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Electricity Consumption and Economic Growth at the state and sectoral levels in Ghana: A cointegration analysis

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ABSTRACT

This thesis examines the relationship between electricity consumption and economic growth in Ghana both at the state and sectoral level in Ghana. It considers GDP as well as the value-added of the major sectors in the economy of Ghana with the corresponding amount of electricity consumed by these sectors from 2000 to 2020. These sectors are the industry, service and agriculture sectors. The Augmented Dickey-Fuller test was used as the test of stationarity in the time series data while the Johansen cointegration test was conducted to ascertain whether there was long-run relationship among the variables. The vector autoregressive (VAR) model was used to determine the direction of causality between the variable where are the Granger causality test was used to determine whether past values of electricity consumption contained useful information in predicting economic growth in Ghana.

The findings revealed that cointegration was evident only at the state level but same could not be found at the disaggregated levels. From the VAR model, it was found that there is a unidirectional causality running from economic growth to electricity consumption in Ghana whereas no significant direction of causality was determined between economic growth and electricity consumption at the sectoral levels. The was a unidirectional Granger causality running from economic growth to electricity consumption at the state level and the services sector. This is an indication that lagged values of GDP was useful in predicting electricity consumption both at the national level and services sector. However, there was no direction of Granger causality running from electricity consumption and economic growth in the industry and agriculture sectors.

Electricity conservative practices are recommended in Ghana. This is because economic growth has been found to influence electricity consumption and not the other way round.

KEYWORDS: electricity consumption, economic growth, Granger causality, VAR model, Johansen cointegration

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The increase in the demand for electricity coupled with the desire for economic growth in Ghana has necessitated studies in this field. The role of electricity in economic growth cannot be overemphasized. In recent times, economists have conducted several studies on the relationship between energy consumption and economic growth because knowing the direction of causality between these has great implications in modeling growth policies (Appiah, 2018; Polemis & Dagoumas, 2013). In poorer countries, access to electricity has begun to grow, energy efficiency is improving, and renewable energy is making significant impact in the electricity sector (IEA, 2019). Access to electricity is considered a critical element in the achievement of sustainable development. For that matter, electricity coverage as an index of development cannot be exaggerated. The significant consumption of clean energy has been considered as an index of poverty assessment by the United Nations (UN) as it is the seventh item on the list of indices which constitute the Sustainable Development goals (SDG) of the UN (Parra et al., 2020). The SDGs is a call to action to eradicate poverty and promote peace and prosperity across the globe.

The Ghanaian economy has experienced growth over the years. This growth has been attributed to the availability of electricity for socio-economic purposes. A report published on Statista indicated that the share of the population with access to electricity in Ghana increased to 83.5 percent in 2019 as against 80.4 percent in 2018. This shows that access to electricity in Ghana has increased over the years (Doris Dokua Sasu, 2021).

1.2 Objective of the study

The focus of this thesis is to study the relationship between electricity consumption and economic growth in Ghana. This will help to determine some of the necessary factors which need to be focused on to set the country on the path of development. It will also inform policy makers on the role of economic growth in making energy policies relating to the current shortage of electricity in the country. What is the direction of causality between electricity consumption and sectoral value-added of Ghana? Does electricity consumption necessarily increase the value-added by the major sectors of the Ghanaian economy? According to the World Bank criteria, Ghana was ranked a middle-income status in 2010 after the discovery of oil. How does the increase in per capita income affect the consumption of electricity in the country?

The key sectors of the Ghanaian economy are the industry, service and the agriculture sector. The challenge of data accessibility has limited a lot of researchers to assess the relationship between electricity consumption and economic growth of Ghana only at the macro level. This has restricted the focus of many scholars to electricity consumed by the whole population and the gross domestic product of the country (Adom, 2011). However, this thesis assesses the direction of causality between electricity consumption and economic growth at the disaggregated level, considering each of the major sectors of the economy. Therefore, the policy suggestion which would be arrived at by this paper shall be focused on improving the value generated by each of the sectors under consideration.

In assessing the relationship between electricity consumption and economic growth of Ghana, the augmented Dickey Fuller test is used to test for the presence of unit root in the variables. The Johansen test is used to test cointegration between the variables. The Vector Autoregressive model is specified to determine the direction of causality while the Granger causality test is run to determine whether lagged values of electricity consumption contain some information in predicting the future values of economic growth and vice versa.

1.3 Problem Statement

Researchers have studied the causal relationship between electricity consumption and economic growth. However, the focus of these studies has been on different countries, time periods and proxy variables. Several econometric methodologies have also been used in the quest to explain this causal relationship. However, some of the empirical results of these studies have been found to confirm previous findings while others are conflicting. The variation in the outcomes could be due to the kind of causal relationship which exists, and the time-period being studied. In view of this, the conclusions of the previous literature are not enough to provide policy recommendation which could be applied across countries. Hence, most of the literature have country specific recommendations. This is to say that a suggestion which may work in one country may not fit the situation at another location.

The demand for electricity is driven by modernization, urbanization, industrialization, and improvement in general standard of living in the economy (Ali et al., 2016). Electricity consumption and economic growth have a relatively stable and positive correlation with a very small deviation if there should be any (Lin & Liu, 2016). This implies that an increase in the consumption of electricity has the tendency to support economic growth. However, energy conservation strategies could lead to increasing productivity while reducing the quantity of energy consumed. This gives an indication that the inadequate supply of electricity poses a threat to the progress of the country. No economy can develop without the significant consumption of electricity in contemporary times of which Ghana is not an exception. This is an indication that electricity is an essential ingredient to set a nation on the path of development.

1.4 Organization of study

The remaining chapters of the paper are organized in the following order. Literature review on energy consumption and economic growth is presented in chapter 2. In this chapter, relevant theorical and empirical literature is reviewed. Chapter 3 contains the data and methodology used in this study. Here, the source of data and the transformation necessary for the analysis are described. The results and discussion shall be presented in chapter 4 while conclusion and suggested policy recommendations from the study are presented in the final chapter.

CHAPTER 2

LITERATURE REVIEW

The connection between energy consumption and economic growth has been examined by several researchers. According to Ilhan Ozturk (2010), the connection between energy consumption and economic growth could be assessed from various points of view. Most empirical studies concentrate on either measuring the role of energy (electricity) in stimulating economic growth or exploring the path of causality between the two variables. It is easy to assume that the consumption of energy should positively affect economic growth (Ozturk, 2010). However, empirically, there are conflicting results about the direction of causality between electricity consumption and economic growth. Ozturk argues that researchers should focus more on new methods and perspectives rather than using the usual techniques which focuses on common variables for different countries and different time periods since this does not contribute much to the existing literature. They only succeed in merely adding up to the growing number of contradictory findings and major doubts about the reliability of policy implication on electricity.

According to Ozturk, researchers need to concentrate their efforts on new methods such as the autoregressive distributed lags (ARDL) bound test, two-regime threshold co-integration models, panel data approach, multivariate systems including new variables such as real gross fixed capital formation, labor force, carbon dioxide emissions, GDP deflator, population, exchange rates and interest rates. He also proposes that scholars should focus on the portions of the economy which is not tracked. He believes that, in this way, researchers would contribute meaningfully to the existing literature.

The main objective of researchers who focused on the link between economic growth and energy consumption is to determine the causal direction between these two variables. Some scholars identified a one-way causal relation running from energy consumption to economic growth while others have found that there is a causal relationship running from economic growth to energy consumption. On the other hand, others have also found out that there is a bi-lateral relationship between economic growth and energy consumption (Lee & Chang, 2007); (Apergis & Payne, 2009)

The type of relationship between electricity consumption and economic growth could be classified into four (Apergis & Payne, 2009); (Omri et al., 2014). The direction of the relationship has important implications for energy policy. These are:

- Neutrality hypothesis: This is sometimes referred to as no direction of causality. This suggests that there is no determinable causal relationship between electricity consumption and growth in output. Thus, there is no causal relationship between electricity consumption and real output. This implies that it is impossible to detect a realistic change in real output no matter the amount of electricity consumed. Countries which have such characteristics can promote energy conservation policies since the amount of electricity consumed has no effect on output.
- Conservation hypothesis: This is sometimes referred to as the unidirectional causality running from economic growth to energy consumption. This hypothesis is validated if there is positive relationship between energy consumption and economic growth such that the consumption of energy is determined by changes in real output. That is to say that the concept of conservational hypothesis is validated if an increase in real GDP leads to an increase in energy consumption.
- Growth hypothesis: This is sometimes referred to as the unidirectional causality running from energy consumption to economic growth. This concept is validated if there is a positive relationship between energy consumption and the change in real output such that change real output is dependent on the change in energy consumption. That is to say that an increase in the consumption of energy leads to economic growth; and the conservation of energy leads to a reduction in real output. Therefore, a country with such a characteristic may decide on the amount of energy to consume to reach a desired level of output. The conservation of energy in such an economy is a recipe to stagnate its level of output.
- Feedback hypothesis: This is also known as the bi-directional causality between energy consumption and economic growth. It implies that both energy consumption and real output are determined by each other. This is to say that both the consumption of energy and the growth in output are jointly decided and affected at the same time. Changes in the value of one affects the other in the same direction.

The above explains the possible relationships which could be concluded by our findings at the end of the study.

