IOSR Journal of Economics and Finance (IOSR-JEF)
e-ISSN: 2321-5933, p-ISSN: 2321-5925. Volume 12, Issue 1 Ser. I (Jan. – Feb. 2021), PP 23-36
www.iosrjournals.org

Energy Consumption and Performance of Manufacturing Sector in Kenya

Edwin Gwaro Ototo
[1](School of Economics/ Kenyatta university, Kenya)

Dr. Charles Nzai
[2](Lecturer, School of Economics/ Kenyatta university, Kenya)

Abstract:
Kenya's manufacturing sector contributes 70% of the industrial sector production with the combined contribution of construction, building and quarrying outputs to the remaining 30%. Kenya Vision 2030 The country's economic plan recognizes the manufacturing sector as one of the fundamental pillar of sustainable annual GDP growth of 10% Manufacturing is among the pillars President Uhuru Kenyatta listed in his 'Big Four Agenda 2018-2022' that will aid in facilitating economic growth in the country. The policy makers plan to increase the contribution of the manufacturing sector to GDP from an approximate existing 8.5 percent to a projected 15 percent according to the goals of the Big 4 Agenda. Numerous problems, however, hinder the results shown by the decline in the sector from 9.6% in 2011 to 9.2% in 2012. While the rate of growth decreased from 3.4% in 2015 to 3.1% in 2016.
Energy plays critical role in manufacturing. It is utilized on production process thus efficient consumption of energy reduces the cost of doing business. The study`s main objective is to investigate the effect of energy consumption on performance of manufacturing in Kenya. The study's specific goals are : To determine effect of renewable energy consumption on manufacturing sector and evaluate effect of non-renewable energy consumption on manufacturing sector and decompose the effect of energy consumption on performance.
The research project will use a non-experimental research method to evaluate economic models. The research will utilize secondary data sources to gather relevant information to achieve our analysis aim and address the research gap while employing a multivariate time series regression model. The study used annual time-series data from the period 1980 to 2019. All relevant time-series tests were performed.
In line with the analysis the result suggested that energy consumption has both bidirectional positive effects to manufacturing performance. Energy is one of the components in production output. A share of renewable energy consumption as a technology has higher effect to performance as opposed to no renewable. More emphasis to address efficiency energy systems and perfect energy market regime policy need to be in place.
***Key Word**: Non-renewable energy, consumption, Renewable energy, Trade openness, off-grid technologies, auxiliary power*

Date of Submission: 28-12-2020 Date of Acceptance: 09-01-2021

I. Introduction

1.1 Background of the study

Energy consumption effects on performance of manufacturing firms has raised debates amongst researchers in the discipline of energy economics and sustainable development on green energy. However, its importance in present-day policy techniques in strength economies is taking a different path starting from evolving to growing economies. Moreover, increase in diver stating impact of non-renewable electricity, the decrease in existing endowment strength sources for energy production, the search for alternative power assets and using those new assets also influence the causal dating between power intake and manufacturing performance to economic growth. (Ghosh, 2002)

According to Raza, Jawaid and Siddiqui (2016) energy is key input in production especially in the current industrial revolution and the manufacturing sector being the largest consumers of the green energy. Subsequently, increase in economic welfare and development may additionally induce the use of more electricity. Industrialization and urbanization may lead to extensively utilization of energy in different form during production set up, domestic level and huge national development projects.

Since energy has evolved since the advent of fossil fuel to current renewable technologies which is a key ingredient for manufacturing sector and development for any country is driven by output and innovations from manufacturing, it improves performance and output productivity of a given sector in the economy. The intensive industry, urban and population growth has elevated utilization of power, especially inside the growing countries increasing demand. Nevertheless, uncertain causal relationship and the direction of the causality among energy utilization along with sustainable development (Chang, 2010). Further increased three dimensions of sustainable development — economic, social, and environmental — underline that sustainable development strategies should focus primarily on structural changes in consumption and output with a view to boosting support for rational use of natural resources, reducing income polarization, and boosting economic competitiveness

Renewable energy is generated from non-fossil sources that is naturally substituted on a human scale, i.e., wind, sunlight, water, rain, and stream heat from geothermal wells. Devolved and distributed renewable energy systems provide huge potential to achieve the instantaneous energy demands of remote organizations, companies, and households (Wanjiru & Ochieng, 2013). Despite government efforts under the rural electrification programme, high costs and low-income link among the huge percentage developing countries citizen such as Kenya exacerbate low access to energy. (Love, 2014). The cost of connecting a household in the rural areas (rural electrification), for example, is estimated at an average of $ 40 US dollar per KWH as opposed to discounted useful life installation and maintenance cost of min grid solar generating systems of $5 per US dollar KWH (Kiplagat, Wang & Li, 2011).

