
2009	Wolde-Rufael	17 African countries	1971-2004	Granger causality	ENG≠Y (Cameroon and Kenya)
2009	Ziramba	South Africa	1980-2005	Toda-Yamamoto Test	ENG(disaggregate)≠Y
2008	Huang et al.	Low-income, Lower-Middle Income, Upper-Middle Income and High-Income Groups	1972-2002	GMM System Approach	ENG≠Y (low-income group)
2008	Yuan et al.	China	1963-2005	Johansen cointegration and VECM	ENG≠Y
2006	Wolde-Rufael	17 African countries	1971-2001	ARDL-Bounds Testing Approach	ENG≠Y (Algeria, Congo, Togo, Kenya, Sudan and South Africa)
2004b	Oh and Lee	Korea	1981-2004	VECM	ENG≠Y (short run)

Notes: ENG, ELC and Y represents energy consumption, electricity consumption & GDP grrowth

2.5 Gap in the Literature

The surveys of the literature have established a strong relationship between energy use and growth of GDP. However, this relationship was clearly interpreted by contradicting and conflicting results on the presence or the direction of the causal connection between economic growth and energy consumption. Therefore, this study is expected to find out the exact causal relationship among the variables aimed at filling this gap.

Likewise, beside economic factors (labour, capital & energy) that determine output and economic growth, other factors such as technological skills, natural resources and institutional quality are factors not well taken by the literature especially in developing economies (Edame & Okoi, 2015). In this regard, this study uses the economic freedom and corruption perception index as a proxy of institutional quality that affects manufacturing performance.

Moreover, dominant studies in the literature investigate the relationship between energy consumption and economic growth at aggregate level. Very few studies were conducted using manufacturing or industrial output such as (Sari *et al.*, 2008; Ziramba, 2009; Liew *et al.*, 2012; Rahman *et al*., 2015). There is therefore, the need to investigate energy consumption and manufacturing performance to provide a more robust evidence by filling this gap, as increase in manufacturing firm performance will in general translate to rise in economic growth.

2.6 Conclusion

As the second chapter, this chapter demonstrated the review of related empirical literature as well as theoretical review of the connection among energy consumption and economic growth. It covers the empirical review and the theoretical review. Under the theoretical review, the neoclassical growth theory, the mainstream theory, the endogenous growth model as well as the biophysical theory are discussed. Finally, the last sub-sections of the chapter handle the literature on the link connecting energy consumption and economic growth in addition to causality base literature. It also demonstrates the gap in the literature as contradicting findings were established.

CHAPTER THREE
METHODOLOGY

3.1 Introduction

This chapter obliges us with the methodology of the study. It commences by introducing the entire chapter. Next, the chapter provides Section 3.2 which accounts on the theoretical framework and then Section 3.3 offers the model specification. Aside of these, section 3.4 provides the justifications of variables, though, the sources of data and variables measurement were greatly explained in Section 3.5. After those points, Section 3.6 provides the method of analysis consisting of Time Series analysis, which includes unit root test for the time series data presented in Sub-Section 3.6.1.1, as Sub-Section 3.6.1.2 contained the ARDL-Bounds test. Furthermore, Sub-Section 3.6.1.3 discussed the Granger causality test based on ARDL model. Similarly, the panel data analysis includes the panel unit root test contained in Sub-Section 3.6.2.1. Sub-Section 3.6.2.2 contained the panel co-integration test whereas Sub-section 3.6.2.3 provides the long run estimation as Sub-section 3.6.2.4 provide panel Granger causality and finally, Section 3.7 offers the conclusion of the chapter.

3.2 The Theoretical Framework

Theoretical framework visualizes theory that linked the relationship between identified factors (Sekaran, 2003). For this reason, the theoretical framework in this study highlighted the importance of energy on output and perfromances. The framework for this study was developed base on the endogenous growth model and the biophysical theoretical perspectives. Therefore, this study is formed along the boundary of the endogenous growth model and the biophysical theoretical perspectives that are developed to explain output and growth by including technology change as endogenous and which accords a more central role to energy in the production process.

The endogenous growth theory and the biophysical theory attempts at pointing out the importance of energy consumption on output and a way to accelerate economic growth. This is for the reason that the Endogenous growth theory incorporates technology into production functions (Beaudreau, 2005a). Similarly, the Biophysical theory emphasizes on the role of energy in the production process. Taking the two models and relate it to the global context, manufacturing sector depends on some facilities such as energy to thrive successfully. Hence, technical progress may operate through efficient energy utilization so that machines utilization becomes more efficient in the long run. As a result, production capacity will increase since the industries will produce at a lower cost and increase output. Along these lines, this will lead to economic growth. Thus, technical progress is important and one of the main factors for the growth of industries.

Similarly, energy input set-up work, which converts material along with capital, as well integrate a range of energy inputs into total output (Thompson, 2006). This is on the grounds that for each economic activity to take place, energy is regarded as an essential input in the process of production. In this way, as an economy which is motivated by rising energy demand, it is confidently admitted that ignoring energy from the production function positively add up to the rejection of an important factor input (Ozkan, Akcaoz, & Fert, 2004).

Stern and Cleveland (2004) follows the endogenous model by arguing that even if labour and capital inputs are improved, still they need the energy to produce economic outputs. The Harrod-Domar growth model as well as the successive Solow growth model, asserted that energy has no function to play in the production of output. Whereas, energy economists are of believe that energy is a central factor of production and the main actor in the process of production (Stern, 2011). In this manner, Pokrovski (2003) uphold the view that energy guided tools operate in lieu of manual labour, and for that reason, it obtained the entire characteristics of a production factor, therefore the result of output is influenced by energy, capital, and labour.

3.3 Model Specifications

The Harrod–Domar model and the succeeding well-known Solow model, along with others, believe that energy has no important function to play in production. Despite the fact that, energy economists still believe on energy importance in the production of output and the main actor in the course of production (Stern, 1993). In that manner, Pokrovski (2003) promotes that energy-guided tools operate as a substitute to manual labour, and for that, it possesses the entire characteristic of factors of production. Therefore, the output will be determined by factor inputs of labour, capital, and energy. In addition, considering the endogenous growth theory that incorporated technology into production functions and economic activities acknowledge energy as an essential input in the course of production. This goes on and on, with the reality, the economy is determined by rising energy demands. As such, it is unequivocally kept up that ignoring energy in the production function could without any doubt amount to evidence of lack of reasoning (Beaudreau, 2005). Taking the instance of US, Stern (1993, 2000) maintained that production output should be ascertained from labour, capital service determined by the stock of capital and productive energy. Ghali and El-Sakka (2004) advanced a production framework that incorporated energy as an input in their analysis connecting factors of production and output for Canada. Furthermore, Oh and Lee (2004a,b) looked into the link among energy and output by including energy as a separate input. Taking after Ghali and El-Sakka (2004) and Oh and Lee (2004a,b), this study, therefore, make use of the following production function:

[3.1] $$Y = f(K, L, E, CPI, EF)$$

[3.2] $$Y = f(K, L, E, I)$$

where *Y* is signify output from the manufacturing sector; and *K*, *L* and *E* represent capital stock, labour and energy input, correspondingly**.** Institutional quality measured by corruption perception index (*CPI*) and economic freedom (*EM*) are the controlled variables in the panel aspect, while inflation rate is used as control variable in the time series aspect.

Econometrically, the model is specifying as:

Model 1: Aggregate Energy Consumption and Manufacturing Performance in SSA using Time Series approach is specify in equation (3.3) as follows:

[3.3] $$MANF_t = \alpha_t + \varphi_1 ENG_t + \varphi_2 CAP_t + \varphi_3 LAB_t + \varphi_4 INF_t + \varepsilon_t$$

Model 2: Aggregate Energy Consumption and Manufacturing Performance in the Sampled SSA within a panel context for low-income, middle income and all income groups in the sampled SSA countries is specify in equation (3.4) as follows:

[3.4] $$MANF_{it} = \alpha_{it} + \beta_1 ENG_{it} + \beta_2 CAP_{it} + \beta_3 LAB_{it} + \beta_4 CPI + \beta_5 EF + \varepsilon_{it}$$

Model 3: Disaggregate Energy Consumption and Manufacturing Performance in the Sampled SSA within a panel context is specify in Equation (3.5) and Equation (3.6) as follows:

[3.5] $$MANF_{it} = \alpha_{it} + \rho_1 ELECT_{it} + \rho_2 CAP_{it} + \rho_3 LAB_{it} + \rho_4 CPI_{it} + \rho_5 EF_{it} + \varepsilon_{it}$$

[3.6] $$MANF_{it} = \alpha_{it} + \gamma_1 FOS_{it} + \gamma_2 CAP_{it} + \gamma_3 LAB_{it} + \gamma_4 CPI_{it} + \gamma_5 EF_{it} + \varepsilon_{it}$$

where MANF represents Manufacturing performance, ENG represents aggregate energy input, CAP is the capital input and LAB represents labour input. CPI and EF are corruption perception index and economic freedom, respectively, which represents institutional quality as control variables in the panel analysis. In addition, INF represents the rate of inflation, which may affect manufacturing performance in SSA countries as the control variable in the time series analysis. Similarly, the ELECT and the FOS are the disaggregated energy of electricity and fossil energy, respectively, while i stand for the country (i = 1, …, 9) and t stand for the period of time (t = 1980, …, 2012 for time series analysis and t = 1995, …, 2012 for panel analysis), are the parameters in the model and a stochastic error term, ε.

The disaggregated energy consumption was specified in the different model so as to avoid the problem of multicolinearity in the relationship. This was owing to the fact that manufacturing sectors in SSA use both electricity and fossil energy for their productivity. In the event of electricity failure (shortage), manufacturing sector uses the component of fossil energy such as gas, diesel, and petrol to fuel generators that provide electricity for their productivity. Thus, specifying them in the same model will amount to multicolinearity.

3.4 Justification of Variables

In this study, the relationship between manufacturing sector performance and energy consumption is examined. The study, therefore, uses manufacturing performance as the dependent variable while the explanatory variables are capital, labour, aggregate energy consumption, electricity consumption and fossil energy consumption. The study further includes inflation rate, corruption perception index and economic freedom as control variables. The description and measurement of these variables are provided in detail in the following subsections.

3.4.1 Manufacturing Performance

Manufacturing performance can be viewed from the increase in manufacturing productivity and value added. Productivity is the increase in the manufacturing output within a given amount of input. It may increase as a result of an improvement in workers' efficiency or technological improvement. In literature, two types of productivity have been reported, labour productivity and multifactor productivity. The multifactor productivity was advanced for the US manufacturing that incorporates capital, labour, energy, materials and services (*KLEMS*) as the inputs of production (Houseman, 2007). This study utilized manufacturing performance as the dependent variable. This is in association with a framework established by the biophysical perspective where capital, labour, and energy are regarded as the main inputs in the manufacturing performance. The relationship interfacing manufacturing performance, labour, energy and capital inputs portrayed in the production function in Equation [3.3] to Equation [3.6] recommended that there might be interconnection movements in the long run. Additionally, allowing for the short run dynamics in the inputs performance will as well imply that previous changes in energy, labour and capital will possibly contain valuable facts that can be used in forecasting future performance. Manufacturing value added is used as a proxy of manufacturing performance by adopting the works of Howarth, Schipper, Duerr and Storm (1991), Soytas, Sari and Ewing (2007), Kebede, Kagochi and Jolly (2010), Rahman *et al.* (2015) and Danmaraya and Hassan (2016). The results of these studies maintained a long run relation connecting manufacturing performance and the independent variables. Based on such research findings, this study makes a hypothesis that there is a strong relationship connecting manufacturing performance and the independent variables.

3.4.2 Capital

In economics, the procedures for output are normally formed by a way of factor inputs, specifically capital and labour, and changes from that origin. Taking all things into consideration, in economics point of view, growth procedure call attention to the affiliation involving the rate of inputs and that of output (Beaudreau, 2005). In this study, capital (*CAP*) is used as one of the independent variables that influence the manufacturing performance. The prominent instrument used in measuring CAP is by way of the gross capital formation to stand-in as capital. Theoretically, it is expected that a strong connection involving manufacturing output and capital input exist. The use of gross capital formation to explain the stock of capital is inconsistent with the works of Soytas and Sari (2006), Narayan and Smyth (2008), Apergis and Payne (2009), Wolde-Rufael (2009), Payne (2011), and Tang and Shahbaz (2013). The results of these studies maintained a significant relationship between capital, output, and manufacturing performance. Based on that, this study makes a hypothesis that *CAP* has significant effects on *MANF*.

3.4.3 Labour

As in the case of capital input, output processes, as a rule, can be represented in terms of labour inputs and changes from that cause. In this case, growth procedures from the economic perspective are attributed to the association involving the growth rate of output and that of input (Beaudreau, 2005). In this study, labour is employed as one of the independent variables that influence manufacturing performance. In economic theory, the a-priory expectation is that there exist a strong relationship between manufacturing out and labour input. This study utilized labour force participation to proxy labour inputs. This solaces the work of Shahbaz and Dube (2012) in Pakistan, Solarin and Shahbaz (2013) in Angola and then the work of Tang *et al*. (2013) in Pakistan. In view of the above studies, this study makes a hypothesis that *LAB* has significant effects on *MANF*.

3.4.4 Total Energy Consumption

The Biophysical theoretical perspectives build it's model by according a more central role to energy in the production procedure. This theory emphasizes importance attached to energy in the course of production (Beaudreau, 2005). In light of the importance agreed to energy as a production factor, this study employed energy as a factor input that affects manufacturing performance. Based on the importance accorded to energy consumption, it is expected that a well-built connection will be established between Manufacturing performance and energy consumption. This study utilized energy consumption measured by energy use (kg of oil equivalent) as a factor input that affects manufacturing performance following the work of Ghali and El-sakka (2004), Soytas and Sari (2007), Lee and Chang (2008), Narayan and Smyth (2008) and Wolde-Rufael (2009). Based on the above research, this study hypothesized that *ENG* has the impact on *MANF*.

3.4.5 Electricity Consumption

Taking after the Biophysical theoretical perspectives where the central role was given to energy in the production process. This study similarly employs electricity consumption (*ELECT)* as a component of aggregate energy consumption. Electricity consumption is used as a factor input that affects manufacturing performance. Base on the biophysical theory, it is expected that a strong relationship exists between manufacturing performance and electricity consumption. This study utilized electricity consumption measured by electric power consumption kWh as an important input following the work of Chen *et al*. (2007) in Asia, Shahbaz and Lean (2012) in Pakistan, Solarin and Shahbaz (2013) in Angola, and Tang and Shahbaz (2013) in Pakistan. Arising from the above research, this study hypothesized that *ELECT* has the impact on *MANF*.

3.4.6 Fossil Energy Consumption

This study, in the same way, applies fossil energy consumption as a component of aggregate energy consumption. Fossil energy consumption *(FOS)* is as well used as an independent variable that affects manufacturing performance. Base on the theory, it is expected that a well-built relationship is established between Manufacturing performance and FOS. Furthermore, this study utilized fossil energy consumption measured by fossil fuel energy consumption percentage of total as a significant input following the work of Payne (2011) in the US, Lotfalipour, Falahi and Ashena (2010) in Iran. This study, therefore, hypothesized that *FOS* has the impact on *MANF*.