The Time Varying Parameter Vector Autoregressive (TVP–VAR) model with stochastic volatility was used to analyze inter-temporal dynamics between the real GDP, electricity consumption and CO_2 emission levels of Saudi Arabia from 1971 to 2010. This is a study of the time-varying pulse responses of real GDP (oil, non-oil), electricity consumption and CO_2 emissions to structural shocks which indicates that the direction of causality is dependent on the magnitude of real GDP structural fluctuations, electricity consumption and shocks in CO_2 emissions. It was realized that growth in GDP positively affects electricity consumption. A school of thought postulates that that high and low volatility regimes of real GDP, shocks in electricity and CO_2 emissions and time-varying dynamics of the relationship between real GDP, electricity use and CO_2 emissions must be considered in energy policies (Mezghani & Haddad, 2017).

Some researchers have also studied the relationship between economic growth and renewable energy consumption. The relationship between renewable energy and economic growth for BRICS countries (Brazil, Russia, India and China) was reviewed by Sebri and Ben Salha (2014) for the period 1971 to 2010. This comprises of countries from various continents. Namely South America, Europe and Asia. The characteristics of the population in these countries is such that policy recommendation which work there have the possibility of fitting a lot of other countries worldwide. The Autoregressive Distributed Lag (ARDL) cointegration test was used. The results indicated that there is a bi-directional Granger causality between variables in the BRICS countries. This implies that the feedback hypothesis was valid for these countries for the reviewed period. Here, the consumption of renewable energy was positively predicted by lagged values of growth in real GDP and vice versa. Therefore, it is valid to say that the consumption of a significant amount of renewable energy is desired to attain a targeted level of real GDP in the BRICS countries (Sebri & Ben-Salha, 2014). This confirms the role of renewable energy in boosting economic growth in BRICS countries.

The relationship between economic growth and renewable energy consumption for 12 European countries was studied by Saad and Taleb in 2018. The panel vector error correction model was applied on the available data from 1990 to 2014. The result indicated that, in the short-run, there is a unidirectional causality running from economic growth to renewable energy consumption. It was also established that a bi-directional causal relationship existed between economic growth and renewable energy consumption in the long run (Saad & Taleb, 2018). This suggests that the conservation hypothesis was valid in the short run while the feedback hypothesis was evident in the long run.

Khobai and Roux (2017) studied the causal relationship between economic growth and renewable energy for South Africa. They used quarterly data for a 24-year period from 1990 to 2014. They used the approach of Granger causality and found out that there is a unidirectional causality flowing form economic growth to renewable energy consumption in the short run (Khobai & Le Roux, 2017). From the results, the authors recommend that in the long run an appropriate and effective public policy is required to ensure sustainable economic growth and development.

Auguste Kouakou (2011) studied the causal relationship between electricity consumption and economic growth of Cote d'Ivoire using a time-series data from 1971 to 2008. Using a cointegration and Granger causality within an error correction model, a bidirectional relationship between per capita electricity consumption and per capita GDP was revealed while there was unidirectional causality running from electricity consumption to industry value added (Kouakou, 2011). In the light of this, it is reasonable to conclude that policies geared towards increasing the availability of electricity could go a long way to boost industry value added thereby charting the country on the path of economic growth.

According to the findings of some researchers, economic growth does not cause energy consumption at the global level. In examining the relationship between economic growth, carbon emission and energy consumption for 116 countries, Acheampong used the panel vector autoregression (PVAR) along with a system generalized method of moments (system GMM). He did this with data spanning 1990 and 2014. It was concluded that economic growth does not cause higher energy consumption at the global level. His finding also revealed that electricity consumption causes economic growth in sub-Saharan Africa even though it negatively causes economic growth globally (Acheampong, 2018).

Liu, Zeng et al (2020) studied the relationship between electricity consumption and economic growth of 8 industries in China using a non-linear Granger causality approach. Their focus was to detect the key causal transmission path of electricity consumption and economic growth among these industries. Quarterly data from 2007Q1 to 2017Q3 was used in this research. It was concluded that economic growth and electricity consumption was interdependent (Liu et al., 2020). This is to say that there is a bilateral causality between electricity consumption and economic growth in the selected industries in China.

Some scholars who studied the relationship between energy consumption and economic growth have also focused on the conservation of energy. Al-Mulali and Ozturk explored the relationship between fossil fuel, electricity consumption and GDP growth of six Gulf Cooperation Council (GCC) countries for the period 1980-2012. Their aim was to find out if energy conservation practices was appropriate to stimulate economic growth within these countries. In investigating this relationship, ARDL was employed. It was revealed that the consumption of energy had a long run positive effect on the growth of GDP within these countries. The growth hypothesis was valid in Omar and Qatar whiles the feedback hypothesis prevailed in Bahrain and the United Arab Emirates. There was no causality between the variables in Kuwait and Saudi Arabia. From the above, it could be concluded that energy conservation policies would not harm the economies of Kuwait and Saudi Arabia since the consumption of fossil fuel energy had no effect on economic growth. In this same light, energy conservation policies would negatively affect the economies of Omar and Qatar in the long run (Al-Mulali & Ozturk, 2014).

The relationship between electricity consumption and economic growth in Vietnam was studied using a cointegration and causality analysis. A time series data spanning 1975 and 2010 was used. It was revealed that, in the short run, there was no causal relationship running from electricity consumption per capita to GDP per capita. However, in the long run, there was causality running from GDP per capita to electricity consumption per capita (Le Quang, 2011). This implies that the neutrality hypothesis was valid in the short-run while the feedback hypothesis was applicable in the long-run in Vietnam for the period under review.

The relationship between electricity consumption and economic growth at the state and sectoral level was studied from 1960-2015 in India by Tiwari et al using heterogenous panel data methods. The panel cointegration tests with the structural break, the heterogeneous panel causality test, and the panel VAR were used in this study. Growth in the agricultural and industry sectors as well as the overall economy was studied. Using Granger causality, the findings revealed that the conservative hypothesis was valid at the aggregate state level and the industry sector while the growth hypothesis was valid for the agricultural sector (Tiwari et al., 2021). Thus, there is a unidirectional causality running from economic growth to electricity consumption at the state level and the industry sector whiles there was a unilateral causality running from electricity consumption to economic growth for the agriculture sector.

Adewuyi and Awodumi (2017); postulate that, studies on the relationship between electricity consumption and economic growth that do not look at the effect of CO_2 emissions do no add much to knowledge since electricity production is highly associated with CO_2 emission. This implies that models which attempt to explain the relationship between electricity consumption and economic growth must include the effect of CO_2 emissions to make them relevant (Adewuyi & Awodumi, 2017).

A summary of the literature review shall be presented in table 1 below.

Table 1: Summary of literature review on energy consumption and economic growth nexus (Arrows show direction of causality)

Author	**Region**	**Method**	**Finding**
Mezghani and Haddad (2010)	Saudi Arabia (1971-2010)	Time-Varying Parameter Vector Autoregressive	GDP → EC
Apergis and Payne (2009)	Commonwealth of independent States (1991-2005)	Heterogeneous panel cointegration test and corresponding error correction model	EC → GDP
Lee and Chang 2007	22 developed and 18 developing countries (1965-2002)	Panel VAR and GMM	EC → GDP
Sebri and Ben Salha 2014	BRICS countries (1971-2010)	ARDL and Granger Causality	EC ↔ GDP
Saad and Taleb 2018	12 European Countries (1990-2014)	Panel VECM	Short run GDP → REC Long run GDP ↔ REC
Khobai and Roux	South Africa (1990-2014)	Granger Causality	EC → REC
Auguste Kouakou	Cote d’Ivoire (1971-2008)	Cointegration and Granger causality	EC ↔ GDP
Acheampong 2018	116 Countries (1990-2014)	Panel VAR and GMM	Sub-Saharan Africa EC → GDP MENA EC ← GDP

Liu et al 2020	8 industries in China (2007-2017)	Non-Linear Granger causality test	EC ↔ GDP
Al-Mulali and Ozturk 2014	6 Gulf Cooperation Countries (1980-2012)	ARDL	Bahrain and UAE EC ↔ GDP Omar and Qatar EC → GDP Kuwait and Saudi Arabi EC − GDP
Le Quang Canh 2011	Vietnam (1975-2010)	Cointegration and Causality Analysis	Short run EC − GDP Long run GDP → EC
Tiwari et al 2021	India (1960-2015)	Heterogenous Panel data methods	Economy & industry EC → GDP Agriculture Sector GDP → EC

CHAPTER 3
DATA AND METHODOLOGY

3.1 Data

3.1.1 Data Sources

The focus of this study is to empirically determine the direction of Granger causality between electricity consumption and economic growth in Ghana. To achieve this, the research uses annual time series data from 2000 to 2020. Data on the amount of electricity consumed by the various sectors was obtained from the energy statistics from the energy commission of Ghana (Energy Commission, 2021) while data on population, GDP statistics and the value-added of the various sectors were obtained from the World Bank World Development Indicator database (https://databank.worldbank.org/source/world-development-indicators).

3.1.2 Data Description

The variables collected include electricity consumption by sectors in GWh; total population; Gross Domestic Product and the value-added of the three main sectors of the economy (Agriculture, Industry and services sectors) to the GDP of Ghana collected in local currency units (GH¢). The sum of the value-added by the Agricultural sector, Industrial Sector and Services sector make up the sectoral composition of GDP.