The economy has extensive renewable energy resources endowment classified as best solar belt, highest velocity of wind intensity, biofuel, biogas, largest geothermal resource, and hydropower the utilization of the resources has been limited. (Mwakubo et al., 2007) renewable growth is characterized by rising demand, increased electricity prices, increasing global fossil fuel costs, and environmental activism. Oil and electricity accounts for about 22.0 percent and 9.0 percent, respectively. In Kenya, energy faces challenges of high reliance on biogas, inaccessibility to clean and sustainable source of power, intermittent supply, poor hydroelectric dependency as well as high dependence on imported fuel. Exploitation of renewable sources to the overall energy mix is therefore vital means of addressing the bottle necks of increasing demand with associated environmental strain.

As of 2010, the installed electricity capacity in Kenya was approximately 1,412.2MW, according to (Kimuyu, et al, 2012). Such generation capacity for power is less than effective demand hence could not meet demand. Thus, to bridge the gap, the initiative by the government to procure additional auxiliary power to the system to satisfy the increasing demand and load-shedding reduction especially during peak moments. The leading source of hydroelectric power is 51.55 percent of the aggregate installed capacity. Thermal (petrol), geothermal, co-generation, and wind contribute respectively 33.1 percent, 13.39 percent, 1.83 percent, and 0.37 percent. In total, renewable sources of energy accounts for about 67.1 percent, and Kenya's production of electricity is now predominantly' green'. In 2017, around 9.52 billion kWh of electricity consumed. In general, renewable energies accounted for about 72.7% of actual total consumption in 2016, which dropped to 72.1% in 2017.

Non-renewable resource does not regenerate itself in meaningful human time frames at a reasonable pace for sustainable economic extraction. A case in point is carbon-based, renewable coal. In presence of heat and pressure, the initial organic material becomes a fuel i.e. oil or gas. According to the International Energy Agency (IEA, 2012), gas and oil reserves (non-renewable energy) production will drop by 2030 to about 40-60%. Wanjiru and Ochieng (2013) have estimated that by 2050 the supply of non-renewable energy will be limited.

Furthermore, Huntington (2009) noted that this form of energy use was often susceptible to disturbances caused by major world events such as conflict, monopoly activities (e.g. OPEC3) and generally more dependent on net oil producing countries ' political stability. In 2016, coal consumption was 1.25 MT, which in 2017 rose further to 1.37MT in 2017, oil consumption dropped to 1.24 billion tons compared to 1.25 billion tons in 2016.The results in Figure 1.3 revealed that there has been a general increasing trend in the contribution of nonrenewable energy to the manufacturing sector. It increased from 28% in the year 1980 to 78% in the year 2016.

1.2 Statement of the problem

Kenya's manufacturing sector contributes 70% of the industrial sector output with the cumulative contribution of mining, real estate, and construction accounting for 30% combined. Vision 2030 Economic Development Blueprint recognizes the manufacturing sector as key drivers to achieve a sustained 10 percent GDP growth per year part from other. The sector's contribution to GDP, however, declined from 9.6% in 2011 to 9.2% in 2014, while the growth rate declined from 3.4% in 2015 to 3.1% in 2016. (KIPPRA, 2017). The sector is characterized with instability and volatility which the research project seeks to address with policy recommendation on energy consumption.

There has been a general decline in contribution of renewable energy to manufacturing sector in Kenya. For example, the electricity accounted for approximately 74 percent of actual total consumption in 2014 but reduced to 72.3 percent in the year 2015. It later reduced to 71 percent in the year 2016. In addition, there has been an inconsistent trend of contribution of non-renewable energy to manufacturing sector. For example, contribution of oil to manufacturing sector in the year 2015 was 9.54. However, the value declined to 4.75 in 2016 but recorded increase to 4.83 in 2017. The reduction in contribution of renewable as well as non-renewable energy to manufacturing sector is said to be causing the poor performance of the manufacturing sector (Kenya Association of Manufacturers, 2019). Therefor presenting three conflicting school of thoughts causality about production growth and consumption of energy, renewable vis –a vis non-renewable consumption to manufacturing performance, and bi-directional link between the two.