3.4.7 Corruption

Corruption is the abuse of public resources in the process of making the decision where a decision maker agrees to deviate from the criteria establish in an institution. Corruption Perception Index *(CPI)* is the ranking of countries according to the extent to which corruption is believed to exist in that country. In this study, *CPI* is used as one of the institutional quality that influences the manufacturing performance. The scale used in measuring *CPI* ranges from zero to 10, starting with zero for highest levels of corruption and 10 for the lowest corruption level. It is expected that high level of corruption will adversely affect the level of manufacturing output. The use of *CPI* to represent institutional quality is inconsistent with the works of Okoh and Ebi (2013), Emmanuel and Ebi (2013) and Edame and Okoi (2015). Arising from the above research, this study hypothesized that high *CPI* impact on *MANF* positively.

3.4.8 Economic Freedom

Economic freedom *(EF)* is the ability of members of a society to undertake economic actions. It is a way to better opening and a better quality of life. It is also the liberty to choose how to produce, sell and use your own resources while protecting the right of others. Economic freedom is also used as the second institutional quality that influences the manufacturing performance. Economic freedom overall score includes freedom from corruption, fiscal freedom, government spending freedom, labour freedom, monetary freedom, trade freedom, investment freedom, financial freedom and property right. It is expected that high economic freedom positively affects the level of manufacturing output. The use of economic freedom to proxy institutional quality is in line with the works of Valeriani and Pelusi (2011), Ologunla, Kareem and Rahman (2014), and, is in accordance with the work of Edame and Okoi (2015). This study, therefore, hypothesized that high *EF* impact on *MANF* positively.

3.4.9 Inflation

Inflation *(INF)* is defined as a sustained rise in the general price levels of goods and services. It is normally measured as the rate of annual percentage increase in the general price of goods and services. The increase in *INF* generally reduces the value of a given currency in a country. In this study, *INF* is used as the control variable that influences the manufacturing performance. *INF* is measured by the consumer price index (annual percentage). It is expected that high rate of inflation will harmfully affect the level of manufacturing output. The use of *INF* as a variable is related to the studies of Van (1993), Masih and Masih (1997), Mahadevan and Asafu-Adjaye (2007) and Zamani (2012). This study, therefore, hypothesized that high *INF* has significant impact on the *MANF*.

3.4.10 Data

Annual data on manufacturing value-added, energy consumption, labour, capital and inflation for the period 1980–2012 is used for the time series analysis as well as, annual data on manufacturing value-added, total energy consumption, electricity consumption, fossil energy consumption, capital, labour, economic freedom and corruption perception index for the period 1995-2012 is utilized for the panel analysis. The data on electricity consumption is measured by electric power consumption kWh, fossil consumption is measured by fossil fuel energy consumption percentage of the total. Manufacturing performance is represented by manufacturing value added constant 2005 US$. Similarly, capital is measured by gross capital formation constant 2005 US$ and, labour is represented by total labour force participation rate, the percentage of total population ages 15-64 years while inflation is measured by consumers price index. All the data are sourced from the World Bank World Development Indicators (WDI) database. Corruption variable is proxy by corruption perception index sourced from Transparency International database while economic freedom data is sourced from Heritage Foundation database.

This study involved nine SSA countries during the period 1995-2012 for the panel analysis and annual data for SSA countries from 1980-2012 for the time series analysis. The countries explored in this study include Congo Republic, Zimbabwe, Botswana, Kenya, Nigeria, South Africa, Sudan, Togo, and Senegal for the panel analysis, as well as the total for SSA countries in the time series analysis. These countries are chosen base on the accessibility of data on the variables incorporated in the work.

3.5 Method of Analysis

In this study, both the panel and the time series analysis are employed. Panel data is usually referred to data that contained time series components for some individuals. In this way, series in panel data involved two dimensions that incorporate the time series dimension, represented by t in addition to cross-sectional dimension, represented by i. This sub-section accommodates the panel unit root tests proposed by Im, Pesaran, and Shin (2003); the panel co-integration test advanced by Pedroni (2004) and lastly, the Granger causality. In the same way, the sub-section also accommodates the time series analysis that includes Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests, ARDL test proposed by Pesaran, Shin and Smith (1999) and the Granger causality test.

3.5.1 Time Series Analysis

Time series analysis consists of analyzing time series data so as to extract meaningful statistics and other features of the data set. It starts by examining the stationary properties of the series and then estimates the long run and the short run relationships.

3.5.1.1 Unit Root Test

Time series analysis requires series to be stationary and in deciding the order of integration of series, there is a need to analyze the stationarity of the data. Maddala and Kim (1998) give an overview of the various statistical tests for stationarity analysis that have been proposed in the literature. The various tests have their strengths and weaknesses under different conditions. The most effectively connected and generally utilized of the unit root tests are the Augmented Dickey-Fuller (ADF) test after Dickey and Fuller (DF), 1979 and the Phillips-Perron (PP) test, after Phillips and Perron (1988).

The ADF test is augmented from an earlier version known simply as DF test. Assume, for example, a first order Autoregressive process of y:

[3.7] $$y_t = \alpha_0 + \alpha_1 y_{t-1} + \varepsilon_t$$

where *α* stands for parameters and $\varepsilon_t$represents white noise error term.Series *y* is said to be stationary if it does not possess a unit root. Meaning that the characteristic root of the processes α_1: *-1*< α_1 <*1*, and non-stationary if α_1 =*1*. By subtracting y_{t-1} from Equation [3.6], the basic test is carried on:

[3.7.1] $$\Delta y_t = \alpha_0 + \rho y_{t-1} + \varepsilon_t$$

where *Δ* stands for difference operator and $\rho = \alpha_1 - 1$ and the test consist of testing the null hypothesis $H_0 : \rho = 0$. ADF parametrically corrects for higher order Autoregressive process by assuming:

[3.7.2] $$\Delta y_t = \alpha_0 + \rho y_{t-1} + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \beta_{p-1} \Delta y_{t-p+1} + \varepsilon_t$$

Like Dickey and Fuller (1979), the Phillips and Perron (1988) test relies on the basic first order Autoregressive specification of Equation [3.6]. The distinction emerges from the way that while ADF parametrically corrects for higher order serial correlation, the PP applies a non-parametric correction on the *t*-statistics of the characteristic root of the first order Autoregressive process ρ to account for serial correlation in the error term ε. This technique makes the PP test more robust to heteroskedasticity and unknown order autocorrelation. Generally, PP test is viewed as more reliable because contrary to ADF, it is known to be robust to a nuisance parameter and it is not affected by weak dependence and heterogeneity of sample data (Katafono, 2000).

3.5.1.2 Autoregressive Distributed Lag (ARDL) Bounds Test

This study utilized the ARDL-bounds testing method in investigating the long-run association involving energy consumption, capital, labour and inflation in addition to manufacturing performance. The ARDL-bounds modelling procedure is proposed by Pesaran and Shin (1999) and subsequently extended by Pesaran, Shin, and Smith (2001). The ARDL-bounds co-integration approach has many advantages while compared to other techniques of co-integration. For instance, the ARDL-bounds test does not set assumption restricting all the variables to be integrated in the same order, which was contrary to other techniques of co-integration. Thus, the ARDL method can be employed without regarding whether the variables are integrated of order zero or order one. Secondly, the ARDL test is appropriate with the even small size of the sample, whereas other techniques of co-integration are responsive to the sample size. Thirdly, the ARDL method offers unbiased estimates of the long-run model and valid t-statistics even when some of the variables are endogenous (Harris & Sollis, 2003). The ARDL model used in this study can be formulated in Equation (3.8) to Equation (3.12):

[3.8]

$$\Delta MANF_t = \alpha_o + ENG_{t-1} + \sum_{i=0}^{n}\alpha_{3i}\Delta CAP_{t-1} + \sum_{t=0}^{n}\alpha_{4i}\Delta LAB_{t-1} + \sum_{t=0}^{n}\alpha_{5i}\Delta INF_{t-1} + \alpha_6 MANF_{t-1} + \alpha_7 ENG_{t-1} + \alpha_8 CAP_{t-1} + \alpha_9 LAB_{t-1} + \alpha_{10} INF_{t-1} + \varepsilon_t$$

[3.9]

$$\Delta ENG_t = \beta_o + \sum_{i=1}^{n}\beta_{1i}\Delta ENG_{t-1} + \sum_{i=0}^{n}\beta_{2i}\Delta MANF_{t-1} + \sum_{i=0}^{n}\beta_{3i}\Delta CAP_{t-1} + \sum_{t=0}^{n}\beta_{4i}\Delta LAB_{t-1} + \sum_{t=0}^{n}\beta_{5i}\Delta INF_{t-1} + \beta_6 MANF_{t-1} + \beta_7 ENG_{t-1} + \beta_8 CAP_{t-1} + \beta_9 LAB_{t-1} + \beta_{10} INF_{t-1} + \varepsilon_t$$

[3.10]

$$\Delta CAP_t = \rho_o + \sum_{i=1}^{n}\rho_{1i}\Delta CAP_{t-1} + \sum_{i=0}^{n}\rho_{2i}\Delta MANF_{t-1} + \sum_{i=0}^{n}\rho_{3i}\Delta ENG_{t-1} + \sum_{t=0}^{n}\rho_{4i}\Delta LAB_{t-1} + \sum_{t=0}^{n}\rho_{4i}\Delta INF_{t-1} + \rho_6 MANF_{t-1} + \rho_7 ENG_{t-1} + \rho_8 CAP_{t-1} + \rho_9 LAB_{t-1} + \rho_{10} INF_{t-1} + \varepsilon_t$$

$$\Delta LAB_t = \gamma_o + \sum_{i=1}^{n} \gamma_{1i} \Delta LAB_{t-1} + \sum_{i=0}^{n} \gamma_{2i} \Delta MANF_{t-1} + \sum_{i=0}^{n} \gamma_{3i} \Delta ENG_{t-1} + \sum_{t=0}^{n} \gamma_{4i} \Delta CAP_{t-1} + \sum_{t=0}^{n} \gamma_{5i} \Delta INF_{t-1}$$

[3.11]

$$+\gamma_6 MANF_{t-1} + \gamma_7 ENG_{t-1} + \gamma_8 CAP_{t-1} + \gamma_9 LAB_{t-1} + \gamma_{10} INF_{t-1} + \varepsilon_t$$

$$\Delta INF_t = \gamma_o + \sum_{i=1}^{n} \psi_{1i} \Delta INF_{t-1} + \sum_{i=0}^{n} \psi_{2i} \Delta MANF_{t-1} + \sum_{i=0}^{n} \psi_{3i} \Delta ENG_{t-1} + \sum_{t=0}^{n} \psi_{4i} \Delta CAP_{t-1} + \sum_{t=0}^{n} \psi_{5i} \Delta LAB_{t-1}$$

[3.12]

$$+\psi_6 MANF_{t-1} + \psi_7 ENG_{t-1} + \psi_8 CAP_{t-1} + \psi_9 LAB_{t-1} + \psi_{10} INF_{t-1} + \varepsilon_t$$

where *MANF* is the manufacturing performance; *ENG* is the energy consumption; *CAP* is gross capital formation; *LAB* is the labour; *INF* is the rate of inflation; α, β, ρ, γ and ψ are parameters of the model; Δ is the first difference operator; *t* is the time period; and ε_t is the error term.

The bounds test method is based on the joint F-statistic for cointegration analysis. In this situation, the null hypothesis of no cointegration among the variables in Equation [3.7] is $Ho: \alpha_6 = \alpha_7 = \alpha_8 = \alpha_9 = \alpha_{10} = 0$ against the alternative hypothesis $H_1: \alpha_6 \neq \alpha_7 \neq \alpha_8 \neq \alpha_9 \neq \alpha_{10} \neq 0$. In Equation [3.8], the null hypothesis of no cointegration is $Ho: \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = 0$ against the alternative hypothesis $H1: \beta_6 \neq \beta_7 \neq \beta_8 \neq \beta_9 \neq \beta_{10} \neq 0$, while in Equation [3.9], the null hypothesis of no cointegration is $Ho: \rho_6 = \rho_7 = \rho_8 = \rho_9 = \rho_{10} = 0$ against the alternative hypothesis $H_1: \rho_6 \neq \rho_7 \neq \rho_8 \neq \rho_9 \neq \rho_{10} \neq 0$. Also, in Equation [3.10], the null hypothesis of no cointegration is $Ho: \gamma_6 = \gamma_7 = \gamma_8 = \gamma_9 = \gamma_{10} = 0$ against the alternative hypothesis $H_1: \gamma_6 \neq \gamma_7 \neq \gamma_8 \neq \gamma_9 \neq \gamma_{10} \neq 0$. Finally, in Equation [3.11], the null hypothesis of no cointegration is $Ho: \psi_6 = \psi_7 = \psi_8 = \psi_9 = \psi_{10} = 0$ against the alternative hypothesis $H_1: \psi_6 \neq \psi_7 \neq \psi_8 \neq \psi_9 \neq \psi_{10} \neq 0$. If the calculated statistic is greater than the upper critical bounds value, then the null hypothesis is rejected. Alternatively, If the *F*-statistic falls within the bounds, the cointegration result becomes inconclusive. Lastly, if the *F*-statistic is below the value of the lower bounds, then we failed to reject the null hypothesis of no cointegration.

3.5.1.3 Granger Causality on ARDL Test

Once the long-run relationships have been established, the next stage is to examine the causal link between the energy consumption, capital, labour as well as inflation with manufacturing performance by means of Granger causality. The Granger causality test technique is chosen in this study because it responds favourably to large and small samples. In line with the earlier work of Iyke and Odhiambo (2014), the Granger Causality is specified in Equation (3.13) to Equation (3.17) as follows:

$$\Delta MANF_t = \phi_o + \sum_{i=1}^{n} \phi_{1i} \Delta MANF_{t-1} + \sum_{i=0}^{n} \phi_{2i} \Delta ENG_{t-1} + \sum_{i=0}^{n} \phi_{3i} \Delta CAP_{t-1} + \sum_{i=0}^{n} \phi_{4i} \Delta LAB_{t-1}$$

[3.13]

$$+ \sum_{t=0}^{n} \phi_{5i} \Delta INF_{t-1} + \phi_6 ECM_{t-1} + \mu_t$$

$$\Delta ENG_t = \theta_o + \sum_{i=1}^{n} \theta_{1i} \Delta ENG_{t-1} + \sum_{i=0}^{n} \theta_{2i} \Delta MANF_{t-1} + \sum_{i=0}^{n} \theta_{3i} \Delta CAP_{t-1} + \sum_{i=0}^{n} \theta_{4i} \Delta LAB_{t-1}$$

[3.14]

$$+ \sum_{t=0}^{n} \theta_{5i} \Delta INF_{t-1} + \theta_6 ECM_{t-1} + \mu_t$$

$$\Delta CAP_t = \eta_o + \sum_{i=1}^{n} \eta_{1i} \Delta CAP_{t-1} + \sum_{i=0}^{n} \eta_{2i} \Delta MANF_{t-1} + \sum_{i=0}^{n} \eta_{3i} \Delta ENG_{t-1} + \sum_{i=0}^{n} \eta_{4i} \Delta LAB_{t-1}$$

[3.15]

$$+ \sum_{t=0}^{n} \eta_{5i} \Delta INF_{t-1} + \eta_6 ECM_{t-1} + \mu_t$$

$$\Delta LAB_t = \psi_o + \sum_{i=1}^{n} {}_{1i} \psi \Delta LAB_{t-1} + \sum_{i=0}^{n} \psi_{2i} \Delta MANF_{t-1} + \sum_{i=0}^{n} \psi_{3i} \Delta ENG_{t-1} + \sum_{i=0}^{n} \psi_{4i} \Delta CAP_{t-1}$$

[3.16]

$$+ \sum_{t=0}^{n} \psi_{5i} \Delta INF_{t-1} + \psi_6 ECM_{t-1} + \mu_t$$

$$\Delta INF_t = \lambda_o + \sum_{i=1}^{n} {}_{1i} \lambda \Delta INF_{t-1} + \sum_{i=0}^{n} \lambda_{2i} \Delta MANF_{t-1} + \sum_{i=0}^{n} \lambda_{3i} \Delta ENG_{t-1} + \sum_{i=0}^{n} \lambda_{4i} \Delta CAP_{t-1}$$

[3.17]

$$+ \sum_{t=0}^{n} \lambda_{5i} \Delta LAB_{t-1} + \lambda_6 ECM_{t-1} + \mu_t$$

where *MANF* is the manufacturing performance; *ENG* is the energy consumption; *CAP* is gross capital formation; *LAB* is the labor force participation rate; *INF* is the rate of inflation; ϕ, θ, η, ψ and λ are parameters of the model; Δ is the first difference operator; *t* is the time period; ECM_{t-1} is the error-correction term; and μ_t is the error term.