To control the effect of increase in population on the growth of the economy, we shall consider the variables in per capita terms. The value-addition of the various sectors i.e., agriculture, industry and services sectors were collected in real terms with the year 2000 as the base year. This is done to control fluctuations in inflation which has gone on over the years. Therefore, the sectoral value-added are used in the study as agriculture value-added per capita, industry value-added per capita and services value added per capita.

Electricity consumption (EC) per capita is also measured in kWh. The electricity consumed by the various sectors were collected in the same units. The table below shows a summary of the variables used in this study with their sources.

Table 2: Variables used in the study

Variable	Definition	Data Source
GDP	Measured per capita current local currency units (LCU)	World development Index from World Bank
Population	Estimates were based on the national population census.	World development Index from World Bank
Agriculture value added per capita (Agriculture VA)	Measured by per capita agriculture, forestry and fishing value added at current LCU.	World development Index from World Bank
Industry value added per capita (Industry VA)	Measured by per capita industry (including construction) value added at current LCU	World development Index from World Bank
Services value added per capita (Service VA)	Measured by per capita services value added at current LCU	World development Index from World Bank
Electricity Consumption per capita (Total EC)	Measured in kWh per capita	Energy Commission of Ghana
EC by the Residential sector (Residential EC)	Measured in kWh per capita	Energy Commission of Ghana
EC by the Agricultural sector (Agriculture EC)	Measured in kWh per capita	Energy Commission of Ghana
EC by the Industrial sector (Industry EC)	Measured in kWh per capita	Energy Commission of Ghana
EC by the Services sector (Service EC)	Measured in kWh per capita	Energy Commission of Ghana

The trend of the variables in per capita terms will be presented below in figure 1 below.

Figure 1: Trends in Variables

3.1.3 Descriptive Statistics

The average GDP per capita of Ghana from 2000 to 2020 is GH¢ 3,839 with a minimum value of GH¢140 and a maximum of GH¢13,018 which occurred in the years 2000 and 2020 respectively. The service sector recorded a higher average than the other two sectors. The services sector recorded an average of GH¢1,682 whiles the industry and the agriculture sectors recorded an average of GH¢1,172 and GH¢796 per capita respectively for the period under review.

Electricity consumption per capita for the period under review ranges from 249kWh to 531kWh. The lowest occurred in 2004 whiles the highest was experienced in 2020. On the average, 364 kWh of electricity was consumed per capita. Electricity consumed by the residential, industrial and services sectors accounted for about 42%, 41% and 16% respectively of the total consumed per capita while agriculture and transportation account for about 1% of the total electricity consumed per capita. The descriptive statistics of the variables is presented in table 3 below.

Table 3: Descriptive Statistics of Variables used in the Study from 2000 - 2020

Variable (Per Capita)	Units	Mean	Standard Deviation	Minimum Value	Maximum Value
GDP	GH¢	3838.92	4121.93	140.69	13018.45
Industry VA	GH¢	1171.95	1376.09	35.74	4515.51
Services VA	GH¢	16181.80	1824.31	40.54	5550.11
Agriculture VA	GH¢	796.45	742.21	49.62	2374.27
Total EC	kWh	364.08	79.77	248.83	531.51
Residential EC	kWh	152.44	43.30	104.97	249.68
Industrial EC	kWh	154.89	34.05	102.21	226.94
Services EC	kWh	56.12	56.12	17.04	104.24
Agriculture EC	kWh	0.27	32.97	0.07	0.66
Transport EC	kWh	0.37	0.16	0.18	0.75

Note: VA – Value Added *EC – Electricity Consumption*

3.1.4 Comparison in Electricity consumption from 2000 to 2020

There has been a positive trend in the total amount of electricity consumed in Ghana from 2000 to 2020. The portion of electricity consumed for residential purposes and the services sectors have seen a steady increase while that of the industry sector appears to be constant over time. The amount of electricity consumed by the agriculture and transportation sectors continue to be insignificant for the whole of the period under study. A pictorial comparison of this situation is shown in figure 2 below.

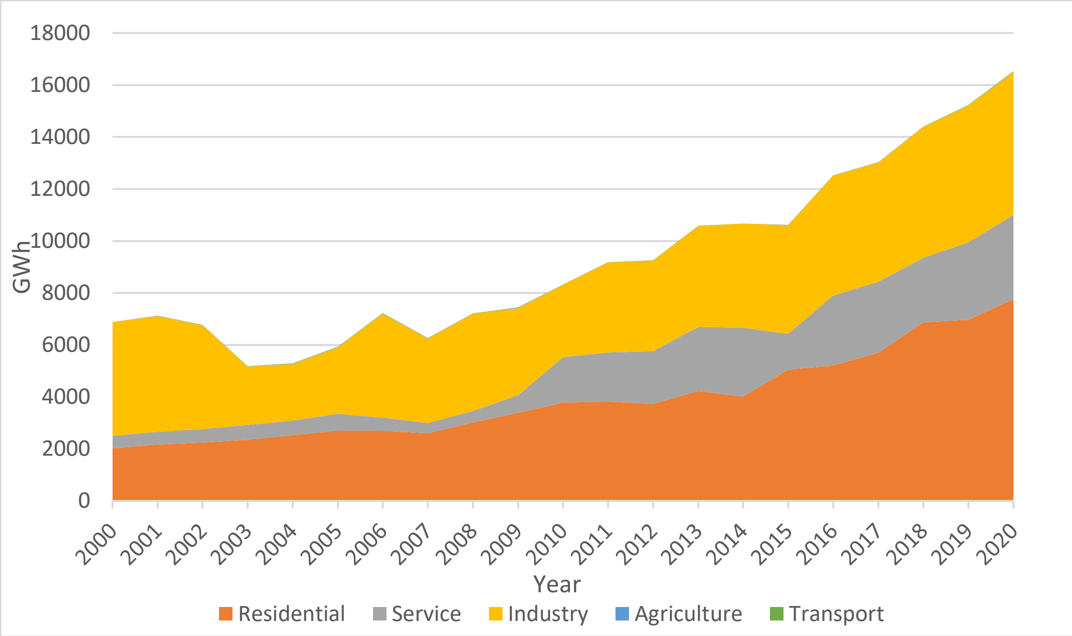

Figure 2: Trend in Electricity consumption by sectors
***Note**: Agriculture and transport are not showing because they are insignificant*
***Source**: Energy Commission of Ghana (2021)*

At the start of the period, in the year 2000, the industrial sector was the largest consumer of electricity, but this was overtaken by the residential sector by 2020. The electricity consumption share of residential sector increased from 29% to 47% while that of the industrial sector reduced from 64% to 33% even though the difference in nominal terms was just 1119 GWh. This implies that the amount of electricity consumed for residential purposes has increased drastically. Electricity consumption by the services sector also increased from 7% in 2000 to 20% in 2020. It is worthy of note that the total consumption of electricity in 2000 was 6,889 GWh whiles a total of 16,530 GWh of electricity was consumed in 2020. This is shown in figure 3 below.

The consumption of electricity by the agriculture and transport sectors appears to be insignificant. A possible explanation to this could be because the transport and agriculture sectors in Ghana are fossil fuel driven.

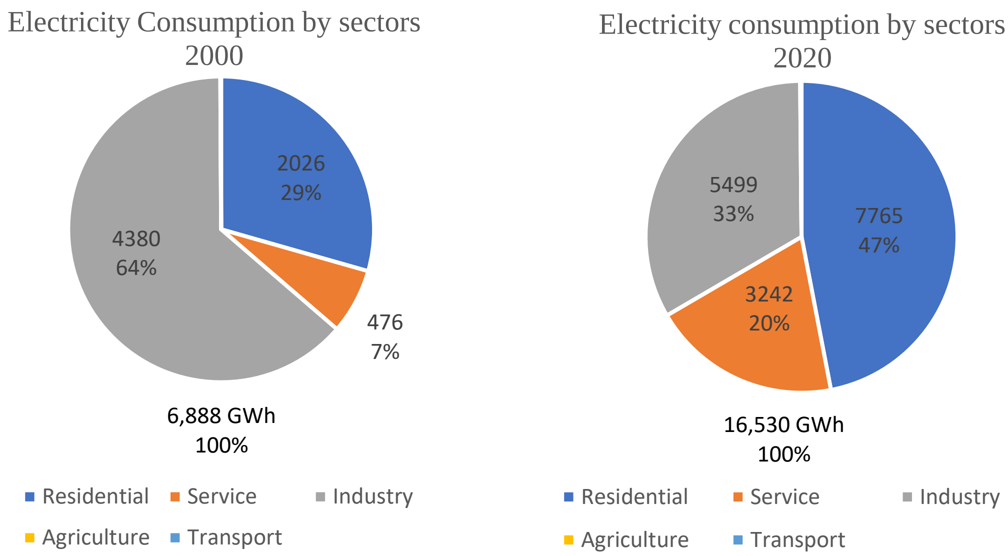

Figure 3: The share of electricity consumption by sectors for 2000 and 2020
Note*: The share of agriculture and transportation are not showing because that are insignificant for both periods*

3.1.5 Trend in Electricity Production and Consumption

The level of consumption of a commodity is dependent on the availability of the product. Over the years, there has been a positive trend in the production of electricity in Ghana. A pictorial description of the trend in electricity production and consumption in Ghana is presented in the figure 4 below.