1.3 Research Objectives

1.3.1 Main objective

The main objective of this study is to investigate the effect of energy consumption on performance of manufacturing sector in Kenya

1.4.2 Specific objectives:

The specific objectives of the study are:

i. To determine effect of renewable energy consumption on manufacturing sector in Kenya.

ii. To determine effect of non-renewable energy consumption on manufacturing sector in Kenya.

1.5 Justification

The research project aims in strengthening manufacturing firm’s policy intervention by providing information on renewable and non-renewable energy efficiency models and how they can embrace them to gain a competitive edge both at a local and global level.

Study of energy consumption in developing countries such as Kenya is an important component of integrated energy planning and policy. Planners and policy makers gain insights of the factors that affect growth and energy trends before they can proceed with future demand forecasts. Considering the capital intensity and long gestation periods of energy projects, supply difficulties and insufficient technologies for energy shortages, comprehensive energy demand studies need to be conducted at both aggregate and sectoral level.

Current study provides information useful by the government of Kenya and other stakeholders in knowing areas that they can support the manufacturers in embracing energy efficiency. The study will also help scholars to improve their literature on renewable besides non-renewable energy consumption and its effect on manufacturing sector performance additionally provide further guidance in filling in the gaps on further studies.

1.6 Scope

The research project scrutinizes the effect of use of renewable as well as non-renewable energy on Kenya's performance for manufacturing sector. For several reasons, the study will limit to the period 1980-2020. First, time series data is available for this period and this period is believed to be long enough to capture the association among renewable and non-renewable energy utilization on manufacturing sector achievement.

II. Literature Review

2.1 Theoretical literature

The study will examine relevant theories that are related to energy consumption as input and production output theories showing patterns of consumption relating to sectorial performance case study of manufacturing sector.

2.2.1 Theory of the Firm:

Firm's theory is the micro-economic concept based on neoclassical economics, which claims that a business unit exists with a sole objective to maximize profits. Manufacturing sector in the economy exist to maximize their output and profit contribution to the GDP. In these theories the firm also is endogenous in microeconomics. In addition, there is claim that other factors will affect pricing, production, jobs, and all other supply side (MC) and demand side (MR) variables does not falsify the marginalized approach in these theory

Indeed, the performance of the firm will be depending on the technology employed for production to optimize the contribution to the economy which is depicted by the production function. Employed firm technology must assess the cost of production that creates demand. Firm seeks to follow this goal of balanced growth, subject to two major constraints: technological and financial the technological constraint is set by the availability and efficiency of the affordable energy for production.

2.2.1.1 Production function

Production function express relationship of inputs technically combined give output provide in equation 2.1.

Y = f (K, L, R) α …………………………………………………….………… 2.1

Where Y represents Manufacturing firms' output, K refers to capital units used in the manufacturing process; this could be assets, machinery and stock, L represents the amount of labor (people and skills), and R represents the quantity of raw inputs in the production of the output (Y). The raw materials include the renewable as well as non-renewable energy being production factors. (Varian, 2006).

The firm's goal aims at maximizing profit, either optimizing output i.e. increasing Y produced or carrying out production at minimal cost-effective manner. The output function indicates the optimal output produced using inputs of labor (L), raw material (R) and capital (K) combinations. Y referred as the total physical product (TPP). An input's marginal physical product (MPP) defined as extra output produced by utilizing additional input unit holding other inputs constant. The return to scale demonstrates production output reaction with changes in inputs level which may be constant, decreasing or increasing (Varian, 2006).

The relationship of output can be expressed in various forms for example linear, polynomial, and functional form of Cobb-Douglas. In 1928, Cobb and Douglas developed this feature to describe the relationship between output, labor, and capital. Cobb Douglas (1928) found that production was an equation of labor supply and linked capital.

Y = f (K, L) α ………………………………………………………….……… 2.2

Where Y is production, K is capital and L is Labor

Current study examines the effect of consumption of renewable and non-renewable energy on manufacturing sector performance in Kenya. Therefore, renewable(R) and non-renewable (NR) energy will also be a function of manufacturing sector performance contribution to gross domestic product (GDP).