3.5.2 Panel Data Analysis

Panel analysis is an analysis that deals with two dimensions. It involves the series of time denoted by '*T*' and series of entity denoted by '*N*', which can be countries, firms, etc.

3.5.2.1 Panel Unit Root Test

To examine the existence of panel co-integration in the relationship, firstly, it is essential to test for stationary so as detect the existence of unit roots in the series (Hassan & Abdullahi, 2014). There are varieties of panel unit root tests, which include: Hadri (2000), Breitung (2000), Im *et al*. (2003), Choi (2001), Levin, Lin and Chu (2002) and Carrion-i-Silvestre et al. (2005). To determine the stationarity characteristics of the variables applied, this study utilized the panel unit root tests advanced by Im *et al*. (2003) which depend on the Dickey-Fuller (DF) procedure. IPS suggested testing stationarity in the panel that integrates facts from cross-sectional aspect with that in the time series aspect in a way that small time information is needed for the test to have power. The use of this method is motivated going by that it is the most commonly used and has a superior test power (Sarantis & Steward, 1999). Many economic researchers such as Lee and Chang (1997), Sarantis and Steward (1999) and, Hassan and Abdullah (2014) have also applied this method in their analysis of the long-run interactions in panel data.

IPS starts by establishing an independent ADF regression used for every cross-section together with each entity reactions and no time trend:

[3.18]
$$\Delta y_{it} = \alpha_i + \rho_{i,t-1} + \sum_{j=1}^{p_1} \beta_{ij} \Delta y_{i,t-j} + \varepsilon_{it}$$

where i = 1,.. .,9 which represents the entity and t = 1,.. ., 17 which represents the time period. The IPS apply individual unit root test in each cross section. The test is built by averaging the ADF statistics across the groups. Following the individual ADF estimation, the average of t-statistics for p_1 from the separate ADF is given by, Equation (3.19) as follows:

[3.19]
$$\bar{t}_{NT} = \frac{1}{N} \sum_{i=1}^{N} t_{iT} (p_i \beta_i)$$

The t - bar ($\bar{t}$) displayed the standardized t statistic which is merged to the standard normal distribution. They further suggest that test performs better even where entity and time period are small. Moreover, cross-sectionally demeaned form for the two tests will be employed in a situation that the errors in other regressions accommodate a typical time-specific element.

3.5.2.2 Panel Co-integration Test

Once there exist a panel unit root, the next step is to find out if a long-run equilibrium link exists among the variables. The Pedroni (1999, 2004) heterogeneous panel test for cointegration that recognizes the cross-section interconnection with diverse individual effects is utilized if there exist heterogeneity in the error variance along with dynamics within the panel as follows:

[3.20] $$MANF_{it} = \alpha_{it} + \delta_i t + \gamma_{1i} ENG_{it} + \gamma_{2i} CAP_{it} + \gamma_{3i} LAB_{it} + \gamma_{4i} CPI_{it} + \gamma_{5i} EF_{it} + \varepsilon_{it}$$

[3.21] $$MANF_{it} = \alpha_{it} + \delta_i t + \gamma_{1i} ELECT_{it} + \gamma_{2i} CAP_{it} + \gamma_{3i} LAB_{it} + \gamma_{4i} CPI_{it} + \gamma_{5i} EF_{it} + \varepsilon_{it}$$

[3.22] $$MANF_{it} = \alpha_{it} + \delta_i t + \gamma_{1i} FOS_{it} + \gamma_{2i} CAP_{it} + \gamma_{3i} LAB_{it} + \gamma_{4i} CPI_{it} + \gamma_{5i} EF_{it} + \varepsilon_{it}$$

where *t* represent the period of time and similarly, *i* represent each entity (country) within the panel. Likewise, the coefficient along with the trend effects gives the chance for country-specific effects in addition to deterministic trends, accordingly. The trend-effects are expected to handle any disturbances that may occur to any members of the panel, which include global disturbances. The estimated residual signify which indicate deviation from the long-run correlation.

For testing the null hypothesis of no cointegration, the following stationary test in Equation [3.23] is administered on the residuals:

[3.23] $$\varepsilon_{it} = \rho_i \varepsilon_{it-1} + w_{it}$$

In the Pedroni (1999, 2004) co-integration analysis, two test for cointegration were advanced. The first test was established on the within the dimension approach that comprises of four statistics test. These include panelv-statistic, panel ρ-statistic, panel PP-statistic, and panel ADF-statistic. Basically, these statistics pool the autoregressive coefficients across different entity (countries) for unit root tests on the estimated residuals. They consider heterogeneity across countries and common time factors.

The second test was established on the between-dimension approach that comprises of three statistics. They include group ρ-statistic, group PP-statistic, and group ADF-statistic test. They are established by taking the individual autoregressive coefficients average related with the residuals of the unit root test for every individual entity within the panel. The entire seven tests are distributed asymptotically as standard normal. From the seven tests, the panel v-statistic is a one-sided test where large positive values that reject the null hypothesis of no cointegration, whereas large negative values for the remaining test statistics reject the null hypothesis of no cointegration. Following Pedroni (1999), the heterogeneous group mean panel and heterogeneous panel cointegration statistics are computed in Equation (3.24) to Equation (3.30) below:

Panel*v*- statistics:

[3.24]

$$z_{\upsilon} = \left(\sum_{i=1}^{N} \sum_{i=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{it-1}{}^{2} \right)^{-1}$$

Panel ρ-statistics:

[3.25]

$$z_{\rho} = \left(\sum_{i=1}^{N} \sum_{i=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{it-1}{}^{2} \right)^{-1} \sum_{i=1}^{N} \sum_{i=1}^{N} \hat{L}_{11i}^{-2} \left(\hat{e}_{it-1} \Delta \hat{e}_{it} - \hat{\lambda}_{i} \right)$$

Panel PP-statistics:

[3.26] $$z_t = \left(\hat{\sigma}^2 \sum_{i=1}^{N} \sum_{i=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{it-1}^2 \right)^{-1/2} \sum_{i=1}^{N} \sum_{i=1}^{N} \hat{L}_{11i}^{-2} \left(\hat{e}_{it-1} \Delta \hat{e}_{it} - \hat{\lambda}_i \right)$$

Panel ADF-statistics

[3.27] $$z_t * = \left(\hat{S} *^2 \sum_{i=1}^{N} \sum_{i=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{it-1}^{*2} \right)^{-1/2} \sum_{i=1}^{N} \sum_{i=1}^{N} \hat{L}_{11i}^{-2} \hat{e}_{it-1}^{*} \Delta \hat{e}_{it}^{*}$$

Group ρ-statistics:

[3.28] $$\tilde{Z}_\rho = \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \hat{e}_{it-1}^2 \right)^{-1} \sum_{t=1}^{T} \left(\hat{e}_{it-1} \Delta \hat{e}_{it} - \hat{\lambda}_i \right)$$

Group PP-statistics:

[3.29] $$\tilde{Z}_t = \sum_{i=1}^{N} \left(\hat{\sigma}^2 \sum_{t=1}^{T} \hat{e}_{it-1}^2 \right)^{-1/2} \sum_{t=1}^{T} \left(\hat{e}_{it-1} \Delta \hat{e}_{it} - \hat{\lambda}_i \right)$$

Group ADF-statistics:

[3.30] $$\tilde{Z}_t * = \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \hat{s}_i^{\,2} \hat{e}_{it-1}^{*2} \right)^{-1/2} \sum_{t=1}^{T} \left(\hat{e}_{it-1}^{*} \Delta \hat{e}_{it}^{*} \right)$$

where $\hat{L}_{11i}^2$ is the estimated long-run covariance matrix for $\Delta\hat{e}_{it}$ and $\hat{e}_{it}$ it is the estimated residual from Equation [3.28]and Equation[3.29]. Likewise, $\hat{\sigma}_i^2$ and

$\hat{s}_i^2(\hat{s}_i^{*2})$ are contemporaneous as well as the long-run variances for individual *i*, respectively. All the seven tests are distributed as being standard normal asymptotically. This needs a standardization based on the moments of the underlying Brownian motion function. The panel *υ*-statistic is a one-sided test where extensive positive values reject the null of no co-integration. The remaining statistics diverge to negative infinitely, implying that the large negative values reject the null hypothesis.

3.5.2.3 Long Run Estimation

Following the establishment of co-integration among the variables next is to estimate the long run coefficient by adopting the Fully Modified Ordinary Least Square (FMOLS) procedure. The FMOLS provide optimal estimates of co-integration regression, which employed estimation of parameters that affect the asymptotic distribution of the OLS. One of the advantages of FMOLS is that it handled serial correlation and non-exogeneity in the model. Also, the model provides efficient and consistent estimation of co-integrating vectors. The co-integrated system of panel data starts by OLS in Equation [3.31].

[3.31] $$y_{it} = \alpha_i + x_{it}^{'}\beta + e_{it}$$

$$x_{it} = x_{i,t1} + \varepsilon_{it}$$

where $\xi_{it} = [e_{it,}\varepsilon_{it}^{'}]$ represents stationary with covariance matrix Ω_i, β becomes consistent if error process satisfy y_{it} and x_{it}.

To eliminate the order bias caused by endogenous regressors, Pedroni (1996, 2000) follows the Phillips and Hansen (1990) approach in correcting the OLS estimators within the panel data context and allowing for short run dynamics heterogeneity. Thus, Equation [3.31] estimates the Pedroni's FMOLS as:

[3.32] $$\hat{\beta}_{FM} = \left(\sum_{i=1}^{N} \hat{\Omega}_{221}^{2} \sum_{T=1}^{T} (x_{it} \hat{x}_t)^2 \right)^{1} \sum_{i=1}^{N} \hat{\Omega}_{11i}^{1} \hat{\Omega}_{22i}^{1} \left(\sum_{t=1}^{T} (x_{it} \overline{x}_t) e_{it} T \hat{\gamma}_i \right)$$

$$\hat{e}_{it} = e_{it} \hat{\Omega}_{22i}^{1} \hat{\Omega}_{21i,} \qquad \hat{\gamma}_1 = \hat{\Gamma}_{21i} + \hat{\Omega}_{21i}^{0} \hat{\Omega}_{22i}^{1} \hat{\Omega}_{21i} (\hat{\Gamma}_{22i} + \hat{\Omega}_{22i}^{0})$$

where $\Omega_i = \Omega_i^0 + \Gamma_i + \Gamma_i$ is the decomposed covariance matrix, Ω_i^0 is the contemporaneous covariance matrix, and, Γ_i is a weighted sum of auto covariances.

3.5.2.4 Panel Granger Causality Test

Once cointegration is establish among the variable, the panel vector error correction is estimated to achieve the causality test. Traditionally, Granger (1988) defined causality on the idea that the future cannot cause the past, but that the past can cause the future (Takaendesa & Odhiambo, 2007). According to Granger's description of causality a time series, X_t, causes another time series, Y_t, if Y_t can be predicted better using past values of X_t than by not doing so. Thus, if previous values of X_t considerably add to predicting Y_t at that moment X_t is believed to Granger causes Y_t. Conversely, causality from *Y* to *X* can as well be defined as when previous values of Y_t considerably donate to predicting X_t, at that moment Y_t is said to Granger causes X_t This study considered the Granger causality test approach as against alternative approaches owing to the fact that it react favourably to small and large samples. Geweke, Meese and Dent (1983) as well as Guilkey and Salemi (1982) have displayed that Granger test is the best approach recommended in the literature. The Granger causality test covers estimating the null hypothesis that X_t does not cause Y_t and vice versa. Equation (3.33) and Equation (3.34) is used in estimating causality:

[3.33]
$$Y_t = \alpha_0 + \sum_{i=1}^{n} \alpha_{1i} Y_{t-1} + \sum_{i=1}^{n} \beta_{1i} X_{t-1} + \varepsilon_t$$

[3.34]
$$X_t = \beta_0 + \sum_{i=1}^{n} \alpha_{2i} Y_{t-1} + \sum_{i=1}^{n} \beta_{2i} X_{t-1} + \varepsilon_t$$

where ε_t is the error term and the number of lagged variables are presented by *n*. The null hypothesis (H_0) of X_t does not Granger cause Y_t is rejected if β_{1i} are jointly significant (Granger, 1969). Similarly, the H_0 that Y_t does not Granger causes X_t is rejected if α_{is} are jointly rejected. However, the traditional causality tests experience two methodological defects (Odhiambo, 2004). Firstly, these standard tests fail to check the fundamental features of the time series variables. In a situation where the variables are found to be co-integrated, then combining other variables using these test will amount to misspecification except where the lagged *ECT* is included (Granger, 1988). Moreover, these tests convert the series to be stationary by taking the difference the variables and consequently, remove some long-run information included in the initial variables. As opposing the traditional Granger causality technique, the causality test based on *ECM* permits the inclusion of the lagged *ECT* derived from the co-integration equation. By including the lagged *ECT*, the long-run information lost as a result of taking difference is revived. The Granger causality model utilized in this study is based on the following model:

Model 1- Energy Consumption and Manufacturing Performance

[3.35]
$$\Delta MANF_{it} = \alpha_{1j} + \sum_{k=1}^{q}\theta_{11ik}\Delta MANF_{it-k} + \sum_{k=1}^{q}\theta_{12ik}\Delta ENG_{it-k} + \sum_{k=1}^{q}\theta_{13ik}\Delta CAP_{it-k} + \sum_{k=1}^{q}\theta_{14ik}\Delta LAB_{it-k} + \sum_{k=1}^{q}\theta_{15ik}\Delta CPI_{it-k} + \sum_{k=1}^{q}\theta_{16ik}\Delta EF_{it-k} + \lambda_{1i}\varepsilon_{it-1} + u_{1it}$$

[3.36]
$$\Delta ENG_{it} = \alpha_{2j} + \sum_{k=1}^{q}\theta_{21ik}\Delta MANF_{it-k} + \sum_{k=1}^{q}\theta_{22ik}\Delta ENG_{it-k} + \sum_{k=1}^{q}\theta_{23ik}\Delta CAP_{it-k} + \sum_{k=1}^{q}\theta_{24ik}\Delta LAB_{it-k} + \sum_{k=1}^{q}\theta_{25ik}\Delta CPI_{it-k} + \sum_{k=1}^{q}\theta_{26ik}\Delta EF_{it-k} + \lambda_{1i}\varepsilon_{it-1} + u_{1it}$$