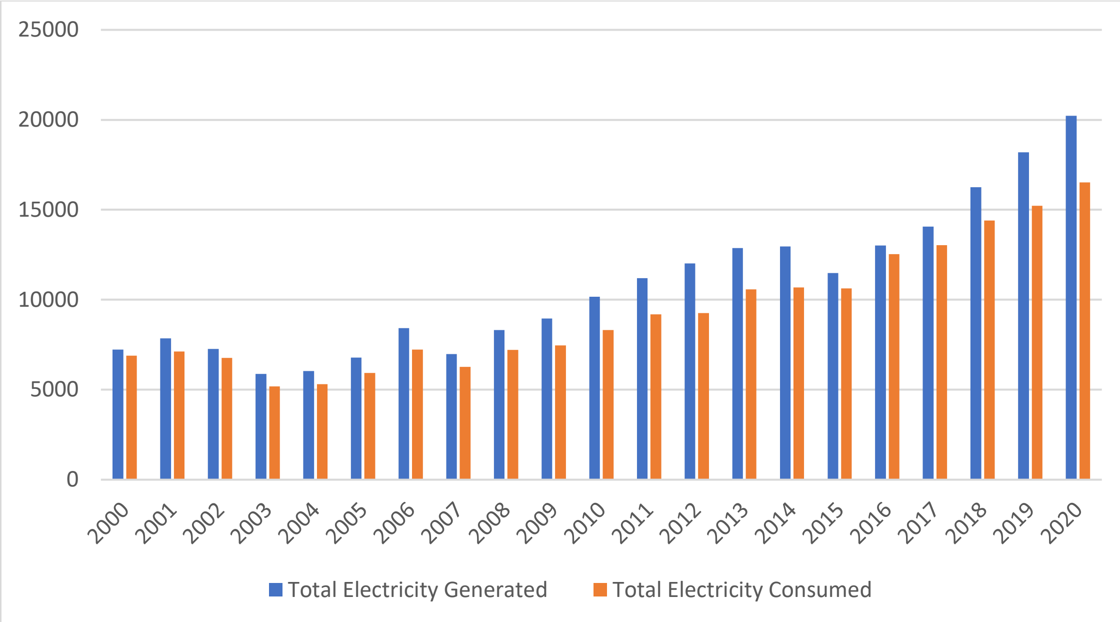

Figure 4: Trends in Electricity Generated and Consumed between 2000 and 2020

The figure above shows that the production of electricity has increased by more than 100% between 2000 and 2020. However, this journey has not been smooth due the fall in production which occurred in some periods; 2001-2004, 2006-2008 and 2014-2015. These periods of shortage in electricity production experienced a lot of blackouts which was dubbed ‘Dumsor’ which literally means ‘off-on’ in the Akan language of Ghana. This has become a household name due to the country’s frequent and unpredictable power outages. The inconsistency in electricity supply causes several loses of productive hours by over half the number of small-scale companies while the others resort to expensive generators (Kumi, 2000). The situation has since been managed with load shedding exercises.

The shortage in power generation could be attributed to the over reliance of hydroelectricity coupled with the tropical nature of the sub-Saharan region (Falchetta et al., 2019). The construction of the Bagre Dam of Burkina Faso on the upper course of the Volta River also restricts the volume of water which flows into the Akosombo Dam. The Akosombo Dam, being the largest hydropower dam in Ghana is on the lower course of the Volta River while the Bagre Dam of Burkina Faso is on the upper side of the same river. Thus, in low seasons, the Akosombo Dam tends to feed on the overflow of the Bagre Dam. This inconvenience shifted the focus to hydro-thermal mix with a greater portion of electricity being generated from thermal sources than from hydro (Asumadu-Sarkodie & Owusu, 2016).

3.1.6 Sectoral Value Added 2000 and 2020

A comparison of the share of the various sectors to GDP would give a clear representation of how the characteristics of the economy has changed over time. At the beginning of the period, the agriculture sector contributed the most to the GDP of Ghana while the service sector contributed the least. However, at the end of the period, the table turned the other way round. A pictorial description of the variation in these periods is shown in figure 4 below.

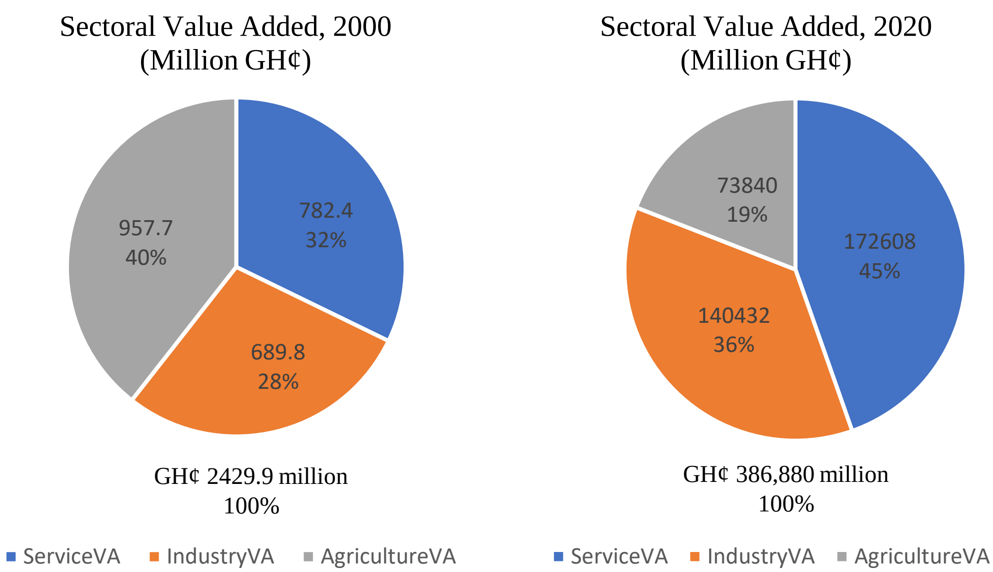

Figure 5: Share of major sectors to GDP for 2000 and 2020
Note*: The share of agriculture and transportation are not showing because that are insignificant for both periods*

In the year 2000, the GDP of Ghana was GH¢ 2,429.9 million. Out of the total, the agriculture sector contributed 40% which amounts to GH¢957.7 million; the services sector contributed 32% and the industrial sector contributed 28% to the GDP of Ghana. A country characterized by such figures could be described as an agrarian economy since the agriculture sector contributes the most to GDP. However, in 2020, with a total of GH¢ 386,880 million, the agriculture sector, services and manufacturing sectors contributed 19%, 36% and 45% respectively to the GDP of the country.

Thus, in this year, services value-added alone contributed almost half of the country's GDP. This is seen pictorially in Figure 4 above.

This clearly shows that the characteristics of the economy has changed drastically from 2000 to 2020. The tertiary sector is now the major contributor to GDP which has become a major concern of many economists (Sultan, Muyed 2008). The contribution of the service sector increasingly dominated the GDP of many countries on their path to development. In the light of this can we empirically conclude that Ghana is developing? Could the growth in the services sector emanate from an increase in electricity consumption?

3.2 Methodology

This section of the paper describes the methodology used in this study. The Autoregressive distributed lag (ARDL) testing procedure is adopted in this study. We shall begin by testing for stationarity using the Augmented Dickey Fuller unit root test. The Johansen Cointegration test would be used to test for cointegration among the variables. The Vector Autoregressive (VAR) model is specified to determine the direction of causality between electricity consumption and economic growth. Finally, the Granger causality test would be used to access the long-run relationship between the variables.

3.2.1 Test of Stationarity

In testing for unit root, the study uses the Augmented Dickey Fuller unit root test. This test is to ascertain the fact that the lagged levels of the series are unable to provide relevant information in predicting changes in the variables. A series which exhibits the characteristic of mean reversion has no unit root and it is stationary. A non-stationary series has a high tendency of being spurious. The effects of shocks in stationary series fade with time. Thus, they are temporal and eventually revert to its mean level. A non-stationary series has permanent components and does not exhibit mean reversal characteristics. This implies that the statistical properties of the data changes with time. A time series data with features of non-stationarity is not reliable and cannot be used for relevant statistical analysis. The null hypothesis states the presence of a unit root. Therefore, the inclusion of a variable in a time series is dependent on the rejection of the null hypothesis.

The Augmented Dickey Fuller unit test is specified by the following model:

$$\Delta Y_t = \beta_1 + \delta Y_{t-1}. + \sum_{i=1}^{m} a_i \Delta Y_{t-i} + u_i$$

Where Y_t is the series of interest at time *t*; *m* is the lag length necessary to get white noise; *Δ* is the first difference operator and u_i is assumed to be the error term which is generated through white noise process with zero mean and constant variance.

H_0: $\delta = 0$

H_1: $\delta < 0$

The null hypothesis is rejected if the absolute value of the calculated t-values is greater than the ADF critical value. This implies that a unit root exists in the time series.