Y = f (K, L, R, NR) α.……………………………………………….……. 2.3

2.2.1.2 Isoquant

"An isoquant is a curve that displays all possible combinations of inputs that are physically capable of yield a given output level," says Ferguson. At the level of the manufacturing firm, renewable or non-renewable energy will be used the sector as energy input to maximize its level of production give a certain level of technology. Isoquant functions are shown as

Max (Q) =f (K, L) ………………………………………………………………. 2.4

Q: Quantity produced /output, K: Input capital quantity, L: Input labor quantity

The manufacturing sector makes a choice to consume any set of combination of renewable with non-renewable energy to produce output. The theory identifies isoquants in different forms, i.e., linear, convex, and concave. For convex and concave isoquants, the marginal rate of technological sustainability between inputs and technologies, i.e., renewable, and non-renewable, produces a declining return while linear isoquants have total replace ability in production inputs and constant scale returns.

In Kenya, environmental activist campaigns for the use of renewable energy despite the country being endowed with coal. The demand for renewable energy is high however the technology faces new challenges of the volatility and stability of the source of the energy. As the level of technological knowledge rises, efficiencies in inputs transformation and output changes as level of technological expertise increases. Because of increased technological progress in the energy sector, greater quantities or better quality of production can be generated for consumption (Kotze, 1970)

2.3 Empirical literature

Kahia, Aïssa and Charfeddine (2016) studied on economic growth effect of use of renewable and non-renewable resources. Research project adopted a multivariate panel framework. Finding on panel error correction model exhibited short-run also long-run bidirectional and unidirectional causality from economic growth to renewable energy use, respectively. Furthermore, results demonstrate bidirectional causality between the consumption of non-renewable energy and economic growth both in the short and long run. In addition, there are several measures and policies that need to be implemented by the authorities to advocate usage of clean and sustainable energy, such as the establishment of several important regional institutions and cooperation, renewable energy generation tax credits and rebates. This study adopted panel data methodology while the current study will adopt time series.

Nevertheless, the Granger carbon emissions cause long-term energy consumption. The lack of long-term causality between income and carbon emissions from Granger provides evidence that carbon emissions are lowered by both the US and Turkey without ignoring economic growth. Applying the boundary checking to the protocol of co-integration in a multivariate model of carbon emissions, electricity usage, income, and international trade. The short-term viewpoint shows the transition to a new paradigm of energy (renewable), while the long-term view refers to the studied factors ' long-term equilibrium. Results show that the patterns of GDP and Renewable Energy Consumption (REC) are independent in the short term.

A research on effect of renewable energy on economic growth and CO2 emissions was conducted by Silva, et, al (2012) using a SVAR approach. The study examined how a growing proportion of clean energy on Electricity Generation (RES-E) affects GDP and emissions from Carbon Dioxide (CO2) using a 3-variable Structural Vector Autoregressive (SVAR) approach. Presence of unit roots has been checked to deduce the variables ' stationarity. the SVAR calculation showed that the growing RES-E share had per capita GDP costs for all countries in the study, apart from the USA. There was also a noticeable decline in per capita CO2 emissions. It was the major contributor to Nigeria's Gross Domestic Product (GDP) as well as the main foreign-exchange source. Nevertheless, the nature of Nigeria's external trade changed dramatically from the mid-1970s (the oil boom period) and upwards when crude oil succeeded in taking the place of conventional agricultural produce as the key source of government revenue

(Tiwari, 2011) conducted a study on renewable and non-renewable energy sources ' comparative impact for European together with Eurasian countries ' economic growth and CO2 emissions: a PVAR approach. In a panel setting, the analysis examined RES and NRES ' relative performance on economic growth in European and Eurasian countries. In relation to CO2 emissions, the dynamics of these variables were also studied. The research used the PVAR method to evaluate for the period 1965 to 2009 and found that NRES growth rate had a negatively impacted on GDP growth rate as well as increased CO2 emissions. RES ' effect on the GDP growth rate is generally found to be positive. The study recommended reducing NRES consumption to achieve higher economic growth, increase economic productivity and employment in Europe and Eurasian countries with a safe and sustainable climate. The study was carried out in Europe and Eurasia, while the current study will be carried out in Kenya.

Research study on econometrics modeling of renewable energy sources with economic growth was performed by Ntanos et al (2018): data from European countries. Study used combination of descriptive statistics, cluster analysis and autoregressive distributed lag (ARDL) resulting to variables being correlated; this indicates link of GDP as dependent variable with Renewable Energy (RES) and Non-RES energy consumption, gross fixed capital creation and long-term labor force. Addition, results showed a higher association between RES consumption and higher GDP countries ' economic growth than those of lower GDP. The study focused only on renewable sources of energy while the current study focuses on renewable and non-renewable sources of energy. The complex relationship between Foreign Direct Investment (FDI), non-oil exports and GDP using the principle of variance decomposition and stimulus response analysis showed that policy shocks to FDI, non-oil exports and Economic growth did not react in the desired direction immediately.