Model 1- Electricity Consumption and Manufacturing Performance

[3.37]
$$\Delta MANF_{it} = \alpha_{1j} + \sum_{k=1}^{q}\theta_{11ik}\Delta MANF_{it-k} + \sum_{k=1}^{q}\theta_{12ik}\Delta ELECT_{it-k} + \sum_{k=1}^{q}\theta_{13ik}\Delta CAP_{it-k} + \sum_{k=1}^{q}\theta_{14ik}\Delta LAB_{it-k} + \sum_{k=1}^{q}\theta_{15ik}\Delta CPI_{it-k} + \sum_{k=1}^{q}\theta_{16ik}\Delta EF_{it-k} + \lambda_{1i}\varepsilon_{it-1} + u_{1it}$$

$$\Delta ELECT_{it} = \alpha_{2j} + \sum_{k=1}^{q}\theta_{21ik}\Delta MANF_{it-k} + \sum_{k=1}^{q}\theta_{22ik}\Delta ELECT_{it-k} + \sum_{k=1}^{q}\theta_{23ik}\Delta CAP_{it-k} + \sum_{k=1}^{q}\theta_{24ik}\Delta LAB_{it-k}$$

[3.38]

$$+\sum_{k=1}^{q}\theta_{25ik}\Delta CPI_{it-k} + \sum_{k=1}^{q}\theta_{26ik}\Delta EF_{it-k} + \lambda_{1i}\varepsilon_{it-1} + u_{1it}$$

Model 2- Fossil Energy Consumption and Manufacturing Performance

$$\Delta MANF_{it} = \alpha_{1j} + \sum_{k=1}^{q}\theta_{11ik}\Delta MANF_{it-k} + \sum_{k=1}^{q}\theta_{12ik}\Delta FOS_{it-k} + \sum_{k=1}^{q}\theta_{13ik}\Delta CAP_{it-k} + \sum_{k=1}^{q}\theta_{14ik}\Delta LAB_{it-k}$$

[3.39]

$$+\sum_{k=1}^{q}\theta_{15ik}\Delta CPI_{it-k} + \sum_{k=1}^{q}\theta_{16ik}\Delta EF_{it-k} + \lambda_{1i}\varepsilon_{it-1} + u_{1it}$$

$$\Delta FOS_{it} = \alpha_{2j} + \sum_{k=1}^{q}\theta_{21ik}\Delta MANF_{it-k} + \sum_{k=1}^{q}\theta_{22ik}\Delta FOS_{it-k} + \sum_{k=1}^{q}\theta_{23ik}\Delta CAP_{it-k} + \sum_{k=1}^{q}\theta_{24ik}\Delta LAB_{it-k}$$

[3.40]

$$+\sum_{k=1}^{q}\theta_{25ik}\Delta CPI_{it-k} + \sum_{k=1}^{q}\theta_{26ik}\Delta EF_{it-k} + \lambda_{1i}\varepsilon_{it-1} + u_{1it}$$

where Δ is the first-difference operator; *q* is the lag length, and *u* is the serially uncorrelated error term. In the manufacturing performance Equation [3.34], short-run causality from energy consumption to manufacturing performance is tested, based on$H_0\colon \theta_{12ik} = 0\forall_{ik}$. In the energy consumption Equation [3.35], short-run causality from manufacturing performance to energy consumption is tested, based on$H_0\colon \theta_{21ik} = 0\forall_{ik}$. In Equation [3.36], short-run causality from electricity consumption to manufacturing performance is tested, based on $H_0\colon \theta_{12ik} = 0\forall_{ik}$. In the electricity consumption Equation [3.37], short-run causality from manufacturing performance to electricity consumption is tested, based on $H_0\colon \theta_{21ik} = 0\forall_{ik}$. In the second manufacturing performance Equation [3.38], short-run causality from fossil energy consumption to manufacturing performance is tested, based on$H_0\colon \theta_{12ik} =$

$0\forall_{ik}$.Finally, in the fossil energy consumption Equation [3.39], short-run causality from manufacturing productivity to the fossil energy consumption is tested based on$H_0: \theta_{21ik} = 0\forall_{ik}$. The null hypothesis of no long run causality in each Equation [3.34] to Equation [3.39], is tested by examining the significance of the *t*-statistic for the coefficient on the respective *ECT* represented by λ.

3.6 Conclusion

As the third chapter, it exhibits the methodological procedures employed for this study. It began by explaining the production frameworks, whereupon the premise of this study is decided for the analysis of production and growth impacts of energy, is explored and then specifies the models of the study. Following the model specification, the chapter further prescribed the justifications of variables and the data sources. It further consists of econometric methodology to be used for this study which includes the panel unit root test, panel co-integration test, and panel test for causality, unit root test base on time series, ARDL-Bounds test and Finally Granger causality test base on ARDL. Under the time series analysis, the study will utilize the Augmented Dickey-Fuller (1979) and Phillips-Perron (1988) unit root test to test for the stationarity properties of the data in Sub-Section 3.6.1.1. Following the unit root test, Sub-Section 3.6.1.2 contained the ARDL-Bounds test. Finally, Sub-Section 3.6.1.3 discussed the Granger causality test base on ARDL model. Similarly, this study used panel unit root test proposed by Im, Pesaran and Shim (2003) which go along with heterogeneous autoregressive coefficients. Once there exist a panel unit root, the next issue is to find out whether a long-run equilibrium relationship exists between the variables. Sub-Section 3.6.2.2 used the heterogeneous panel test for co-integration advanced by Pedroni (1999, 2004) to investigate the long-run relationship between the variables. Also, in Sub-section 3.6.2.3, the FMOLS regression is used to estimate the long-run coefficients of the variables. Given that if the variables are co-integrated, a panel vector error correction model will be estimated to perform Granger-causality tests using the Engle and Granger (1987) as contained in Sub-section 3.6.2.4. This study utilized the data from nine SSA countries for the period 1995-2012 for the panel analysis as well as total data for SSA during the period 1980-2012 for the time series analysis.

CHAPTER FOUR
DISCUSSION OF RESULTS

4.1 Introduction

This chapter is designed to present the estimated results of the analysis and the discussions of findings. It commences by introducing the entire chapter. Section 4.2 offers the descriptive statistics, while Section 4.3 presents the correlation analysis. Section 4.4 consists of the results of time series data analysis, which include: the unit root test result, the optimal lag length, the ARDL Bounds test result, the long-run relationship, the short-run analysis, the Granger causality test results, and lastly, diagnostics checking which include: Cumulative Sum of Recursive Residuals (CUSUM), Cumulative Sum of Recursive Residuals Square (CUSUMQ), Normality, Heteroskedasticity and Autocorrelation. Section 4.5 provides the results of panel data analysis, which comprises of the panel unit root test result, panel cointegration result, the Fully Modified (OLS) result as well as the Granger causality test result and finally, Section 4.7 concludes the chapter.

4.2 Descriptive Statistics

This section provides the explanation about the reliability as well as the degree of confidence of the employed data. Before estimating the manufacturing performance models, this study first described the summary of statistics for all the variables utilized in the study.

4.2.1 Time Series

Within the time series analysis, the description of the data was provided to find out the reliability of the data employed. Table 4.1 presents the summary statistics for the variables in the total data from SSA countries.

Table 4.1
Descriptive Statistics for Time Series Analysis

Variable	Mean	Standard Deviation	Minimum	Maximum
MANF	1.143	0.554	1.041	1.231
ENG	2.837	0.012	2.819	2.848
CAP	10.891	0.277	10.555	11.531
LAB	0.445	0.011	0.426	0.461
INF	0.321	0.026	0.614	0.654

From Table 4.1, it is observed that the data for the SSA countries is normally and evenly distributed. For instance, the mean value, 1.14 for manufacturing performance variable corresponds to the standard deviation of 0.55. Similarly, the average value of energy consumption is 2.83 relates to the standard deviation of 0.01. In addition, in the case of capital, the value of the mean is 10.89, which correspond to the standard deviation of 0.27. Likewise, the average of labour is 0.44, which corresponds to the standard deviation of 0.01 and finally, the mean value of inflation given by 0.32 matches to the standard deviation 0.02. This justifies that the standard deviation is lower than the mean for the observation. It means that the observation is closer to the mean. Therefore, the observation is normally distributed.

4.2.2 Panel Data

In the panel analysis, the descriptive statistics for low-income, middle-income and all income groups in the sampled SSA countries is presented in Table 4.2. The descriptive statistics results presented in Table 4.2 disclosed that the data for the low-income, middle-income and all income groups in the sampled SSA countries is generally normal and evenly distributed.

Table 4.2
Descriptive Statistics for Panel Data Analysis

Variable	Mean	Standard Deviation	Minimum	Maximum
Low Income				
MANF	10.916	1.090	8.996	12.218
ENG	2.659	0.144	2.462	2.932
ELECT	2.257	0.363	1.935	2.947
FOS	1.103	0.388	0.253	1.639
CAP	8.988	0.530	7.932	10.035
LAB	0.353	0.173	-0.187	0.521
CPI	0.376	0.086	0.230	0.643
EF	1.641	0.152	0.687	1.778
Middle Income				
MANF	10.832	1.294	8.864	12.697
ENG	2.853	0.357	2.329	3.474
ELECT	2.560	0.712	1.614	3.704
FOS	1.609	0.271	1.113	1.945
CAP	9.759	0.594	8.774	10.902
LAB	0.344	0.109	0.102	0.563
CPI	0.496	0.231	-0.154	0.812
EF	1.752	0.064	1.583	1.846
All Income				
MANF	10.870	1.205	8.864	12.679
ENG	2.767	0.298	2.329	3.474
ELECT	2.246	0.601	1.614	3.704
FOS	1.384	0.413	0.253	1.945
CAP	9.417	0.683	7.932	10.902
LAB	0.348	0.141	-0.187	0.563
CPI	0.443	0.191	-0.154	0.816
EF	1.703	0.124	0.687	1.846

For instance, the average value of manufacturing performance *(MANF)* for low-income, middle-income and all income groups in the sampled SSA countries are 10.91, 10.83 and 10.87, respectively, which correspond to the standard deviation of 1.09, 1.29 and 1.20 for low-income, middle-income and all income groups in the sampled SSA countries, respectively. Looking at the value of the mean and standard deviation, it can be observed that the standard deviation is lower than the mean for all the observations. This means that all the observations are not far away from their mean.

In summary, the descriptive statistics results presented in Table 4.1 and Table 4.2 disclosed that the data for low-income, middle income, all income groups and total data for SSA countries are generally normal and evenly distributed. It can therefore be concluded that the data is normally distributed.

4.3 Correlation Analysis

Correlation matrix computed the correlation analysis for all the variables. The results of the correlation test between the dependent variable and the independent variables proved to be very useful in pre-estimation analysis especially with regard to the potential relationship suggested by the theory. Thus, the correlations of the variables are investigated before the econometric analysis, as this will help in determining the connection among the variables.

4.3.1 Time Series

In the time series analysis, the correlation between manufacturing performance and the independent variables indicated a weak, an average and a relatively strong correlation for *ENG*, *CAP* and *LAB*, respectively, with regards to *MANF* as shown in Table 4.3.

Table 4.3

Correlation Analysis for SSA (Time Series Analysis)

Variables	MANF	ENG	CAP	LAB	INF
MANF	1.000				

ENG	0.345	1.000			
	(0.049)	-----			
CAP	0.491	0.039	1.000		
	(0.000)	(0.826)	-----		
LAB	0.622	0.822	-0.365	1.000	
	(0.000)	(0.000)	(0.519)	-----	
INF	-0.321	0.654	0.031	0.120	1.000
	(0.001)	(0.763)	(0.058)	(0.781)	-----

Note: Figures in parenthesis represents probability

4.3.2 Panel Data

Within the panel data analysis, correlation analysis is examined for the low-income, middle-income and all income groups in the sampled SSA countries. Table 4.4 displayed the correlation analysis for low-income SSA countries. From the table, the correlation coefficient indicates average relationship between the dependent variable and the independent variables. For example, the coefficient values, 0.51, 0.49, 0.59 and 0.28 indicates an average and positive relationship between *MANF* and the variables such as: *ENG, ELECT*, *FOS*, *CAP* and *LAB*, respectively. It can be concluded that the correlation among the dependent and independent variables of interest is relatively average.

Table 4.4
Correlation Analysis for Low-Income SSA

Variables	**MANF**	**ENG**	**ELECT**	**FOS**	**CAP**	**LAB**	**CPI**	**EF**
MANF	1.000							

ENG	0.517	1.000						
	(0.000)	-----						
ELECT	0.416	0.914	1.000					
	(0.000)	(0.000)	-----					
FOS	0.590	0.917	0.706	1.000				
	(0.000)	(0.000)	(0.000)	-----				
CAP	0.317	0.072	0.088	0.064	1.000			
	(0.006)	(0.547)	(0.461)	(0.591)	-----			
LAB	0.284	0.816	0.889	0.635	0.315	1.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.006)	-----		
CPI	-0.379	0.501	0.499	0.383	0.007	0.352	1.000	
	(0.001)	(0.000)	(0.000)	(0.000)	(0.952)	(0.004)	-----	
EF	0.376	0.130	0.272	0.050	0.333	0.251	0.008	1.000
	(0.001)	(0.276)	(0.020)	(0.676)	(0.004)	(0.004)	(0.451)	-----

Note: Figures in parenthesis represents probability.

Similarly, Table 4.5 describes the correlation between the dependent variable and the independent variables from the middle-income SSA countries. The result shows different pattern of correlation from the low-income SSA. All the independent variables show a weak relationship between manufacturing performance and the independent variables. For instance, the coefficient values, 0.11, 0.001, 0.02 and 0.16 implies a weak relationship between *MANF* and *ENG*, *ELECT*, *FOS*, *CAP* and *LAB*, respectively.

Table 4.5
Correlation Analysis for Middle-Income SSA

Variables	MANF	ENG	ELECT	FOS	CAP	LAB	CPI	EF
MANF	1.000 -----							
ENG	0.117 (0.184)	1.000 -----						
ELECT	0.0018 (0.005)	0.860 (0.000)	1.000 -----					
FOS	0.026 (0.978)	0.518 (0.000)	0.868 (0.000)	1.000 -----				
CAP	0.271 (0.009)	0.672 (0.000)	0.408 (0.000)	0.197 (0.062)	1.000 -----			
LAB	0.165 (0.119)	0.704 (0.000)	0.770 (0.000)	0.647 (0.000)	0.362 (0.000)	1.000 -----		
CPI	0.212 (0.022)	0.481 (0.000)	0.776 (0.000)	0.812 (0.000)	0.075 (0.481)	0.562 (0.000)	1.000 -----	
EF	0.159 (0.133)	0.524 (0.000)	0.794 (0.000)	0.839 (0.000)	0.176 (0.096)	0.626 (0.000)	0.789 (0.000)	1.000 -----

Note: Figures in parenthesis represents probability.

Meanwhile, Table 4.6 described the correlation between manufacturing performance and the independent variables for all income groups in SSA. The finding shows an average relationship between the dependent variable and the independent variables. The coefficient values, 0.41, 0.61, 0.51 and 0.49 indicates an average relationship for *ENG*, *ELECT, FOS* and *LAB*, respectively, while *CAP* has a weak relationship with *MANF*.