3.2.2 Johansen Cointegration Test

Most time series data contain a unit root, but a liner combination of two or more nonstationary series may be stationary. Nonstationary series are said to be cointegrated if a linear combination exists. This linear combination can be used to specify a long-run relationship among variables (Engle & Granger, 1987). In this paper, a cointegration analysis propose by Johansen and Julius (1990) is used to examine whether there is a long run association between electricity consumption per capita and economic growth. The test is used to determine the number of cointegrating vectors that describe the relationship between variables. Most of the time, the number of cointegrating equations is equal to the number of endogenous variables.

The hypothesis tested by the Johansen cointegration test is that:

H_0: no cointegration: cointegration index < 5% critical value

H_1: cointegration exist: cointegration index > 5% critical value

A rejection of the null hypothesis shows the presence of cointegration and evidence of a long-run relationship. However, this is not enough to determine the course of this relationship.

The results from the cointegration test helps us to specify the vector autoregression (VAR) and perform further causality test.

3.2.3 Vector Autoregressive Model

A vector autoregression (VAR) model is derived through the stochastic process which is used to capture the relationship between multiple variables as they change over time. In this model, each variable has an equation which models its evolution over time. The VAR model is constituted by the variables own lagged values, the lagged values of the other variables and an error term.

A VAR model is constructed only when the variables are integrated of order one. This implies that the variable should be stationary after first difference. All the variables in a VAR system are endogenous. This model is characterized by the number of lags used in the model. A bivariate VAR model is specified in the equation below.

$$LEC_t = A_1 + \sum_{i=1}^{p} B_i LEC_{t-i} + \sum_{i=1}^{k} C_i LGDP_{t-i} + u_{1t}$$

$$LGDP_t = B_2 + \sum_{i=1}^{p} D_i LEC_{t-i} + \sum_{i=1}^{k} E_i LGDP_{t-i} + u_{2t}$$

From the equation above, EC and GDP are electricity consumption and Gross Domestic Product respectively. With respect to the various sectors, these represent electricity consumed and their corresponding value-added respectively. The *u*s represent white noise error terms which are referred to as impulses or innovations or shocks in the language of VAR (Gujarati, 2015).

3.2.4 Granger Causality Test

This thesis uses the Granger causality test to figure out whether data of electricity consumption is useful in predicting growth in the various sectors of the Ghanaian economy and vice versa.

The Granger causality test is used to determine the predictive power of one variable on another. This approach is used to determine whether the lagged values of one time series is contains valuable information in forecasting another. A statistical relationship cannot logically imply causation. In other words, a simple regression is inadequate to logically imply causation between variables. Therefore, a theorical consideration must be made to ascribe causality. The underlying theory of regression in a single-equation model indicates how much a dependent variable will change by varying the quantities of some factors. It is possible for time series data to move simultaneously. This relationship is shown a bivariate regression in the equation below:

$EC_t\left(GDP_{t-p}\right) = b_0 + b_1 EC_{t-p} + b_2 GDP_{t-p}$

$GDP_t(EC_{t-p}) = b_0 + b_1 GDP_{t-p} + b_2 EC_{t-p}$

The Granger causality test is examined on the premise that:

$H_0: b_2 = 0$

$H_1: b_2 \neq 0$

A rejection of the null hypothesis is a confirmation of Granger causality. Hence the lagged values of the time series contain enough information in predicting the value of the other variables.

Granger causality is a test of the ability of one time series to predict the future values of another variable. The use of the term "causality" is misleading as this econometric test focuses on the predictive power rather the usual meaning of the term "cause". Granger causality test whether one time series can forecast another. This is to say that Granger causality test is not a test of causality in the traditional meaning of the word "causality". The traditional definition of causality is the relationship between cause and effect.

CHAPTER 4

RESULTS AND DISCUSSIONS

This section of the paper contains the findings of all the statistical tests conducted in this study. The statistical data shall be presented in a systematic and intuitive manner. Considering the objectives and the nature of the time-series data used in this study, I shall start with testing for the presence of the unit root using the Augment Dickey-Fuller procedure; move on to test for integration among the variables; specify Vector Autoregressive model and then move on to the Granger causality test to ascertain whether the lagged values of electricity consumption could predict the value generated by the main sectors of the Ghanaian economy and vice versa.

4.1 Unit Root test

The Augmented Dickey-Fuller (ADF) procedure is the unit root test for stationarity used in this study. The result of the ADF test is presented in table 3 below.

Table 4: ADF Unit Root test of the log of variables at level and first difference

Variables	Level		1st Difference	
	Without Trend	With Trend	Without Trend	With trend
GDP	-1.837	-1.051	-4.401	-4.941
	(0.362)	(0.937)	(0.000)	(0.000)
Agriculture VA	-2.791	-1.291	-3.820	-4.761
	(0.060)	(0.890)	(0.003)	(0.001)
Industry VA	-0.761	-1.520	-3.498	-3.424
	(0.830)	(0.822)	(0.008)	(0.048)
Services VA	-1.683	-1.168	-4.301	-4.707
	(0.440)	(0.917)	(0.000)	(0.001)
Total EC	-0.237	-2.543	-4.170	-4.761
	(0.934)	(0.307)	(0.001)	(0.001)
Industry EC	-2.745	-2.639	-4.083	-4.317
	(0.067)	(0.262)	(0.001)	(0.003)
Agriculture EC	-2.040	-2.006	-4.560	-4.416
	(0.269)	(0.598)	(0.000)	(0.002)
Services EC	-0.923	-2.183	-4.163	-4.044
	(0.780)	(0.499)	(0.008)	(0.008)

Source: Author's computation using Stata 16.0 *NB: Figures in parenthesis are p-values*

The table above shows the results for the stationarity test using the Augmented Dickey-Fuller procedure. The results show figures of ADF test for the variables both at level and first difference. It also shows that the upward trend in the variables is significant. It is evident that all the variables in the model are non-stationary at level. However, the null hypothesis of no unit root for all the variables is rejected at the 5% level of significance. Therefore, we conclude that all the variables are stationary at first difference and that they are integrated of order one. This is an indication that the points in the time series can neither be modelled nor predicted.

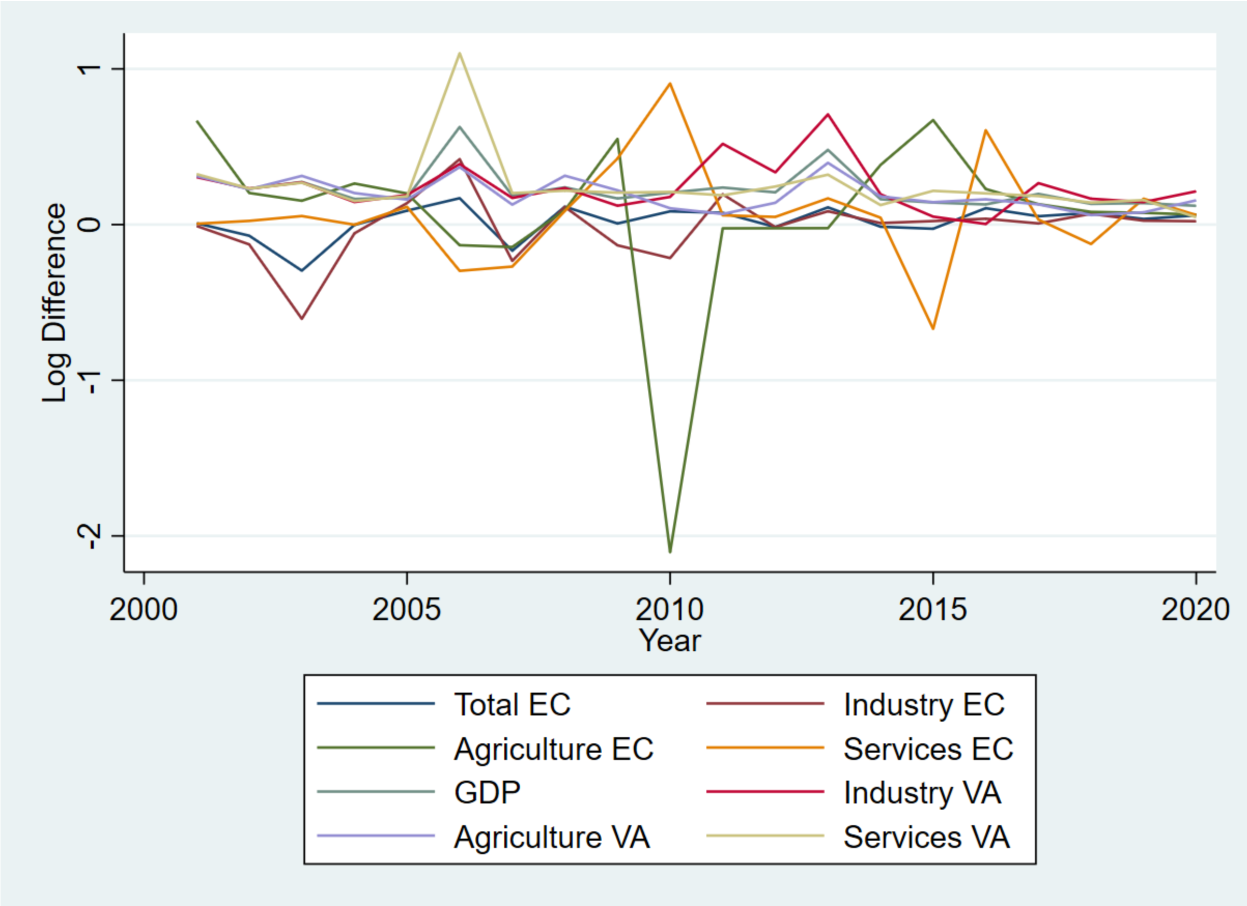

Figure 6: First Difference of the log of variables

A graph of the first difference of the variables exhibiting mean reversal characteristics is presented in figure 9. This implies that there is stationarity at the first difference of the log of the variables. Agriculture EC increased from 9kWh to 16kWh from 2008 to 2009 and it sharply dropped to 2kWh in 2010. The figure remained constant for three years and increased gradually to 12GWh in 2020. It is quite surprising how the figure in 2008 appears to be higher than that of 2020.