Onuonga (2008) conducted a study in Kenya's manufacturing sector on an econometric analysis of energy use. This research modelled the trans log function to evaluate total factor specifications with inter-fuel replacements. It was measured in two phases. The study finding indicated energy price, cross price, production, technology, capital price, and unexpected shocks had an impact on energy consumption. The results for the inter-fuel model showed that in the Kenyan manufacturing sector demand for electricity and oil were substitutes also inelastic to price. Fuel cross price elasticity obtained was low but statistically significant. Few options for replacement between electricity and oil have been identified in this market. Recommendation that totals cost shares of the factor illustrated that energy demand and labor was price inelastic on the other hand unitary elasticity for capital. However, those of resources, labor and capital were substitutes, but the degree of substitution was found to be very small among the variables. Onuonga (2008) failed to link the energy utilization with manufacturing sector performance.

(Miranga, 2011) dissertation on review of household energy choices in Nairobi sub counties, in Kenya using descriptive statistics, data were analyzed. The research findings were that in the choice of household resources, income and education play a key role. The study recommended that the policy intervention on tax cuts and holiday for petroleum products, especially commonly utilized liquefied petroleum gas for cooking and illuminating kerosene for lighting, to make it affordable to households. The study was carried out in Nairobi with a sampled data which might not be reflective of energy consumption at the nation level.

Kiplagat, Wang and Li (2011) conducted a study on Kenya's renewable energy: potential resource and exploitation status. Notable high reliance on traditional form of energy wood biomass hence leading to a supply and demand imbalance according to the study. Considerable strain on the remaining forest and plant stocks, speeding up land degradation processes. Amidst numerous challenges of rural connectivity to electricity grid, has made deliberate progress towards universe access to clean energy. With the new energy Act 2019, Kenya partially liberalized energy sector at distribution level to enhance efficiency by opening to competition. Country's energy mix comprise 80% renewable sources in electricity grid. Significant proportion of renewable energy, however, the price per Kwh is expensive. For potential renewable sources, approximately 30% for country's reserve from hydropower is about 4% of potential geothermal production, and much smaller proportions of wind and solar potential have been harnessed. The study focused only on renewable sources of energy while the current study focuses on renewable and non-renewable sources of energy.

Kasae (2014) conducted a study of Kenya's manufacturing companies ' energy efficiency and operational performance. Dataset analyzed with respect to baseline and current data. The baseline data been the data before implementation of EEMs by the companies while the current data been the data collected in after implementation of EEMs. The data was analyzed using regression model. To test the relevance of the linear best-fit curve for energy consumption, production and SEEI, the Pearson correlation coefficient for both baseline and current data were examined. The study established a considerable use of EEMs by Kenya`s manufacturing firms with 92 percent of the targeted firms having implemented EEMS. finding depicted a positive link between the use of EEMs and the efficiency of the project. This finding was not definitive, however, as some companies showed low correction coefficients of the variables at both the baseline and the current level indicating further research.

(Gitone, 2014) researched on renewable energy adoption determinants in Kenya. The study used bivariate probit model to account for interdependence in adoption decisions. However, the results indicated that decisions to adopt solar and biogas are independent. The research therefore used different probit equations to examine the effect on the adoption of both solar and biogas of household head characteristics, household characteristics and economic factors. The result revealed that household heads with secondary and post-secondary education and household size significantly influence adoption of solar energy while gender and the size of the family have a significant explanation on biogas adoption. Current study focused only on renewable sources of energy while the current study focuses on renewable and non-renewable energy.

2.4 Overview of literature

Silva, et, al (2012) performed an impact analysis on economic growth and Carbon Oxide emissions from renewable energy sources — a SVAR method. The study focused on only one type of energy which is renewable energy thus presenting a contextual gap. The current study will focus on renewable and non-renewable energy consumption. Tiwari (2011) carried out an analysis on the comparative effect of renewable and non-renewable energy sources on developed economies of Europe's and Eurasian countries ' economic growth and Carbon oxide emissions: A PVAR approach. The study was carried out in Europe and Eurasian countries thus presenting a scope gap. The current study will be conducted in Kenya.