Table 4.6
Correlation Analysis for All Income Group in SSA

Variables	MANF	ENG	ELECT	FOS	CAP	LAB	CPI	EF
MANF	1.000							

ENG	0.414	1.000						
	(0.184)	-----						
ELECT	0.616	0.873	1.000					
	(0.005)	(0.000)	-----					
FOS	0.526	0.606	0.703	1.000				
	(0.000)	(0.000)	(0.000)	-----				
CAP	0.219	0.557	0.407	0.384	1.000			
	(0.005)	(0.000)	(0.000)	(0.000)	-----			
LAB	0.491	-0.583	-0.689	-0.523	-0.018	1.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.819)	-----		
CPI	-0.232	0.536	0.755	0.621	0.219	-0.386	1.000	
	(0.002)	(0.000)	(0.000)	(0.000)	(0.005)	(0.000)	-----	
EF	0.227	0.288	0.292	0.401	0.431	0.0144	0.434	1.000
	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)	(0.854)	(0.000)	-----

Note: Figures in parenthesis represents probability.

4.4 Time Series Analysis

This sub-section is aimed at examining the long run co-integration by using the ARDL-Bounds testing approach. This is in addition to examining the short run and the long run coefficients of the time series data. It further examines the causal relationship among the variables and finally concludes the sub-section with stability and diagnostic checking.

4.4.1 Unit Root Test Result

The first process in the analysis of the relationship between energy consumption and manufacturing performance within the ARDL framework is to start by testing the stationarity properties of the series. This is because statistical inferences cannot be done when the variables in the model are non-stationary. In addition, the procedure for ARDL-Bounds test is applicable when the series are I(0), I(1) or mixed.

Unit root tests were developed to examine the stationary properties of the time series observations. This study utilized the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to investigate the unit root properties of the variables. Table 4.7 displays the unit root test result for SSA countries.

Table 4.7
Unit Root Test for SSA Countries

Series	**ADF**		**PP**	
	Levels	**First Difference**	**Levels**	**First Difference**
MANF	-0.033	-5.273*	-2.110	-5.300*
	(0.948)	(0.000)	(0.520)	(0.000)
ENG	-1.035	-6.728*	-1.689	-6.839*
	(0.923)	(0.000)	(0.732)	(0.000)
CAP	-1.126	-4.749*	-1.126	-4.794*
	(0.908)	(0.003)	(0.918)	(0.002)
LAB	-0.948	-4.782*	-0.985	-4.684*
	(0.936)	(0.000)	(0.932)	(0.002)
INF	-3.867*	-7.179*	-3.867*	-14.176*
	(0.025)	(0.000)	(0.025)	(0.000)

Notes: * represents statistically significant at 5 percent level of significance. Figures in parenthesis represent probability.

In Table 4.7, the unit root test results of the variables show that the null hypothesis of unit roots for manufacturing performance, energy consumption, capital formation and labour cannot be rejected at levels. However, after differencing the variables, the null of the hypothesis of unit roots for manufacturing performance, energy consumption, capital formation and labour are rejected at 5 percent significance level. Thus, differencing the variables turn the series to be stationary at first difference. It is, therefore, worth concluding that manufacturing performance, energy consumption, capital formation and labour are stationary at I(1). In the case of inflation variable, the null hypothesis of unit roots is rejected at levels at 5 percent significance level. Thus, inflation is concluded as I(0) variable.

4.4.2 Optimal ARDL Model Selection

This sub-section deals with the selection of the optimum ARDL model for the purpose of analysis. The optimal number of lags to be included in the model based on Akaike Information Criteria (AIC). The model selected is displayed in Table 4.8. From the Table, the optimal ARDL model is given by ARDL (1, 1, 4, 4, 3).

Table 4.8
Optimal ARDL Model Selection. ARDL (1, 1, 4, 4, 3)

Variable	Coefficient	Standard Error	t-Statistic	Prob.
MANF(-1)	0.180	0.194	0.930	0.032*
ENG	0.391	0.327	1.195	0.257
ENG(-1)	1.163	0.310	3.753	0.003*
CAP	-0.013	0.043	-0.294	0.774
CAP (-1)	-0.150	0.060	-2.507	0.029
CAP (-2)	-0.005	0.062	-0.080	0.938
CAP (-3)	0.159	0.077	2.061	0.064
CAP (-4)	-0.111	0.039	-2.872	0.015*
LAB	-2.751	1.253	-2.195	0.051
LAB (-1)	1.611	2.404	0.670	0.517
LAB (-2)	0.804	2.726	0.295	0.774
LAB (-3)	-3.160	2.555	-1.237	0.242
LAB (-4)	3.672	1.576	2.330	0.040*
INF	0.017	0.017	1.018	0.330
INF (-1)	0.002	0.014	0.107	0.916
INF (-2)	-0.011	0.013	-0.839	0.419
INF (-3)	-0.042	0.021	-1.999	0.047*
C	-2.233	0.967	-2.310	0.041

Note: * represents 5 percent level of significance

4.4.3 The ARDL Bounds Test

Following the confirmation of the optimal lag length, the long run co-integration among the variables is examined by utilizing the ARDL bound testing procedure. In this sub-section, the Autoregressive Distributive Lag (ARDL) bounds testing approach is be used to find out co-integration relationship among the variable in the long run, as well as the long run and the short run coefficients. This study therefore examines the bounds *F*-test to find out the long run connection among the variables. Table 4.9 reports the Bounds test result for SSA.

Table 4.9
ARDL Bounds Test Results

Variables	***F*-stat**	**Lag**	**Sig. Level**	Critical values **I(0)**	Critical values **I(1)**
$F_{MANF}[MANF / ENG, CAP, LAB, INF]$	5.050*	4	10%	2.45	3.52
$F_{ENG}[ENG / MANF, CAP, LAB, INF]$	2.314	4	5%	2.86	4.01
$F_{CAP}[CAP / MANF, ENG, LAB, INF]$	4.598*	4	1%	3.74	5.06
$F_{LAB}[LAB / MANF, ENG, CAP, INF]$	7.347*	4			
$F_{INF}[INF / MANF, ENG, CAP, LAB]$	4.870*	4			

Note: * represents 5 percent level of significance

The result of the *F*-statistics offered in Table 4.9 revealed that when *MANF* is used as dependent variable, the calculated *F*-statistics 5.05 is greater than the upper bound at 5 percent significance level. Similarly, employing *CAP* as the dependent variable, the *F*-statistics of 4.59 is greater than the upper bound at 5 percent level of significance. Moreover, when *LAB* is utilized as the dependent variable, the *F*-statistics of 7.34 is greater than the upper bound at 5 percent level of significance. Also, when *INF* is used as the dependent variable, the *F*-statistics of 4.87 is greater than the upper bound at 5 percent level of significance. However, utilizing *ENG* as the dependent variable, the *F*-statistics of 2.31 is less than the lower bound at 10 percent significance level.

This result suggests that the null hypothesis of no co-integration is rejected when manufacturing performance, capital, labour and inflation are used as the dependent variables at 5 percent significance level. On the contrary, when energy consumption is used as the dependent variable, the null hypothesis of no co-integration cannot be rejected at 10 percent level of significance. Overall, this implies that there is co-integrating relationships among the variables in the models.

4.4.4 The Long Run Relationship

Establishing the existence of long run relationship between manufacturing performance and the independent variables for SSA countries allowed this study to estimate the coefficients of the long run among the variables. The long run coefficients are presented in Table 4.10.

Table 4.10
Long Run Coefficients. Dependent Variable: Manufacturing Performance, ARDL (1,1, 4, 4, 3)

Regressors	Coefficients	Standard Error	T-statistics	Prob.
ENG	1.896	0.415	4.567	0.001*
CAP	0.145	0.012	12.053	0.000*
INF	-0.042	0.025	-1.690	0.119
LAB	0.217	0.517	0.419	0.683
C	-2.725	1.035	-2.633	0.023

Note: * represents 5 percent level of significance

In Table 4.10, the estimated long run coefficient of *ENG* and *CAP* are statistically significant at 5 percent level of significance for SSA countries. The coefficient, 1.89 means that one Kg increase in energy consumption will cause USD 1.89 increase in manufacturing performance. Higher level of energy consumption means increase in manufacturing performance and thereby facilitating increase in value added in the SSA countries. This finding is related to the studies of Sari *et al.* (2008) for US, Ozturk and Acaravci (2010) for Albania, Bulgaria, Hungary and Romania, Odhiambo (2009) for Tanzania and Danmaraya and Hassan (2016) for Nigeria. For instance, Danmaraya and Hassan (2016) employed the ARDL technique for Nigeria in studying the relationship between manufacturing productivity and electricity consumption. Their finding established long run positive relationship between manufacturing productivity and electricity consumption.

Similarly, the coefficient, 0.14 explained that USD1 increase capital caused USD 0.14 increase in the performance of the manufacturing sector. Thus, increase in capital formation will increase manufacturing performance. By implication, energy and capital will in general increase the performance of the manufacturing sector, which is in line with the a-priori expectation. The result of capital formation is in line with the studies of Narayan and Smyth (2008) for G-7 countries, Lee and Chang (2008) for China and Indonesia, and Lee (2005) for 18 developing countries. Taking the instance of Lee (2005), the co-movement and causality among energy consumption, capital and GDP is examined in 18 developing countries. The findings of the study revealed that capital is positive and significant in explaining economic growth in 14 out of the 18 developing countries.

4.4.5 The Short Run Relationship

Following the successful estimation of the long run relationships, the study further estimates the short run dynamic of the model. Table 4.11 displayed the short run coefficients of the model.

Table 4.11
Short Run Coefficients. Dependent Variable: Manufacturing Performance, ARDL (1,1,4, 4, 3)

Regressors	Coefficients	Standard Error	t-statistics	Prob.
C	7.653	1.186	6.452	0.003*
ΔMANFf(-1)	0.474	0.715	0.662	0.019*
ΔENG	1.163	0.310	3.753	0.003*
ΔCAP	-0.013	0.043	-0.294	0.774
ΔCAP(-1)	0.005	0.062	0.080	0.938
ΔCAP(-2)	-0.159	0.077	-2.061	0.064
ΔCAP(-3)	0.111	0.039	2.872	0.015*
ΔLAB	-2.751	1.253	-2.195	0.051
ΔLAB(-1)	-0.804	2.726	-0.295	0.774
ΔLAB(-2)	3.160	2.555	1.237	0.242
ΔLAB(-3)	3.672	1.576	2.330	0.040*
ΔINF	0.017	0.017	1.018	0.330
ΔINF(-1)	0.011	0.013	0.839	0.419
ΔINF(-2)	0.042	0.021	1.999	0.071
ECT(-1)	-0.820	0.194	-4.227	0.001*

Notes: * represents statistically significant at 5 percent level of significance

Table 4.11 examined the short run relationship between manufacturing Performance, energy consumption, capital, labour and inflation through the use of the *ECM*. The *ECT* is the degree of the divergence of the explanatory variables away from the long run position. The size of the *ECT* coefficient -0.82 point out about 82 percent speed of correction towards the long run equilibrium within a year. The result was in consistent with the study of Soytas, Ewing and Sari (2008) for the US, Menyah and Wolde-Rufael (2010) for South Africa and Tang and Tan (2015) for Vietnam. For instance, Tang and Tan (2015) investigate foreign direct investment, income, CO_2

emissions and energy consumption in Vietnam and revealed about 64 percent speed of adjustment back to equilibrium.

Similarly, in the short run, energy consumption, capital and labour are positively related to manufacturing performance while inflation is insignificant in explaining manufacturing performance in the short run. During the short run, 1kg increase in energy consumption will incresase manufacturing perpormanfce by USD1.163. Also, USD1 increase in capital formation will increase manufacturing performance by USD0.11. Similarly, one percent increase in labour will increase manufacturing performanfce by USD3.67. This follows the studies of Paul and Bhattacharya (2004) for India, Kumar and Kumar (2013) for Kenya and South Africa and, Tang and Tan (2015) for Vietnam.

4.4.6 Granger Causality

This sub-section provides the time series based Granger causality. Table 4.12 displayed the Granger causality test result for aggregate energy consumption in SSA countries.

Table 4.12
Granger Causality Test Result

Null Hypothesis	**F-statistics**	**Prob.**	**Conclusion**
ENG does not Granger cause *MANF*	0.206	0.814	Zero
MANF does not Granger cause *ENG*	0.427	0.656	causality
CAP does not Granger cause *MANF*	1.229	0.308	Unidirectional
MANF does not Granger cause *CAP*	9.687	0.000*	causality
LAB does not Granger Cause *MANF*	2.017	0.153	Zero
MANF does not Granger cause *LAB*	1.074	0.356	causality
INF does not Granger Cause *MANF*	1.372	0.331	Zero
MANF does not Granger cause *INF*	0.489	0.661	causality

Note: * represent significance at 5 percent.

Table 4.12 shows the Granger causality result for SSA countries. From the table, zero causality was found existing among *MANF* and *ENG*, among *MANF* and *LAB* and, *MANF* and *INF* as unidirectional causality running from *MANF* to *CAP* was maintained in SSA countries. Thus, neutrality hypothesis was maintained between manufacturing performance and energy consumption, between manufacturing performance and labour and, between manufacturing performance and inflation. Also the result maintained one way causality from manufacturing performance to capital formation. The result for energy follow the studies of Masih and Masih (1997) for Malaysia, Singapore and Philippines; Akinlo (2008) for Cameroon, Cote d' Ivoire, Nigeria, Kenya and Togo and, Ozturk and Acaravci (2011) for 11 Middle East and North American countries. Taking the study of Ozturk and Acaravci (2011), evidence of no causality between electricity consumption and economic growth was maintained for Middle East and North America.

4.4.7 Diagnostic Checking

The competency of the specified model is additionally confirmed through diagnostic tests to ensure that the results are free from spurious inference. Table 4.13 demonstrates the diagnostic test of the ARDL Model.

Table 4.13
Diagnostic Test of the ARDL Model

Test Statistics	***F*-statistics**	**Prob.**
Autocorrelation	1.893	0.193
Normality	0.818	0.664
Heteroskedasticity	1.267	0.351

The result from Table 4.13 established that the null hypothesis of no serial correlation, homoskedasticity as well as the normality of the distribution of the residuals cannot be rejected. For this reason, it is concluded that the model has passed the diagnostic test.

The strength and stability of the model can be additionally measured by applying the Cumulative Sum of Recursive Residuals (CUSUM) and Cumulative Sum of Recursive Residuals Square (CUSUMQ) tests as proposed by Brown and Durbin (1975). Figure 4.1 and Figure 4.2 depict the CUSUM stability test and CUSUMQ stability test, respectively.