4.2 Electricity Consumption and GDP at the state level

This section of the paper shall consider the relationship between electricity consumption per capita and GDP per capita of Ghana from 2000 to 2020.

4.2.1 Cointegration between Electricity Consumption and GDP

Given that both electricity consumption and GDP are integrated of order one, we shall move to test whether there exists a long-run relationship between these two series. As afore mentioned, cointegration is used to confirm the existence of long-run relationship between variables. The Johansen cointegration test requires us to determine the optimal lag length in order to proceed to the cointegration test. The optimal lag length for annual data is usually 1 or 2 (Wooldridge, 2015) which was confirmed by the Akaike's, Hannan-Quinn and Schwarz Bayesian information criteria. The results of the Johansen cointegration test are presented in table 5 below.

Table 5: Johansen Cointegration Results at the State Level

No. of Cointegrations	Max-Eigen Statistics	5% Critical value	Trace statistics	5% critical value
None	19.29	15.41	13.93	14.07
At most 1	5.35	3.76	5.35	3.76

Source: Author's computation using Stata 16.0

The Johansen cointegration test above shows results for the situation where there is no cointegration and when there is at most one cointegrating equation between the variables at the state level.

Testing the hypothesis when the rank of integration between per capita electricity consumption and per capita GDP is zero, the maximum Eigen statistics of 19.29 is greater than the critical value of 15.41 at 5%. In this case, we reject the null hypothesis of no cointegration between the variables. The trace statistics of 13.93 is less than the 5% critical value of 14.07. In this situation the max and the trace statistics contradicts the rejection of the null hypothesis of no cointegration at the 5% level of significance.

Next, we shall test the hypothesis that the rank of cointegration is at most 1. Here, the value of the max statistics and the trace statistics are the same. Given that the cointegrating index of 5.35 is greater than the critical value at 5%, we reject the null hypothesis that there is no cointegrating relationship between GDP and electricity consumption. A combination of the test results implies that there is a cointegrating relationship between GDP per capita and Electricity consumption per capita in Ghana from 2000 to 2020. Thus, there exist a long run relationship between the variables and for that matter they can be combined in a linear fashion. Shocks in the short run will affect movement in GDP per capita and electricity consumed per capita but they will converge in the long run.

To statistically determine the direction of causality we shall proceed to conduct the causality tests on these variables.

Table 6: Results from VAR at the Macro Level

	Lag 1	Lag 2
Per capita GDP causes Per Capita	-0.32	0.39
electricity consumption	(0.030) **	(0.005) ***
Per capita electricity consumption	0.27	-0.43
causes per GDP	(0.38)	(0.11)

Source: Author's computation using Stata 16.0

*Note: ** statistically significant at 5%, *** statistically significant at 1%*

Number in parenthesis are p-values

The figures from the VAR test results indicate that causality runs from GDP per capita to electricity consumption per capita in Ghana at a 5% and 1% for the first and second lags of electricity consumption per capita respectively. This implies that we can reject the null hypothesis of no causality running from GDP to electricity consumption per capita.

With respect to the direction of causality running from electricity consumption to GDP per capita, the VAR test result shows that there is no direction of causality. Thus, the VAR test result fails to reject the null hypothesis of no causality running from electricity consumption to GDP per capita.

We shall move on to conduct the Granger causality test to find out if lagged values of either electricity consumption or GDP can predict the other.

Table 7: Results of Granger Causality Test at Macro Level

Direction of Granger causality	Granger Causality Wald Test	Decision
Per capita GDP Granger causes Per Capita electricity consumption	30.57 (0.000) ***	EC → GDP
Per capita electricity consumption Granger causes per capita GDP	2.71 (0.258)	GDP - EC

**** statistically significant at 1% level*

Number in parenthesis are p-values

The results from the standard Granger causality test shows a Wald test statistic of 30.57 with a p-value of 0.00 indicating that the null hypothesis of no causality running from GDP per capita to electricity consumption per capita is rejected at 1% level of significance. This implies that lagged values of GDP can predict future values of electricity consumption per capita in Ghana.

Considering the direction of Granger causality from electricity consumption to GDP per capita, a Wald test result of 2.71 with a p-value of 0.258 implies that we fail to reject the null hypothesis in this situation. This implies that lagged values of electricity consumption are not capable of predicting lead values of GDP per capita.

In the light of this, we conclude that there is unidirectional Granger causality running from GDP to electricity consumption per capita in Ghana.

4.3 Electricity Consumption and Industrial Value-Added

This section of the paper will consider the direction of causality between electricity consumed in the industrial sector and the sectorial value-added of the same. The variables to be considered are industrial electricity consumption per capita and industry value-added per capita in Ghana from 2000 to 2020.

4.3.1 Cointegration between Industry EC and Industry VA

From the results of the ADF test in table 4, we realized that the data on both electricity consumption by the industry sector and the industry value added were stationary at first difference. This is to say that both of these time series are integrated of order 1 at 5% level of significance which is a requirement for the Johansen cointegration test. With an optimal lag length of 2, we shall proceed to conduct the Johansen test of cointegration.

Table 8: Johansen Cointegration Test in the Industry Sector

No. of Cointegrations	Max-Eigen Statistics	5% Critical value	Trace statistics	5% critical value
None	14.049	14.07	14.994	15.41
At most 1	0.945	3.76	0.945	3.76

Source: Author's computation using Stata 16.0

The results from the Johansen cointegration test shows the situation where there is no cointegration and the situation where there is at most one cointegration. The maximum Eigen statistics of 14.049 is less than the 5% critical value of 14.07. This implies that the null hypothesis of no cointegration cannot be rejected. The trace statistics of 14.994 appears to also be less than the 5% critical value of 15.41 which implies that the null hypothesis cannot be rejected here as well.

Considering the case where there is at most one cointegration among the variables, the maximum Eigen statistics appears to be the same as the trace statistics. Therefore, the cointegrating index of 0.945 which is less than the 5% critical value of 3.76 indicates that the null hypothesis can be rejected. This implies that there is no cointegration between per capital electricity consumption in the industry sector and the per capita industry value added in Ghana for the period 2000 to 2020.

Therefore, we shall proceed to perform VAR test to check if we can determine a direction of causality among the variables.

Table 9: VAR test results in the Industry Sector

	Lag 1	Lag 2
Per capita Industry VA causes per	-0.12	0.16
capita Industry EC	(0.575)	(0.456)
Per capita Industry EC causes per	-0.17	-0.05
capita Industry VA	(0.427)	(0.784)

Source: Author's computation using Stata 16.0
Note: Numbers in parenthesis are p-values.

The results from the VAR test shows that there is no direction of causality between industry EC and industry value-added in the short run at all levels of significance. With respect to the direction of causality from industry VA per capita to per capita industry EC, there is no significant direction between these two variables. Both the first and second lags of industry VA are incapable of significantly predicting a variation in the per capita industry EC in the short run.

Table 10: Granger Causality Test in the Industry Sector

	Granger Causality Wald Test	Decision
Per capita Industry VA Granger causes per capita Industry EC	3.40 (0.182)	Industry VA - Industry EC
Per capita Industry EC Granger causes per capita Industry VA	1.49 (0.476)	Industry VA - Industry EC

Source: Author's computation using Stata 16.0

Note: Numbers in parenthesis are p-values

The results of the Granger causality test show the Wald test statistic of 3.40 with a p-value of 0.18 implying the null hypothesis of no Granger causality running from per capita industry VA to industry EC per capita cannot be rejected. Hence lagged values of per capita industry VA are incapable of predicting future values of industry EC per capita in Ghana.

With respect to the direction of Granger causality running from per capita industry EC to industry VA, a Wald test statistic of 1.49 with a p-value of 0.478 implies a rejection of the null hypothesis. This implies that lagged values of per capita industry EC are not capable of predicting lead values of industry VA per capita.

In conclusion, there is no Granger causality running from industry VA and industry EC per capita in Ghana. Hence the neutrality hypothesis is evident in the industry sector of Ghana.

4.4 Electricity Consumption and Services Value-Added

In this section of the paper, we shall talk about electricity consumption in the services sector. Here we shall consider the services value added and electricity consumed in this sector for the period 2000 to 2020.

4.4.1 Cointegration in the Services Sector

The ADF test result in table 4 shows that services VA and services EC are both integrated of order 1 at the 5% level of significance. Assuming a lag length of 2, we shall proceed to conduct the Johansen cointegration test on these variables to examine whether a long-run relationship exists among these variables.