Ntanos et al (2018) conducted a study in European countries on renewable energy and economic growth. The statistical analysis was based on analysis of cluster and a methodological gap was posed by autoregressive distributed lag (ARDL). Onuonga (2008) conducted a study on Econometric Analysis of Energy Utilization in the Kenyan Manufacturing Sector. Study utilized trans log model in scrutinizing total factor demands and inter-fuel substitution thus presenting a methodological gap. The current study employs a non-experimental research design which will use economic models for analysis. Furthermore, empirical study had a research gap that links the consumption of energy to the manufacturing sectorial performance.

III. Methodology

The chapter contains research methodology. It begins with describing research design employed; theoretical framework suggested and concludes with definition of variables and their measurement.

3.1 Research Design

The research intends to utilize non-experimental research approach to examine with quantitative time series data using economic models. For the period 1980-2017, time series data set for the following variables will be analyzed: GDP, renewable, non-renewable, energy prices, labor as well as trade accessibility. The design is advantageous in that researcher can deduce the casual and explanatory relation between consumption on renewable and non-renewal energy consumption on manufacturing performance.

3.2 Theoretical Framework

3.2.1 Production model

According to theory of the firm production function, output is related to various inputs and may be expressed

$$Y = f(A, K, L) \quad \text{……………………………… ……………} \quad 3.1$$

Where Y is production, K is capital and L is Labor, A is efficiency parameter.

This study will adopt Cobb-Douglas production function that will guide the development of empirical model with a top-down analysis of energy demand. Cobb and Douglas introduced this function to clarify the relationship between production output, labor inputs and capital inputs with productivity of the technical factor (technology level) Cobb-Douglas production function is generally expressed.

$$Y = AL\alpha K\beta \text{……………………………………………………….3.2}$$

Where α and β are share of labor and capital with a constant return to scale.

$$\alpha + \beta = 1 \text{ ……………………………………………………………3.3}$$

3.3 Model specification and Estimation

According to production function, exploring the role of labor growth as an input of production in terms of population growth, manufacturing performance measured as real GDP growth, with changes in relative fuel prices affected demand for energy. The production function will be derived from section (3.2) it will be used as the baseline function for our model specification.

$$Y = A^* L\alpha {}^* K\beta \text{…………………………………………………3.4}$$

Using OLS after logarithmic transformation, we can estimate the total factor productivity and measure how efficiently the inputs are utilized.

$$\text{Log } Y^* = \log A^* + \alpha \log L^* + \beta \log K \text{…………………………3.5}$$

We endogenous our model, where Labor (population) enters the model tautological relationship between labor and aggregate demand for energy consumption.

Since β = 1- α and using capital per effective labor and assumption of constant return to scale with perfect substitute of labor and other form of inputs. We introduce partial demand model specification which reveals substantial difference in per capita energy consumption as opposed to population (labor growth) which is misleading indicator thus modification to per effective labor. The study will use cobb Douglas theory in equation 3.4 with partial demand model specification yields

$$E_t = A\, GDP_t^{\alpha}\, PE_t^{\beta} \text{ ....3.6}$$

where: E_t is the aggregate energy consumption demand, GDP real gross domestic product PE relative energy prices and A; total factor productivity.

The model fails in differentiating long term effects with short term effects. using process analysis, the relationship between energy consumption demand and aggregate capital stock is substitutional rather than imitational i.e. fixed proposition means there is a choice between more and less energy consumption. Thus, expressed as.

$$Y_t^{\alpha} = \left(\frac{E_t^{\gamma}}{A^* PE_t^{\beta}} \right) \text{....................................3.7}$$

E_t^{γ} is the energy mix comprising of renewable (E_t^{γ}), non-renewable (nE_t^{τ}) substituted like a form of capital k, Price introduces to the model for demand as determinate of demand; linearize the equation logarithm are introduced.

$$Yt = A, E_t^{\gamma}, PE_t^{\beta} \text{..3.8}$$

$$Y_t = \alpha K_t^{\beta}, E_t^{\gamma}, nE_t^{\tau}, O_t^{\varphi}\, Pe_t^{\gamma}\mu \text{ ....3.9}$$

Where:

Relative energy prices (Pet), Renewable energy consumption (Et), Non-renewable energy consumption (nE) at time t , Manufacturing performance output (Yt,), K being capital, technology (A) and μ is white noise error term. Trade openness(O) will also be used as control variables and therefore will be added in the model. And taking the logarithms of equation (9) gives

$$\text{Ln } Y = \alpha (\beta \text{Ln } K + \gamma \text{Ln } E + \eta \text{Ln } nE + \varphi \text{Ln } O + \eta \text{ Ln } Pe) + \mu \text{................................3.10}$$