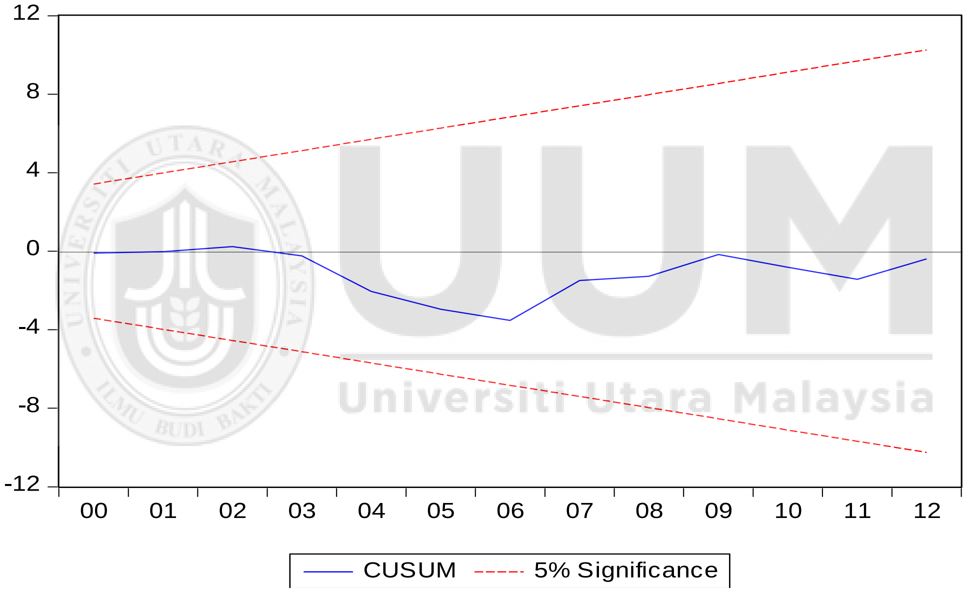

Figure 4.1
CUSUM Stability Test

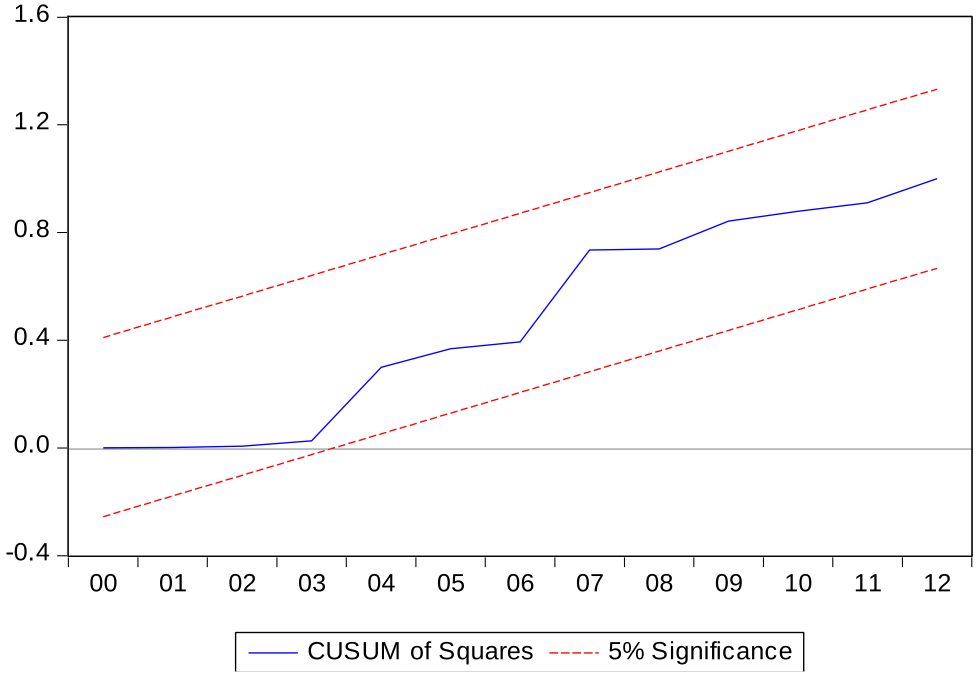

Figure 4.2
CUSUMQ Stability Test

From Figure 4.1 and Figure 4.2, the plots of the stability test exposed that the series are within the critical bound at 5 percent significance level. This therefore justify the stability of the model over time.

4.5 Panel Data Analysis

The aim of this sub-section is to examine long run cointegration between manufacturing performance and the independent variables within the panel data framework. The sub-section further investigates long run coefficients as well as the causal relationship between manufacturing performance and energy consumption. The panel data analysis covers the low-income, middle-income and all income groups in the sampled SSA countries.

4.5.1 Panel Unit Root Test Result

The starting point for macro panel data analysis is to examine the stationarity property of the series. Stationarity of series is essential for a meaningful statistical inference. It is also used in determining the order of integration of the variables. Following the objectives of the study, the panel unit root tests result are applied separately to the low-income, middle-income and all income groups in the sampled SSA countries. The unit root tests results are based on constant with no time trend and constant with the time trend. Table 4.14 displays the panel unit root tests result for all income groups in the sampled SSA countries.

Table 4.14
Panel Unit Root Test Result for the All income Groups in Sample SSA Countries

Variables	**Level**		**First Difference**	
	Constant	**Constant + Trend**	**Constant**	**Constant + Trend**
MANF	4.173	0.433	-6.148*	-6.190*
	(1.000)	(0.677)	(0.000)	(0.000)
ENG	1.523	-1.064	-8.428*	-6.776*
	(0.936)	(0.143)	(0.000)	(0.000)
ELECT	2.774	-0.174	-7.969*	-7.416*
	(0.099)	(0.088)	(0.000)	(0.000)
FOS	-0.824	0.314	-8.384*	-6.495*
	(0.204)	(0.623)	(0.000)	(0.000)
CAP	4.313	-0.455	-8.255*	-6.240*
	(1.000)	(0.324)	(0.000)	(0.000)
LAB	-1.062	5.024	-2. 422*	-10.507*
	(0.144)	(1.000)	(0.007)	(0.000)
CPI	-0.960	-0.649	-7.264*	-6.224*
	(0.168)	(0.257)	(0.000)	(0.000)
EF	-1.404	-1.492	-13.413*	-10.340*
	(0.080)	(0.089)	(0.000)	(0.000)

Note: * indicates 5 percent level of significance. Figures in parenthesis represent probability.

Table 4.14 shows that the series are non-stationary at levels for both constant with no time trend and constant with time trend. However, after taking the first difference, the series becomes stationary at 5 percent significance level for both constant with time trend and constant with no time trend. Similarly, Table 4.15 and Table 4.16 represent the panel unit root test result for the low-income SSA countries and the panel unit root tests results for the middle-income SSA countries, respectively.

Table 4.15
Panel Unit Root Test Result for the Low-income SSA Countries

Variables	Level		First Difference	
	Constant	**Constant + Trend**	**Constant**	**Constant + Trend**
MANF	1.918	0.056	-3.146*	-3.457*
	(0.997)	(0.522)	(0.000)	(0.000)
ENG	0.186	-1.527	-4.656*	-3.542*
	(0.574)	(0.063)	(0.000)	(0.000)
CAP	2.982	-1.268	-6.262*	-5.786*
	(0.998)	(0.102)	(0.000)	(0.000)
LAB	2.385	2.935	-2.302**	-9.351*
	(0.908)	(0.970)	(0.010)	(0.000)
CPI	-0.239	-0.127	-3.701*	-2.914*
	(0.405)	(0.449)	(0.001)	(0.001)
EF	-1.339	-1.424	-11.156*	-7.130*
	(0.061)	(0.074)	(0.000)	(0.000)

Note: * indicates 5 percent level of significance. Figures in parenthesis represent probability.

Table 4.16
Panel Unit Root Test Result for the Middle-income SSA Countries

Variables	Level		First Difference	
	Constant	**Constant + Trend**	**Constant**	**Constant + Trend**
MANF	3.928	0.537	-5.527*	-5.252*
	(1.000)	(0.704)	(0.000)	(0.000)
ENG	1.846	-0.038	-7.133*	-5.931*
	(0.967)	(0.484)	(0.000)	(0.000)
CAP	3.171	0.427	-5.469*	-3.252*
	(0.999)	(0.665)	(0.000)	(0.000)
LAB	0.764	-0.632	-1.154	-5.685*
	(0.777)	(0.263)	(0.124)	(0.000)
CPI	-1.076	-0.770	-7.044*	-5.813*
	(0.140)	(0.220)	(0.000)	(0.000)
EF	-0.477	-0.816	-7.773*	-7.502*
	(0.316)	(0.207)	(0.000)	(0.000)

Note: * indicates 5 percent level of significance. Figures in parenthesis represent probability.

As in Table 4.14, similar result is shown in Table 4.15 and Table 4.16. The results in Table 4.15 and Table 4.16 also displays that the series are non-stationary at levels using both constant with no time trend and constant with time trend. On the other hand, the series becomes stationary at 5 percent significance level after taking the first difference for both constant with time trend and constant with no time trend.

The null hypothesis of each series is non-stationary cannot be rejected at levels for both the low-income, middle-income and the all income groups in the sampled SSA countries. However, after differencing the series, the null hypothesis of each series is non-stationary is rejected at 5 percent level of significance for both the low-income, middle-income and all income groups in the sampled SSA countries. Thus, it can be concluded that the series are *I(1)* and this qualifies the series to proceed to cointegration test.

4.5.2 Panel Cointegration Analysis

Following the stationarity test, which confirms the series to be stationary at first difference, next is to apply Pedroni (1999, 2004) co-integration test to investigate whether the variables are co-integrated or otherwise. The results of the Pedroni panel co-integration for the aggregate energy consumption, electricity consumption and fossil energy consumption in the sampled SSA countries are shown in Table 4.17.

Table 4.17

The Pedroni Panel Cointegration Test for the Aggregate and Disaggregate Energy Consumption in Sampled SSA Countries

	AGGREGATE ENERGY		**ELECTRICITY**		**FOSSIL ENERGY**	
Test	**Statistics**	**Prob.**	**Statistics**	**Prob.**	**Statistics**	**Prob.**
Panel υ-statistics	0.177	0.429	0.565	0.285	0.572	0.283
Panel ρ statistics	2.248	0.987	2.945	0.998	3.090	0.999
Panel PP-statistics	-2.887	0.001*	-1.633	0.048*	-1.542	0.048*
Panel ADF-statistics	-2.670	0.003*	-2.095	0.018*	-1.726	0.039*
Group ρ-statistics	3.430	0.999	4.336	1.000	3.704	0.999
Group PP-statistics	-3.548	0.000*	-2.572	0.005*	-1.994	0.023*
Group ADF-statistics	-2.620	0.004*	-1.646	0.046*	-2.746	0.003*

Note: * indicates 5 percent level of significance.

Table 4.17, displayed the aggregate energy consumption, electricity consumption and fossil energy consumption models. The aggregate energy consumption model demonstrates that the null hypothesis of no co-integration cannot be rejected for Panel υ-statistics, Panel ρ-statistics and Group ρ-statistics. However, the null hypothesis of no co-integration is rejected for Panel PP-statistics, Panel ADF-statistics, Group PP-statistics and Group ADF-statistics at 5 percent level of significance. Thus, it can be concluded that the panel co-integration tests result for the aggregate energy consumption proved that the independent variables possess co-integration in the long run for the samples SSA countries with respect to manufacturing performance.

In the electricity consumption and fossil energy consumption models, the panel co-integration result suggests that the null hypothesis of no co-integration cannot be rejected for Panel υ-statistics, Panel ρ-statistics and Group ρ-statistics. Conversely, the null hypothesis of no co-integration is rejected for Panel PP-statistics, Panel ADF-statistics, Group PP-statistics and Group ADF-statistics at 5 percent level of significance. Therefore, it can be concluded that the panel co-integration tests result for the disaggregate energy (electricity and fossil energy) consumption models established that the independent variables possess co-integration in the long run for the samples SSA countries with respect to manufacturing performance.

Table 4.17 above displayed co-integration in the whole sampled SSA countries. Moreover, as part of the objective of this study is to examine the relationship across the low-income group and the middle-income group in SSA countries, Table 4.18 reports the results of the Pedroni co-integration for the low-income and middle-income groups in the sampled SSA countries.

Table 4.18
The Pedroni Panel Cointegration Test for the Aggregate Energy Consumption in Low-Income and Middle-Income SSA Countries

	LOW-INCOME SSA		**MIDDLE-INCOME SSA**	
Test	**Statistics**	**Prob.**	**Statistics**	**Prob.**
Panel υ-statistics	-0.774	0.780	-1.684	0.046*
Panel ρ statistics	1.510	0.934	1.655	0.951
Panel PP-statistics	-1.739	0.048*	-2.490	0.006*
Panel ADF-statistics	-1.945	0.025*	-1.765	0.038*
Group ρ-statistics	2.528	0.994	2.340	0.990
Group PP-statistics	-2.145	0.016*	-2.841	0.002*
Group ADF-statistics	-2.417	0.007*	-1.635	0.048*

Note: * indicates 5 percent level of significance.

In Table 4.18, the low-income SSA group revealed that the null hypothesis of no cointegration cannot be rejected for Panel *υ*-statistics, Panel *ρ*-statistics and Group *ρ*-statistics. However, the null hypothesis of no co-integration is rejected for Panel PP-statistics, Panel ADF-statistics, Group PP-statistics and Group ADF-statistics at 5 percent level of significance. Likewise in the middle-income SSA group, the null hypothesis of no co-integration cannot be rejected for Panel ρ-statistics and Group ρ-statistics. But, the null hypothesis of no co-integration is rejected for Panel υ-statistics, Panel PP-statistics, Panel ADF-statistics, Group PP-statistics and Group ADF-statistics at 5 percent level of significance. Accordingly, it can be concluded that the panel co-integration tests result for the aggregate energy consumption provide evidence that the independent variables possess co-integration in the long run for the low-income and middle-income groups in the sampled SSA countries with respect to manufacturing performance.

In summary, the Pedroni (1999, 2004) tests indicates that the independent variables possess co-integration in the long run for the low-income, middle-income as well as, the all income groups in the sample of SSA countries with respect to manufacturing performance. Following the confirmation of the existence of long run relationship among manufacturing performance and the independent variables next is to estimate the coefficients of the long run relationship.

4.5.3 Estimation of the Long Run Relationship

Establishing the existence of a long run relationship between manufacturing performance and the independent variables for the low-income, middle-income and total sampled SSA countries qualified this study to estimate the FMOLS regression. Table 4.19 represents the FMOLS regression for the aggregate and the disaggregate energy consumption in the sampled SSA countries.

From the aggregate energy consumption model in Table 4.19, the estimated coefficient of *ENG*, *CAP*, *LAB*, *CPI* and *EF* are statistically significant at 5 percent level of significance for SSA countries. The coefficient of 0.54 means that one kg increase in energy consumption caused USD 0.54 increase in the value of manufacturing output of the sampled SSA countries. Higher level of energy consumption means the manufacturing sector is performing, thus facilitating increase in output and value added in the sampled SSA countries. This is in line with the studies of Lee and Chang (2008) for 16 Asian countries, Akinlo (2008) for 11 SSA and Ouedrago (2013) for ECOWAS. For instance, Lee and Chang (2008) applied the heterogeneous panel co-integration and the fully modified OLS for 16 Asian countries and established that energy consumption positively affect economic growth in 11 Asian countries. Similarly, Ouedrago (2013) investigated energy-growth nexus in ECOWAS and maintained that energy is a key determinant of economic growth.

Also, the coefficient of 0.18 explained that USD1 increase in capital caused USD 0.18 increase in manufacturing performance in the sampled SSA countries. This finding follows the studies of Narayan and Smyth (2008) for G-7 countries, Lee and Chang (2008) for China and Indonesia, and Lee (2005) for 18 developing countries. Taking the instance of Lee (2005), the co-movement and causality among energy consumption, capital and GDP is examined in 18 developing countries. The findings of the study revealed that capital is positive and significant in explaining economic growth in 14 out of the 18 developing countries .Similarly, the coefficient of 0.25

implied that one percent increase in economic freedom would transform into USD 0.25 increases in manufacturing performance of SSA countries. Therefore, the higher the freedom of economic activities, the higher will likely be the performance of manufacturing sector in SSA countries.