Table 11: Johansen Cointegration Test in the Services Sector

No. of Cointegrations	Max-Eigen Statistics	5% Critical value	Trace statistics	5% critical Value
None	7.57	14.07	10.71	15.41
At most 1	3.14	3.76	3.14	3.76

Source: Author's computation using Stata 16.0

The Johansen cointegration test result in table 11 shows the case where there is no cointegration and the case where there is at most 1 cointegrations between Services VA and Services EC in Ghana. In the case of no cointegration, the maximum Eigen statistics of 7.57 is lower than the 5% critical value of 14.07. The null hypothesis of no cointegration cannot be rejected in this situation. The trace statistics 10.71 is also lower than the 5% critical value of 15.41. The result of the trace statistic confirms that of the Max Eigen. Hence the null hypothesis cannot be rejected here.

In the case where there is at most 1 cointegration equation, the maximum Eigen and the trace statistics are equal. The cointegration index of 3.14 is less than the 5% critical value of 3.76. This is an indication that the null hypothesis of no cointegration between the variables cannot be rejected. This is an indication that there is no long run relationship between electricity consumption and the service value added per capita.

Table 12: VAR test in the Services Sector

	Lag 1	Lag 2
Per capita Services VA causes per capita Services EC	-0.324 (0.304)	0.501 (0.107)

Per capita Services EC causes per capita Services VA	0.016 (0.922)	0.026 (0.575)

Source: Author's computation using Stata 16.0
Note: Figures in parenthesis are p-values

The results of the VAR test show the direction of causality between the Services EC and Services VA and vice versa with their first and second lags. With Services EC, both lags 1 and 2 do not show any significant direction of causality to Services VA. This implies that the per capita electricity consumption in the services sector is unable to cause significant changes in the per capita services VA in Ghana.

With respect to the direction of causality between Services VA and Services EC, the VAR test shows that there is no direction of causality running from services VA to electricity consumption in the services sector.

Table 13: Granger Causality Results

	Granger Causality Wald Test	Decision
Per capita Services VA Granger causes per capita Services EC	8.65 (0.013)	Services VA → Services EC
Per capita Services EC Granger causes per capita Services VA	0.12 (0.943)	Services VA - Services EC

Note: Figures in parenthesis are p-values

Table 13 is the Granger causality test result between Services VA and Services EC per capita. On one hand, a Wald test score of 8.65 with a p-value of 0.013 shows that there is Granger causality running from services VA to services EC per capita. On the other hand, a Wald test score of 0.12 with a corresponding p-value of 0.943 implies that there is no Granger causality running from services EC to services VA. Thus, there is a unilateral Granger causality running from services VA to services EC. This implies that lagged values of services VA are capable of predicting future values of services EC in Ghana.

4.5 Electricity Consumption and Agricultural Value Added

Here, we shall discuss the direction of causality between agricultural value added and electricity consumed in the agricultural sector. The variables to be considered are the agriculture value added per capita and the electricity consumed in the agriculture sector per capita of Ghana from 2000 to 2020.

4.5.1 Cointegration between Agriculture VA and Agriculture EC

The ADF test results in table 3 shows that both Agriculture VA and Agriculture EC per capita are stationary at first different ie they are both integrated of order 1 at 5% level of significance. We shall proceed to the Johansen cointegration test with an optimal lag length of 2.

Table 14: Johansen Cointegration Test result

No. of Cointegrations	Max-Eigen Statistics	5% Critical value	Trace statistics	5% critical Value
None	7.67	14.07	10.92	15.41
At most 1	3.25	3.76	3.25	3.76

Source: Author's computation using Stata 16.0

The Johansen cointegration test in Table 14 shows the situation where there is no cointegration and at most one cointegration between Agriculture VA and Agriculture EC in Ghana for the period under review. In the case of no cointegration, the max Eigen statistics of 7.67 is smaller than the 5% critical value of 14.07. The null hypothesis of no cointegration between the variables cannot be rejected in this case. The trace statistics of 10.92 is also lower than the 5% critical value. Which implies that the null hypothesis cannot be rejected here as well.

In the case where there is at most one cointegration among the variables, the max Eigen statistics value is equal the trace statistics which is 3.25. The cointegration index appears to be lower than the 5% critical value. This means we cannot reject the null hypothesis in this situation as well.

Table 15: VAR test result in the Agriculture Sector

	Lag 1	Lag 2
Per capita Agriculture VA causes	0.547	-0.54
per capita Agriculture EC	(0.698)	(0.685)
Per capita Agriculture EC causes	-0.015	-0.053
per capita Agriculture VA	(0.676)	(0.127)

Source: Author's computation using Stata 16.0

Table 15 shows the VAR coefficients for the first and second lags of the variables under consideration. Considering the direction of causality from Agriculture VA to Agriculture EC per capita, the first lag had a coefficient of 0.547 with a p-value of 0.70 while the second lag had a coefficient of -0.54 with a p-value of 0.69. This is an indication that there is no causality running from agriculture EC to agriculture VA. Thus, changes in the value of electricity consumed in the agriculture sector is unable to cause significant changes in agriculture VA per capita.

With regards to the direction of causality from Agriculture EC to Agriculture VA per capita, the first lag had a coefficient of -0.015 with corresponding 0.68 p-value whiles the second lag had a coefficient of 0.053 with a 0.13 p-value. This implies that there is no significant direction of causality running from Agriculture EC to Agriculture VA per capita as well.

Table 16: Granger Causality in the Agriculture Sector

	Granger Causality Wald Test	Decision
Per capita Agric VA Granger	0.21	Agric VA - Agric EC
causes per capita Agric EC	(0.90)	
Per capita Agric EC Granger	2.89	Agric VA - Agric EC
causes per capita Agric VA	(0.24)	

Source: Author's computation using Stata 16.0

The Granger causality test results shows that there is no Granger causality running from agriculture EC to agriculture VA and vice versa. Thus, lagged values of agriculture EC cannot predict future values of agriculture VA and the lagged values of agriculture VA are also incapable of predicting lead values of agriculture EC in Ghana.

4.6 Discussion of Findings

This section of the paper links the findings of the study to its objectives as well as to relevant literature to properly assess the situation in Ghana based on data collected from 2000-2020. The quest to increase accessibility to electricity has a desired effect on economic growth and development. Improving upon the quality of life and alleviating poverty are the primary aims of nations on their quest to development (Ngo & Nguyen, 2020). However, all things being equal, the effect of increased electricity production may not be adequately felt if the demand by the population grows at the same rate or faster than the growth in electricity production. In the light of this, the study considers per capita values of the variables used in the research. In accessing the relationship between electricity consumption and economic growth in Ghana both at the national and the disaggregated level, data on total electricity consumed and a breakdown into the major sectors of the economy were collected. GDP data and the contribution of the various sectors to the Ghanaian economy were also collected for the same period under review. All these were converted to per capita terms so that the effect of the population growth could be controlled.

The Johansen Cointegration test revealed that a long run relationship existed between GDP per capita and electricity consumption per capita. The direction of the relationship was examined using the VAR test. This showed that there was a unidirectional causality running from GDP per capita to electricity consumption at a 5% level of significance. The Granger causality test confirmed this case implying that lagged values of GDP per capita has a potential to determine the lead quantity of electricity consumed in the country. This implies that the conservation hypothesis is valid in the case of Ghana. This indicates that increasing the consumption of electricity in Ghana has no significant improvement on GDP per capita. Thus, policies geared towards energy conservations would not harm the economy of Ghana. A similar situation was realized in the case of Saudi Arabia, Vietnam, Middle East and Northern Africa (Mezghani and Haddad, 2010; Le Quang Canh, 2011; Acheampong, 2018) but contradictory to the case of the Sub-Saharan African study conducted by Acheampong in 2018.

Electricity has the potential to enhance the productivity of other factors of production. Energy appears to be the single most important input which drives the other factors of production (Apergis & Payne, 2009). Therefore, the adequate consumption of this commodity has the potential of improving the efficiency of other inputs of production. Given the release of greenhouse gas (GHG) emissions associated with the consumption of fossil fuel, this study considers the use of electricity in Ghana. In contemporary times, it is nearly impossible to do without electricity. One of the objectives of this study is to determine whether data on electricity consumption has the potential of affecting the economic growth of Ghana both at the macro and the disaggregated level of the Ghanaian economy or vice versa. We also want to find out if the growth in GDP has a significant effect on the consumption of electricity or whether electricity consumption drives economic growth in the Ghanaian setting.

The result of this study has proven that there is a unidirectional Granger causality running from GDP to electricity consumption in Ghana. A possible explanation to this is the fact that, the agriculture sector contributes significantly to GDP but consumes an insignificant amount of electricity in the country. The agriculture sector contributes about 20% to the GDP of Ghana but accounts for less than 1% of total electricity consumed in the country. Therefore, given the asymmetric growth in GDP in relation to electricity consumption could be a tangible explanation to the situation in Ghana.