3.4 Data Analysis

This research will use a regression model of time series to study the effects of renewable and non-renewable energy on Kenya's manufacturing performance. Using standard OLS technique to non-stationary information arrangement will result 'spurious relapse'. In other words, the regression can provide high R-squared, low Durbin-Watson (DW) measurements with t-estimates of the coefficients evaluated showing significant causality between dependent and independent variables while reality they are disconnected. Therefor we test the unit root using below equation

$$\Delta y_t = \alpha + \beta y_{t-1} + \sum_{j=1}^{k} \lambda_j \Delta y_{t-j} + e_t \text{ ………………………………………………3.11}$$

Ho: The variable is nonstationary (i.e., it has a unit root)

Hi: The variable is stationary (i.e., it has no unit root)

With goal orientation to prepare for the likelihood of a spurious relationship whereas keeping up information/results, two primary methodologies provide sensible arrangements. First, Hendry and his co-researchers developed unrestricted error correction modeling (ECM) (Hendry, 1995). Second method, co-integration approach spearheaded by Engle and Granger (1990). The Engle and Granger spearheading technique is suitable while managing non-stationary information that are incorporated of similar manner. Then again, Hendry's ECM methodology (1995) can be extended combined data with different orders (Hendry, 1995)

The Engel Granger method and the Johansen co- integration method will be used. Having obtained the results of the unit root test above, if the series are integrated of the same order, the Johansen's procedure is used to determine whether there exists a cointegrating vector among the variables (Johansen, 1988). The cointegrating test is used to determine the long-run relationship between two variables (Hwang, 1998).

Additionally, the ECM furnished assessing with substantial t-values even within the sight of endogenous explanatory variables (Inder, 1993). No variable is excluded from the autoregressive equation for any of the variables in the system. In this study, we employed the reduced form VAR which models every endogenous variable in the system, as a function of the lagged values of itself and of all the endogenous variables in the system (Engle and Granger, 1987).

IV. Results and Findings

4.1 Multivariate Time Series Preliminary Analysis

In this section the model specification problems emerging from the OLS is addressed using multivariate time series analysis. The first step of preliminary analysis of the data is the selection of the optimal lag length, perform stationarity checks and thereafter identify the cointegrating rank before specifying the model and testing it for adequacy. To check for stationarity, we use time series plots, correlogram plots and the Augmented Dickey Fuller (ADF) test. If the data is found to be non-stationary, we shall proceed to determine the order of integration, before deciding on the appropriate time series model to fit.

4.1.1 Lag selection

The first step in the analysis is to select an appropriate lag length. This ensures that the error term is correctly specified (Enders 1995). There are various selection criteria available including the Sequential modified Likelihood ratio (LR) criterion, the Final Prediction Error (FPE) criterion, the Akaike Information Criterion (AIC), the Schwarz Bayesian Information Criterion (SBIC) and the Hannan-Quinn Information Criterion (HQC). There is no unanimous agreement on which criterion to use in case of conflicting results among the above methods. However, the decision rule is to choose the model with the lowest value of information criteria. In our case lag selection information criteria are shown in table 4.3 below.

Table 4.1: Results of Lag Selection-order criteria

Lag	LL	LR	Df	P	FPE	AIC	HQIC	SBIC
0	-662.098				1.5e+10	40.4908	40.5824	40.7629
1	-572.831	178.54	36	0.000	6.4e+8	37.2625	37.9033	39.1671
2	-499.271	147.12	36	0.000	8.3e+7	34.9861	36.1763	38.5233
3	-429.801	138.94	36	0.000	2.2e+7	32.9576	34.6971	38.1274
4	-251.96	355.68*	36	0.000	25060.3*	24.3612*	26.65*	31.1635*

Sample: 1987 – 2019 (number of obs = 33)

The lowest information criterion for LR, FPE, AIC, HQIC and SBIC is lag 4. In the event of conflict in lag length selection, the appropriate way is to plot the correlogram of residuals and select the lag length That is where all the autocorrelations fit within the given limit. Therefore, we conclude the optimal lag 4.

4.1.2 Testing for Stationarity

When non-stationary time series data are used for analysis, we may end up with spurious results because estimates obtained from such data will possess non-constant mean and variance (Dimitrova, 2005). thus, to establish the stationarity of the data. A time series is said to be stationary when its mean, variance and covariances are time invariant. The study utilized time series graphs to check for stationarity. The results indicate possible non stationarity since their movement exhibit a trend. The correlograms also indicate that the variables may be non-stationary since they die away slowly. To confirm empirically the stationarity of the data we used the Augmented Dickey Fuller (ADF) unit root tests whose results are shown in table 4.2 below.