Furthermore, the coefficient of 0.12 explained that one percent increase in corruption perception index would increase manufacturing performance by USD 0.12. Thus, the higher the corruption index, the higher will be the performance of the manufacturing sector. However, the coefficient of -0.20 explained that any one percent increase in labour input will decrease the value added of manufacturing sector by USD 0.20. Therefore, labour is inversely related to manufacturing performance. This also is relevant to the work of Lee and Chang (2008) for India and Iran and, Ziramba (2009) for South Africa.

While the result for energy consumption, capital, corruption and economic freedom in the aggregate energy consumption model is in line with a-priori expectation (positive effect on manufacturing performance), the result for labour is not. It is expected that positive increase in labour input to have a positive effect on manufacturing performance in SSA countries.

Table 4.19
FMOLS Regression for Aggregate and Disaggregate Energy Consumption in Sampled SSA

	AGGREGATE ENERGY		**ELECTRICITY**		**FOSSIL ENERGY**	
Variables	**Coefficient**	**t-Statistics**	**Coefficient**	**t-Statistics**	**Coefficient**	**t-Statistics**
ENG	0.543*	8.732	-	-	-	-
	(0.062)		-		-	
ELECT	-	-	0.545*	7.132	-	-
	-		(0.076)		-	
FOS	-	-	-	-	0.320*	3.914
	-		-		(0.081)	
CAP	0.183*	5.339	0.136*	6.940	0.214*	11.602
	(0.034)		(0.019)		(0.018)	
LAB	-0.202*	-7.280	-0.113	-1.428	-0.238*	-2.718
	(0.027)		(0.079)		(0.087)	
CPI	0.122*	2.239	0.310*	4.456	0.330*	4.112
	(0.054)		(0.069)		(0.080)	
EF	0.256*	7.639	0.109	1.807	0.150*	2.149
	(0.033)		(0.060)		(0.070)	

Note: * indicates 5 percent level of significance. Figure in parenthesis represents standard error.

Similarly, the electricity consumption model revealed the estimated coefficient of *ELECT*, *CAP* and *CPI* to be statistically significant at 5 percent level of significance for SSA countries. On the other hand, *LAB* and *EF* are found to be insignificant in explaining manufacturing performance in the electricity model. The coefficient of 0.54 for electricity consumption means that 1 kWh increase in electricity consumption caused USD 0.54 increase in the value of manufacturing output of the sampled SSA countries. Higher level of electricity consumption means the manufacturing sector is performing, thereby making possible increase in the performance of manufacturing sector of SSA countries. This result was also maintained by Ziramba (2009), Mozumder and Marathe (2007), Soytas and Sari (2007) and Tang (2008). For instance, Tang (2008) re-examine the relationship between electricity consumption and economic growth in Malaysia and established that electricity consumption is significant in explaining economic growth. In the same way, by assessing the disaggregate energy consumption and industrial production in South Africa, Ziramba (2009) maintained that electricity consumption influence industrial production.

Moreover, the coefficient of 0.13 provides that USD1 increase in capital formation lead to USD 0.13 increase in manufacturing performance in the electricity model. This explains that increase in capital formation will as well increase manufacturing performance in the sampled SSA countries. The studies of Menyah and Wolde-Rufael (2010) for South Africa, Shahbaz and Dube (2012) for Pakistan and Ozturk and Al-Mulali (2015) for GCC countries establish similar findings. In the study of Ozturk and Al-Mulali (2015), economic growth and natural gas consumption was examined by incorporating labour and capital as a separate variables. The result suggested significant positive effect of capital on economic growth in Oman and Kuwait.

Additionally, the coefficient of 0.31 revealed that increase in corruption perception index would increase manufacturing performance by USD 0.31. As a result, the higher the corruption index, the higher will be the performance of the manufacturing sector. While the result for electricity consumption capital and corruption in the electricity model are in line with a-priori expectation result (positive effect on manufacturing performance), the result for labour is found to be insignificant in explaining manufacturing performance in SSA countries.

Meanwhile, the fossil energy models revealed the estimated coefficient of *FOS*, *CAP*, *LAB*, *EF* and *CPI* to be statistically significant at 5 percent level of significance for the sampled SSA countries. The coefficient of 0.32 for fossil energy consumption signifies one percent rise in fossil energy consumption leads to USD 0.32 rise in the value of manufacturing output of SSA countries. More fossil energy consumption entails more manufacturing performance in the sampled SSA countries. The result for fossil energy was also in accordance with Soytas and Sari (2007); Lotfalipour, Falahi and Ashena (2010); Nnanji, Chuckwu and Moses (2013) and, Al-Mulali and Ozturk (2014). For instance, Nnanji et al. (2013) revealed that fossil fuel consumption have a long run positive impact on economic growth by investigating fossil fuel, electricity consumption and economic growth in Nigeria.

Similarly, the coefficient of 0.21 provides that USD1 increase in capital formation would lead to USD 0.21 increases in manufacturing performance in the sampled SSA countries. Accordingly, the higher the capital formation, the higher the performance of manufacturing sector in the fossil model of the sampled SSA countries. The finding of capital is related to the studies of: Wolde-Rufael (2009); Eggoh, Bangake and Rault (2011); and, Shahbaz, Loganathan, Zeshan and Zaman (2015). The study of Wolde-Rufael (2009) for 17 African countries revealed that capital significantly contributes to output growth in 15 out of the 17 African countries.

In the same way, the co-efficient of 0.15 implied that one percent increase in economic freedom will convert into USD 0.15 increases in manufacturing performance of SSA countries. Consequently, the higher the freedom of economic activities, the higher will likely be the performance of manufacturing sector in SSA countries. Additionally, the coefficient of 0.33 revealed that increase in corruption perception index would increase manufacturing performance by USD 0.33. As a result, the higher the corruption index, the higher will be the performance of the manufacturing sector. Also, the coefficient of -0.23 established that a one percent increase in labour input will transform into a decrease in manufacturing performance by USD 0.22. While the result for fossil energy consumption, capital, corruption and economic freedom in the fossil consumption model is in line with a-priori expectation result (positive effect on manufacturing performance), the result for labour is found to be affecting manufacturing performance negatively in the fossil energy model in SSA countries.

As in Table 4.19, Table 4.20 represents for the FMOLS regression for low-income and middle-income SSA countries. From the table, the low-income SSA model disclosed the estimated co-efficient of *ENG*, *CPI* and *CAP*, to be statistically significant at 5 percent level of significance for SSA countries. On the other hand, *LAB* and *EF* for are found to be statistically insignificant in explaining manufacturing performance in the low-income SSA model. The coefficient of 1.54 for energy consumption means that one kg increase in energy consumption caused USD 1.54 increase in the value of manufacturing output in low-income SSA countries. Accordingly, greater level of energy consumption means the manufacturing sector is performing, thereby making possible increase in the performance of manufacturing sector of SSA countries. . This is in accordance with the studies of Lee and Chang (2008) for 16 Asian countries, Stern and Eflo (2013) for Swedish and, Alper and Oguz (2016) for EU member countries. In the study of Alper and Oguz (2016), energy consumption and economic growth is investigated for EU countries and maintained that energy consumption has positive impact on economic growth.

Table 4.20
FMOLS Regression for Low-Income and Middle-Income SSA Countries

	LOW-INCOME		**MIDDLE-INCOME**	
Variables	**Coefficient**	**t-Statistics**	**Coefficient**	**t-Statistics**
ENG	1.548*	3.611	0.341*	2.842
	(0.428)		(0.005)	
CAP	0.111*	4.723	0.110*	4.490
	(0.023)		(0.000)	
LAB	-0.069	-0.629	2.126*	7.514
	(0.109)		(0.000)	
CPI	0.331*	2.467	0.064	1.035
	(0.134)		(0.304)	
EF	0.081	0.293	0.141	0.745
	(0.061)		(0.458)	

Note: * indicates 5 percent level of significance. Figure in parenthesis represents standard error.

Similarly, the coefficient of 0.11 provides that USD1 increase in capital lead to USD 0.11 increase in manufacturing performance of energy consumption in low-income SSA countries. This is in accordance with the studies of Ouedraogo (2010) for Burkina Faso, Shahbaz and Dube (2012) for Pakistan and, Ozturk and Al-Mulali (2015) for GCC countries. Additionally, the coefficient of 0.33 revealed that increase in corruption perception index would increase manufacturing performance by USD 0.33. As a result, the higher the corruption index, the higher will be the performance of the Manufacturing sector. While the result for energy consumption, capita and corruption index are in line with a-priori expectation result (positive effect on manufacturing performance), the result for labour was found to be insignificant in explaining manufacturing performance in low-income SSA countries.

Furthermore, the middle-income SSA model revealed the estimated co-efficient of *ENG*, *LAB* and *CAP*, to be statistically significant at 5 percent level of significance for middle-income SSA countries, while *EF* and *CPI* are statistically insignificant in explaining manufacturing performance. The coefficient of 0.34 for energy consumption explains that one kg increase in energy consumption caused USD0.34 increase in the value of manufacturing output in middle-income SSA countries. Hence, greater level of energy consumption implies the manufacturing sector is performing, thereby making possible increase in the performance of manufacturing sector of SSA countries. This finding follows the studies of Shahbaz and Lean (2012) for Tunisia; Bartleet and Gounder (2010) for New Zealand and Odhiambo (2014) for different income group.

Likewise, the coefficient of 0.11 explained that USD1 increase in capital leads to USD 0.11 increase in manufacturing performance of energy consumption in low-income SSA. As well, the coefficient of 2.12 maintained that one percent increase in labour input would increase manufacturing performance b USD 2.12. The result for energy consumption, labour and capita are in line with a-priori expectation result (positive effect on manufacturing performance) in explaining manufacturing performance in SSA countries.

4.5.4 Granger Causality Result

As described in the methodology, this sub-section provides the panel based Granger causality. Table 4.21 displayed the Granger causality test result for aggregate energy, electricity consumption and fossil energy consumption for all income groups in sampled SSA countries.

Table 4.21
Granger Causality Result for Aggregate and Disaggregate Energy in All Income Sampled SSA Countries

Null Hypothesis	*F*-Statistics	Prob.	Conclusion
Panel A: Aggregate Energy			
ENG does not Granger Cause *MANF*	2.081	0.037*	Bidirectional
MANF does not Granger Cause *ENG*	3.494	0.000*	causality
CAP does not Granger Cause *MANF*	1.444	0.148	Unidirectional
MANF does not Granger Cause *CAP*	5.211	0.000*	causality
LAB does not Granger Cause *MANF*	1.132	0.103	Zero
MANF does not Granger Cause *LAB*	1.501	1.115	causality
CPI does not Granger Cause *MANF*	3.562	0.000*	Bidirectional
MANF does not Granger Cause *CPI*	3.215	0.001*	causality
EF does not Granger Cause *MANF*	1.564	0.117	Unidirectional
MANF does not Granger Cause *EF*	4.241	0.003*	causality
Panel B: Electricity Consumption			
ELECT does not Granger Cause *MANF*	0.389	0.690	Zero
MANF does not Granger Cause *ELECT*	1.888	0.059	causality
CAP does not Granger Cause *MANF*	1.444	0.148	Unidirectional
MANF does not Granger Cause *CAP*	5.211	0.000*	causality
LAB does not Granger Cause *MANF*	3.971	0.000*	Bidirectional
MANF does not Granger Cause *LAB*	17.961	0.000*	causality
CPI does not Granger Cause *MANF*	3.562	0.000*	Bidirectional
MANF does not Granger Cause *CPI*	3.215	0.001*	causality
EF does not Granger Cause *MANF*	1.564	0.117	Unidirectional
MANF does not Granger Cause *EF*	4.241	0.000*	causality
Panel C: Fossil Energy Consumption			
FOS does not Granger Cause *MANF*	0.543	0.586	Unidirectional
MANF does not Granger Cause *FOS*	2.131	0.033*	causality
CAP does not Granger Cause *MANF*	1.444	0.148	Unidirectional
MANF does not Granger Cause *CAP*	5.211	0.000*	causality
LAB does not Granger Cause *MANF*	3.971	0.000*	Bidirectional
MANF does not Granger Cause *LAB*	17.961	0.000*	causality
CPI does not Granger Cause *MANF*	3.562	0.000*	Bidirectional
MANF does not Granger Cause *CPI*	3.215	0.001*	causality
EF does not Granger Cause *MANF*	1.564	0.112	Unidirectional
MANF does not Granger Cause *EF*	4.241	0.000*	causality

Note: * represents 5 percent level of significance

From Table 4.21, Panel A, Panel B and Panel C represent aggregate energy consumption, electricity consumption and fossil energy consumption models, respectively. In Panel A the result of Granger causality result shows that *MANF* and *ENG* Granger causes each other just as *MANF* and *CPI* cause one another. Also, *MANF* Granger causes *CAP* and *EF* as zero causality exist among *MANF* and *LAB*. It can therefore be concluded that there is a bidirectional causal relationship between manufacturing performance and energy consumption, and between manufacturing performance and corruption variable, as well as a unidirectional causality running from manufacturing performance to capital and economic freedom. On the contrary, there is no causal relationship between manufacturing performance and labour. Thus, the result maintained the neutrality hypothesis.

The result in the aggregate energy model for energy consumption and manufacturing performance in all-income groups of SSA countries replicate the findings of Ghali and El-Sakka (2004) for Canada, Tsani (2010) for Greece, Fuinhas and Marques (2012) for Portugal, Greece, Italy, Turkey and Spain, and Solarin and Shahbaz (2013) for Angola. For example, Ghali and El-Sakka (2004) use a multivariate framework that include energy, capital and labour for Canada and maintained bidirectional causality between energy use and output growth for Canada. Also, Fuinhas and Marques (2012) established a feedback relationship between energy consumption and economic growth for Portugal, Italy, Greece, Spain and Turkey.

Similarly, in Panel B, the result of Granger causality result shows that *MANF* and *LAB* Granger causes each other just as *MANF* and *CPI* cause one another. Also, *MANF* Granger causes *CAP* and *EF* as zero causality exist among *MANF* and *ELECT*. It can therefore be concluded that there is a bidirectional causal relationship between manufacturing performance and labour, and between manufacturing performance and corruption variable, as well as a unidirectional causality running from manufacturing performance to capital and economic freedom. On the contrary, there is no causal relationship between manufacturing performance and electricity consumption. Thus, the result maintained the neutrality hypothesis.

The result in electricity model for electricity consumption and manufacturing performance was explain in the studies of Masih and Masih (1997) for Malaysia, Singapore and Philippines; Mozumder and Marathe (2007) for Bangladesh; Narayan and Prasad (2008); and Ozturk and Acaravci (2011) for Middle East and North America. Taking the study of Mozumder and Marathe (2007) in examining the causal relationship between economic growth and electricity consumption, the neutrality hypothesis was maintained for Bangladesh. In addition, Ozturk and Acaravci (2011) used the ARDL-Bounds test for 11 Middle East and North African countries and established no causality between electricity consumption and economic growth.

Furthermore, in Panel C, the result of Granger causality result shows that *MANF* and *LAB* Granger causes each other just as *MANF* and *CPI* cause one another. In addition, the result showed a one-way causality running from manufacturing performance to fossil energy consumption, capital and economic freedom. Base on this, it can be concluded that there is a bidirectional causal relationship between manufacturing performance and labour, and between manufacturing performance and corruption variable, as well as a unidirectional causality running from manufacturing performance to fossil energy consumption, capital and economic freedom.