Following the target of the first Millennium Development Goal, Ghana achieved a considerable reduction in poverty. In 2011, with a little increase in income disparity, Ghana was able to reduce its poverty rate by half. Considering the poverty threshold of $1.90 per day, Ghana's poverty rate was 13.3% amounting to about 3.5 million people living in extreme poverty with a majority of these people living in the rural areas (Doris Doua Sasu, 2021). The concentration of poor people in Ghana is within the Volta and the Northern regions. However, the rate of poverty fell from 76% to 45.2% between 2005 and 2016. This appears to be lower than the Sub-Saharan African's average poverty rate and also lower than the average poverty rate among middle-income countries (Group, 2019). With these statistics coupled with the fact that the conservative hypothesis is evident in the case of Ghana, it is valid to say that most people living in Ghana tend to spend on their basic needs i.e., food, shelter, clothing, rather than on electricity powered appliances when their incomes increase. Perhaps, electricity powered appliance might be considered as luxury goods to most people.

Economic growth has the potential to increase the real income of individuals and households to the extent that the demand for electricity intensive items could be created. In other words, an increase in GDP per capita could be a driving force to an increase in the consumption of electric powered appliances such as televisions, computers, mobile phones, food processors, refrigerators, washing machines, air conditioners, etc. Generally, an increase in GDP leads to an increase in the consumption of normal good. Households tend to spend more on normal goods when their income increases. Given the unidirectional Granger causality running from GDP to electricity consumption per capita, it could be inferred that people in Ghana tend to spend of energy saving appliances as income increases.

Moreover, the increase in the demand for energy saving appliances is a driving forces to an increase in the production of same. Hence the need to increase the supply of electricity to match the increasing demand for these gadgets. Blackouts are inevitable when the demand for electricity exceeds its supply. In the light of this, the production of electricity should be increased to match the increasing demand for electricity powered appliances.

The first difference of the log of industry VA per capita and electricity consumed in the sector are integrated of order 1. The results from the Johansen cointegration test indicated that there was no cointegration between industry VA and industry EC. The VAR test shows that there is no direction of causality running from industry VA to industry EC and vice versa. Thus, these variables could not be combined in a linear fashion. The Granger Causality Wald Test reinforces this that there is no Granger causality running from industry VA to industry EC per capita in Ghana. This implies that lagged values of industry VA per capita cannot predict future values of industry EC in Ghana. This is an indication that problems associated with power supply has no effect of industry VA in Ghana. It can also be inferred from the result that industry VA does not determine how much electricity is consumed in the sector. The neutrality hypothesis is evident in the industry sector of Ghana. A similar situation could be seen in the case of Kuwait and Saudi Arabia (Al-Mulali & Ozturk, 2014). Same could be mentioned of Vietnam (Le Quang Canh 2011).

The industry sector of Ghana is an energy intensive one. It is dominated by micro and small firms which are privately owned and mostly located in urban areas such as Accra, Tema, Kumasi, Takoradi, etc. Since the independence of Ghana, the industry sector has been dominated by the manufacturing sector which is gradually being taken over by the mining and quarrying sectors. This due to the discovery of oil and gas along the shores of the country (Ackah, et al, 2014). The validation of the neutrality hypothesis in the industry sector of Ghana is an indication that growth in the industry sector cannot be attributed to the consumption of electricity. It can rather be inferred that production in the industry sector of Ghana is mostly driven by other forms of energy other than electricity.

The ADF test in table 4 indicates that services VA and services EC are non-stationary and integrated of order 1. The Johansen cointegration test shows that there is no cointegration between services VA and services EC in Ghana. The VAR test shows that there is no direction of causality running from services VA and services EC per capita. However, the Granger causality test shows a unilateral Granger causality running from services VA to service EC per capita. This implies that lagged values of services VA can predict services EC per capita in Ghana but not the other way round. This is an indication that the conservative hypothesis is evident in the services sector of Ghana. The conservative hypothesis is seen to be evident also in the case of Saudi Arabia (Mezghani & Haddad, 2017). It is also seen in the long run situation of Vietnam (Le Quang Canh 2011).

The services sector contributes the most to the GDP of Ghana. It contributes about 44% of GDP and employs about 49% of the labour force (World Bank, 2020). Banking services and telecommunication form the main components of the services sector. The emergence of mobile phone technology and the need for internet connectivity has lead to the expansion of the telecommunication industry in Ghana. Given that the conservation hypothesis is valid in this sector, an increase in the consumption of electricity does not necessarily increase the output of sector. That is, energy conservation practices have proven not to negatively affect the earnings in this sector. This assertion is in line with reality as the production of energy saving appliances is on the rise.

In the agriculture sector, economic growth per capita and electricity consumption per capita are non-stationary at first difference. The Johansen cointegration test also shows that there is no long-term relationship between the consumption of electricity and the economic growth in this sector. The VAR test also shows that there is no causality running from agriculture EC to agriculture VA and vice versa. This is not surprising as the amount of electricity consumed by the agriculture sector appears to be insignificant in the case of Ghana. The Granger causality test reinforces this as the lagged values of agriculture VA are incapable of determining agriculture EC and vice versa. The neutrality hypothesis is evident in this case as well.

About 30% of the workforce in Ghana are employed in the agriculture sector. According to the FAO, arable lands make up about 57% of the country's land area. Most of the cultivated lands in Ghana is made up of small and medium-sized farms. Energy is an important input in agriculture. Fuel or electricity is used directly to operate machinery and equipment, lighting, heating, and the preservation of agricultural produce. In poultry for instance, electric bulbs are used to provide heat in keeping coops warm for day-old chicks. Electricity is also used in operating incubators in the process of hatching eggs. Refrigerators and freezers also ran on electricity in the preservation of agricultural produce. Some crop farmers also use electricity in operating water pumping machines in irrigating their farms. One major drawback to the use of electricity in the agriculture sector in Ghana is the unreliable and costly supply of electric power as well as the financial deficit of the sector (USAID, 2020).

A summary of the findings is shown in table 17 below.

Table 17: Summary of Findings

Sector	Johansen Cointegration	VAR	Granger Causality
State	Yes	GDP → EC	GDP → EC
Industry	No	GDP - EC	GDP - EC
Service	No	GDP - EC	GDP → EC
Agriculture	No	GDP - EC	GDP - EC

CHAPTER 5
CONCLUSION AND RECOMMENDATION

6.1 Summary and conclusion

This study examined the relationship between electricity consumption and economic growth in Ghana both at the state level and disaggregated level using the Granger causality approach. The Johansen cointegration test was used to assess the long run relationship between the variables. It focused on the direction of causality between electricity consumption and economic growth. Some of the research questions this paper seeks to answer include whether the attainment of the middle-income status of Ghana has contributed to an increase in the consumption of electricity in Ghana.

The findings showed that at the macro level, the conservation hypothesis was valid. This implies that there is a unidirectional causality running from GDP per capita to electricity consumption per capita. Hence, the attainment of middle-income status of Ghana has lead Ghana to adopt more energy conservative practices.

The neutrality hypothesis was valid in the industry and agriculture sectors. The implies that the consumption of electricity had no significant effect on the growth of these sectors. It is also noted that growth in these sectors do not significantly affect their consumption of electricity in Ghana.

In general, it is appropriate to say that relying on energy conservation technologies could be beneficial to the economy of Ghana since the consumption.

6.2 Recommendation

The outcome of this study has proven that electricity conservation practices would not harm the economy of Ghana. Based on this, it is recommended that policy makers should focus on making energy conservation attractive to the various sectors of Ghanaian economy especially the services sector. This is because the services sector contributes the most to GDP. Given that the services sector in Ghana appears to be electricity intensive, it is prudent to say that efficient usage of electricity should be encouraged rather than just its conservation to ensure economic growth. The prices of electricity efficient appliances could be subsidized to make them desirable.

The findings from this study also showed that there was no Granger causality running from economic growth to electricity consumption in the industry and the agriculture sectors of Ghana.

This probably means that other forms of energy are being used in these sectors given that they are energy intensive. With consideration to the environment and greenhouse gas (GHG) emissions, I recommend that the industry and the agriculture sectors should be encouraged to increase their consumption of electricity while cutting down on the usage of fossil fuels. Electricity should be made available at affordable prices to these sectors so that economic agents would adjust their behaviour on energy usage to increase their consumption of electricity.

Other scholars could investigate the direction of causality between the consumption of the other forms of energy and economic growth of Ghana as this study focused only on electricity. The Generalized method of moment (GMM) approach could also be used in future research to confirm or refute the conclusions arrived at by this paper.

6.3 Limitations

Granger causality as used in this study refers to the predictive power of one variable to forecast another but not in the traditional meaning of the word "causality". One major drawback of the bivariate Granger causality approach is the omitted variable bias (Lean & Smyth, 2010). This has brought about the lack of consensus among scholars on the Granger causality approach. As a result, several Granger causality studies examining the relationship between aggregate output and energy (electricity) consumption have begun to incorporate other important factors such capital and labour. These were not considered in this study on the grounds of data availability as there is not much information on capital and labour for the various sectors of the economy of Ghana which was the focus of this study.

It is worthy of note that this research could be improved on the grounds of data availability. Hence, the research was limited to the relationship between electricity consumption and economic growth in Ghana with consideration to the available data.

6.3 Policy implication

Electricity conservation practices should be encouraged since the amount of electricity consumed does not necessarily lead to economic growth in Ghana. The validity of the conservation hypothesis in Ghana is an indication that increasing the consumption of electricity does not necessarily promote economic growth. Therefore, restricting the consumption of electricity will not harm the economy of Ghana however its efficient usage should be encouraged. Energy saving technologies should be encouraged to promote the efficient used of electricity in Ghana.

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