The findings in the fossil energy model and manufacturing performance in all-income groups of SSA countries were in line with the studies of Al-Iriani (2006) for Gulf Co-operation countries and Wolde-Rufael (2009) for 17 African countries.

Table 4.22
Granger Causality Result for Income Groups in SSA Countries

Null Hypothesis	***F*-Statistics**	**Prob.**	**Conclusion**
Panel A: Low-Income Group			
ENG does not Granger Cause *MANF*	2.189	0.028*	Bidirectional
MANF does not Granger Cause *ENG*	2.020	0.043*	causality
CAP does not Granger Cause *MANF*	1.247	0.212	Unidirectional
MANF does not Granger Cause *CAP*	4.904	0.000*	causality
LAB does not Granger Cause *MANF*	2.943	0.003*	Bidirectional
MANF does not Granger Cause *LAB*	10.840	0.000*	causality
CPI does not Granger Cause *MANF*	2.498	0.012*	Unidirectional
MANF does not Granger Cause *CPI*	1.351	0.176	causality
EF does not Granger Cause *MANF*	0.969	0.332	Zero
MANF does not Granger Cause *EF*	1.827	0.067	causality
Panel B: Middle-Income Group			
ENG does not Granger Cause *MANF*	0.834	0.403	Unidirectional
MANF does not Granger Cause *ENG*	2.881	0.004*	causality
CAP does not Granger Cause *MANF*	0.822	0.410	Unidirectional
MANF does not Granger Cause *CAP*	2.605	0.009*	causality
LAB does not Granger Cause *MANF*	2.695	0.007*	Bidirectional
MANF does not Granger Cause *LAB*	14.401	0.000*	causality
CPI does not Granger Cause *MANF*	2.545	0.010*	Bidirectional
MANF does not Granger Cause *CPI*	3.105	0.001*	causality
EF does not Granger Cause *MANF*	1.231	0.218	Unidirectional
MANF does not Granger Cause *EF*	4.055	0.000*	causality

Note: * represents 5 percent level of significance

Table 4.22 displayed the Granger causality result for income groups in SSA. From the table, Panel A represents low-income group in SSA as Panel B represents middle-income group in SSA. In Panel A, bidirectional causality exist between *MANF* and *ENG*, and among *MANF* and *LAB* as zero causality was maintained between *MANF* and *EF*. Thus, there is a feedback between manufacturing performance and energy consumption, and between manufacturing performance and labour, as well as neutrality hypothesis among manufacturing performance and economic freedom in low-income SSA countries. Moreover, unidirectional causality was found existing from *MANF* to *CAP* and from *CPI* to *MANF*. The result for the low-income SSA follows the studies of Jumbe (2004) for Malawi, Mahadevan and Asafu-Adjaye (2006) for 20 net energy exporting and importing countries, Bowden and Payne (2008) for US, Apergis and Payne (2010) for OECD countries, Wasseh and Zoumara (2012) and Stern and Enflo (2013) for Sweden. In the study of Bowden and Payne (2008) for US, bidirectional causality among energy consumption and economic growth was maintained b using the Toda-Yamamoto long run causality test.

Similarly, in Panel B, bidirectional causality exist among *MANF* and *LAB*, and among *MANF* and *CPI* as unidirectional causality was found existing from *MANF* to *ENG*, *CAP* and *EF*. Thus, feedback hypothesis is applied among manufacturing performance and labour, and among manufacturing performance and corruption variable. The result for middle-income SSA is in agreement with the studies of Kraft and Kraft (1978) for US; Zhang and Cheng (2009) for China; Al-Iriani (2007) for GCC countries; Wolde-Rufael (2009) for 11 SSA countries and Odhiambo (2014) for Ghana and Cote d' Ivoire.

4.5.5 Comparison Analysis between Low-Income and Middle-Income SSA Countries

Comparing low-income groups in SSA countries with the middle-income groups in SSA countries will further explain the nature of the relationship between the dependent variable and the independent variables. For example, in both the low-income and middle-income models, cointegration was maintained for the panel of SSA countries. Explaining the coefficients of the long run relationship, the findings showed positive significant relationship with manufacturing performance and energy consumption in both low-income and middle-income SSA countries. Thus, it worth concluding that energy consumption play important role in determining the performance of manufacturing sector in both low-income and middle-income SSA countries.

Furthermore, the result for capital variable maintained a positive significant relationship for both low-income and middle-income SSA countries. This explains that capital is a key factor in explaining manufacturing performance in both low-income and middle-income SSA countries. On the contrary, the result for labour variable was showing a negative significant relationship for low-income SSA countries whereas, in the middle-income SSA countries, the result was positive and significant in explaining manufacturing performance. Generally, on labour input, it can be concluded that increase in labour affect manufacturing performance negatively in the low-income SSA countries and positively in the middle-income SSA countries.

Meanwhile, for corruption variable, whereas positive significant relationship was maintained in low-income SSA countries, the reverse is the case for middle-income SSA countries. Thus, corruption may influence manufacturing performance in the low-income SSA countries. In addition, economic freedom was found insignificant for both low-income and middle-income SSA countries.

On the causal relationship, conflicting findings was established in both low-income and middle-income SSA countries. For instance, whereas bidirectional causality was established between manufacturing performance and energy consumption in the low-income SSA countries, a unidirectional causality was found running from manufacturing performance to energy consumption in the middle-income SSA countries. Moreover, the result established a unidirectional causality running from manufacturing performance to capital in both low-income and middle-income SSA countries.

Similarly, bidirectional causality is maintain among manufacturing performance and labour for both low-income and middle-income SSA countries, as neutrality hypothesis is maintained between manufacturing performance and economic freedom in low-income SSA countries. Finally, a unidirectional causality running from manufacturing performance to corruption variable was revealed for low-income SSA and from manufacturing performance to economic freedom in the middle-income SSA countries.

4.6 Conclusion

As the fourth chapter, it displayed the analysis of data and the discussions of finding. It started by describing the data and examining the correlation among the variables.

Following the descriptive statistics and the correlation matrix, the study used the Im, Pesaran and Shim panel unit root test which go along with heterogeneous autoregressive coefficients. The result of the IPS unit root test established that all the variables are stationary at first difference. Following the stationarity test, the study further moves ahead to find out whether a long-run equilibrium relationship exists between the variables using the heterogeneous panel test for co-integration. The finding maintained a long run relationship among the variables. The study further utilized the FMOLS to find the coefficient of the relationship. Following that, a panel Granger-causality tests were used to examine the direction of the causality among the variables. Similarly, under the time series analysis, the study utilized the ADF and PP unit root test to test for the stationarity properties of the data. The result of the ADF and PP unit root test established that all the variables are stationary at first difference. Following the stationarity test, the study further moves ahead to find out whether long-run equilibrium relationship exists between the variables using the ARDL-Bounds testing approach to co-integration. The finding maintained long run relationship among the variables. The study further revealed both short run and long run coefficients of the variables and finally, Granger-causality tests was used to examine the direction of the causality among the variables.

CHAPTER FIVE
CONCLUSION AND POLICY IMPLICATION

5.1 Introduction

This chapter is designed to present the summary and the conclusion of the study. It commence by introducing the entire chapter. Section 5.2 offers the summary of findings, while Section 5.3 presents the policy implications. Section 5.4 provides the limitations of the study, as Section 5.5 offers the suggestion for future research, and finally, Section 5.6 concludes the chapter.

5.2 Summary of Findings

This study is primarily set out to investigate the effect of energy consumption on manufacturing performance in SSA countries. Base on the objectives of the study, the analysis is presented in two dimensions, i.e., the panel data aspect, and the time series aspect. The analysis begins by applying the heterogeneous panel model to empirically investigate the relationship between energy consumption and manufacturing performance for the low-income, middle-income, and all income SSA countries as well as the disaggregate energy consumption for all income in the sampled SSA countries from 1995 to 2012. The study also applies the time series approach for aggregate energy consumption in the SSA countries from 1980 to 2012.

The result of the panel estimate for the first objective suggested that the variables possess co-integration in the long run for both the aggregate and the disaggregate energy models in the sampled SSA countries. Furthermore, the panel estimated result for all income groups in the aggregate energy model maintained that the effect of energy consumption, capital formation, corruption and economic freedom are significantly positive in determining manufacturing performance but significantly negative on labour input.

Also, the effect of disaggregate energy (electricity & fossil energy), capital formation, corruption variable and economic freedom are significantly positive in explaining manufacturing performance, while labour turn to be negatively related to manufacturing performance for the fossil energy model and insignificant for electricity model.

Equally important, the panel estimated result for low-income and middle-income SSA for objective three revealed co-integration among the variables. In addition, the panel estimated result for low-income and middle-income SSA suggested that energy consumption and capital formation are the determinants of manufacturing performance in low-income and middle-income groups. Similarly, labour and corruption variable explain manufacturing performance in the middle-income and low-income SSA, respectively.

Again, the time series analysis in objective two is aimed at explaining long run co-integration in addition to examining the short run and the long run coefficient. The findings establish co-integration among variables. Also, the long run coefficient explained that energy consumption and capital are the key determinants of manufacturing performance in the long run and then, in the short run, only energy determines manufacturing performance. The short run result further shows about 45% speed of adjustment to equilibrium.

The last aspect of this analysis deals with achieving the causality objective. Firstly, within the panel data analysis for the all income group in SSA countries, bidirectional causality was established between energy consumption and manufacturing performance and, corruption and manufacturing performance. Also, unidirectional causality was maintained from manufacturing performance to capital and, from manufacturing performance to economic freedom as the neutrality hypothesis was shown for labour and manufacturing performance in the aggregate energy model.

In the same way, the electricity consumption model displayed the feedback hypothesis relationship for labour and manufacturing performance and, for corruption and manufacturing performance while, unidirectional causality was established from manufacturing performance to capital and from manufacturing performance to economic freedom. Finally, zero causality is established among electricity consumption and manufacturing performance. For the fossil energy model, the result demonstrates unidirectional causality from manufacturing performance to fossil energy consumption; from manufacturing performance to capital formation and from manufacturing performance to economic freedom against, bidirectional causality between labour and manufacturing performance and, between corruption and manufacturing performance.

Furthermore, the analysis for low-income group establish bidirectional relationship among energy consumption and manufacturing performance and, among labour and manufacturing performance as well as unidirectional causality from manufacturing performance to capital and from corruption to manufacturing performance and lastly, zero causality among economic freedom and manufacturing performance in both low-income and middle-income SSA. In the middle-income SSA model, a feedback relationship was revealed for labour and manufacturing performance and, for corruption and manufacturing performance as well as, a unidirectional causality from manufacturing performance to energy; from manufacturing performance to capital and from manufacturing performance to economic freedom.

Likewise, in the time series analysis, the neutrality hypothesis was establish between energy consumption and manufacturing performance and between labour and manufacturing performance as unidirectional causality was maintained from manufacturing performance to capital formation.

Finally, from the theoretical perspective, the findings of this study justified the argument of the endogenous and biophysical theories where they argued that energy is an important factor in production process and therefore assumed a more central role in production. In addition, the findings of this study conform to the empirical studies in the field of energy economics.

5.3 Policy Implications

Having established that energy consumption, electricity consumption, and fossil energy consumption are positively related to manufacturing performance, and that the performance of the manufacturing sector depends on energy and other related inputs in both low-income, middle-income, all income groups in the sample SSA and whole SSA countries, this study recommends the following:

Firstly, the findings emphasized the importance of policies on energy both aggregate and disaggregate, on manufacturing performance. This is because electricity, fossil energy and aggregate energy are primary factors in determining manufacturing performance. Considering the fact that electricity, fossil energy and aggregate energy stimulates manufacturing performance, there is the therefore, the need to implement policies that will enhance energy supply in SSA countries, such as a policy that will remove monopoly and encourage private sector participation. Consequently, policy on energy and the restructuring of sector should meet up with the designed goal of enhancing energy consumption.

Equally important, based on the findings of the study, policies on increasing investment in energy supply to meet the region growing energy need should be provided to encourage energy consumption in SSA countries. This is in consideration of manufacturing sector heavily relying on energy input and that energy preservation policy in SSA countries can have an adverse effect on manufacturing performance and economic growth in general. In this respect, SSA countries should provide a better way of managing the region's energy resources to support sustainable economic growth. In addition, the region should expand policies on deeper regional energy cooperation to increase the reliability and affordability of energy.

Moreover, there is the need to review energy policies that will strengthen energy regulatory framework to ensure orderly development of the sector and ensure that the reviewed energy policies are enacted into law by the legislature. For example, SSA countries should adopt viable national and regional Renewable Energy Portfolio Standard (RPS) in their respective energy policies that would mandate a certain percentage of electricity to be produced by renewable energy annually. In addition, the region should adopt the Nigerian Power Sector Reform Act (2005) to enable private companies to participate in electricity generation, transmission and distribution. This is owing to the fact that majority of SSA countries are prone to unnecessary policy changes arising from changes in government.

Lastly, SSA countries should designed a program that will provide low interest loans to manufacturing firms for investment in oil conservation machineries to produce goods and services efficiently. In addition, manufacturing sector energy consumption should be subsidies to produce cheaper goods, as this will provide a better chance to compete with the world output.

5.4 Limitations of the Study

This study centered on examining energy consumption and manufacturing performance in SSA countries. Certain variables (such as emissions, energy prices and other disaggregated energy variables) that have been used in previous studies, but due to the availability of data on the variables, these variables were not considered in this study. The panel data aspect was limited to the period 19980 to 2012 due to the availability of data for long time period especially the corruption and economic freedom variables. This further limits the application of these variables to only panel analysis, as the time series analysis, required the series to have at least 30 observations.

Furthermore, the study was limited to only 9 SSA in the panel analysis due to the availability of data for all the variables employed as many countries in SSA have missing data especially data on energy and manufacturing performance. Moreover, the data employed in this study has limited the choice of using other estimations techniques such as the Generalized System of Moments (GMM) which requires a large number of the cross-section.

5.5 Suggestions for Further Research

Following the limitations of this study, the study suggests that further research should consider the following issues. Firstly, future studies should expand the coverage by making use of a more rich data set to cover the whole SSA countries as the issue of energy is not only limited to the sampled SSA countries, but rather, the whole SSA countries.

Furthermore, this study only examines energy consumption and its relationship with manufacturing performance by including labour, capital and institutional quality as the determinants of manufacturing performance, but there are other factors that determine manufacturing performance, which were not included in this study. Therefore, future research should look in to these other factors and integrated them into the relationship to see how they affect manufacturing performance. This will require a larger data set that will include all countries in SSA.

Finally, this study utilizes Pedroni panel co-integration in the panel data aspect of the research, future studies may consider other approach such as GMM to study energy consumption and manufacturing performance in SSA. Also, in the time series aspect, this study employs the ARDL model in investigating energy-manufacturing performance nexus, therefore future studies can consider using VECM model or VAR model to examine this relationship to see the reliability of the model. Besides, future research should expand the scope of this study by making a comparison with other continents in the world to see the extent to which the result differs across different continents.

5.6 Conclusion

As the final chapter, this chapter starts by summarizing the major findings of the study. Following the summary of findings, the chapter presents the policy implications for this study from which policies on energy that will enhance manufacturing performance were suggested. The study was limited to some factors, which include data availability, coverage of the study, and the methodology employed. Following the limitations of the study, the study suggested future research on data set that will cover the whole SSA countries, comparison analysis among continents and different methodology to be employed. Finally, the chapter was closed with conclusion.

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