Table 4.2: Unit Root Tests Results

Variable		ADF Test statistic Z(t)	T-statistic 5%	MacKinnon approximate p-value for Z(t)
Manufacturing Performance	No Trend	-2.136	-2.972	0.2303
	Trend	-2.160	-3.560	0.5122
Renewable Energy consumption	No Trend	-0.971	-2.972	0.7636
	Trend	-1.218	-3.560	0.9067
Non-renewable energy consumption	No Trend	-2.125	-2.972	0.2347
	Trend	-2.057	-3.560	0.5699
Energy Price	No Trend	-1.389	-2.972	0.5878
	Trend	-2.229	-3.560	0.4736
Trade Openness	No Trend	-2.847	-2.972	0.0518
	Trend	-2.785	-3.560	0.2024
Real Gross Fixed capital	No Trend	-1.569	-2.972	0.4991
	Trend	-1.661	-3.560	0.7677

Data is stationary when ADF statistic is less than critical value. The results indicated the variables were not stationary since ADF statistic > t-statistic. We therefore difference the data to achieve stationarity. Differencing detrends the value to achieve stationarity.

Table 4.3: Unit Root test after differencing Results

Variable		ADF Test statistic Z(t)	T-statistic 5%	MacKinnon approximate p-value for Z(t)
Manufacturing Performance	No Trend	-4.396	-2.980	0.0003*
	Trend	-4.311	-3.572	0.0030*
Renewable Energy consumption	No Trend	-7.396	-2.980	0.0000*
	Trend	- -7.331	-3.572	0.0000*
Non-renewable energy consumption	No Trend	-4.806	-2.980	0.0001*
	Trend	-4.749	-3.572	0.0006*
Energy Price	No Trend	-3.062	-2.972	0.0295*
	Trend	-3.104	**-3.560**	0.1053
Trade Openness	No Trend	-5.899	-2.980	0.0000*
	Trend	-5.785	-3.572	0.0000*
Real Gross Fixed capital	No Trend	-4.806	-2.980	0.0001*
	Trend	-4.724	-3.572	0.0006*

Table 4.3 displays the results of the ADF test after the data is differenced three times. The data is stationary if the ADF test statistic is less than the critical value. All variables become stationary after the third difference indicating that the variables are integrated to order three, I (3).

4.2 Cointegration Test

Investigating the long run relationship between the manufacturing performance and energy consumption, we test the series for cointegration. Cointegration is used to establish the long run relationship between variables. If the series is cointegrated, we use the error correction model to investigate causality and the short run equilibrium between the variables. The Granger representation theorem states that there is a corresponding error correction term, and an error correction model must be constructed. However, if the series are not cointegrated, then the VEC model is reduced to a basic VAR. Depending on the cointegrating relationship, we perform the Granger causality test to investigate the causal linkage between the variables. (Amalendu, 2012).

In this study, the series are I (4), we therefore proceed to test for cointegration using the Johansen cointegration test. As proposed by Johansen and Juselius (1990), we compute the trace (λ trace) and maximum eigenvalue (λ max) statistics. We test the null hypothesis that there is r=0 cointegrating vectors against the alternate that there is at least one cointegrating vectors. Having established earlier the appropriate lag length to be four, we proceed to determine the number of cointegrating equations.

Johansen tests for cointegration

Trend: none — Number of obs = 33
Sample: 1987 - 2019 — Lags = 4

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value	1% critical value
0	108	-474.05623		435.8647	82.49	90.45
1	119	-393.30651	0.99251	274.3653	59.46	66.52
2	128	-329.09202	0.97959	145.9363	39.89	45.58
3	135	-293.96811	0.88101	75.6885	24.31	29.75
4	140	-269.6454	0.77102	27.0431	12.53	16.31
5	143	-257.61935	0.51754	2.9910*1*5	3.84	6.51
6	144	-256.12385	0.08665			

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value	1% critical value
0	108	-474.05623		161.4994	36.36	41.00
1	119	-393.30651	0.99251	128.4290	30.04	35.17
2	128	-329.09202	0.97959	70.2478	23.80	28.82
3	135	-293.96811	0.88101	48.6454	17.89	22.99
4	140	-269.6454	0.77102	24.0521	11.44	15.69
5	143	-257.61935	0.51754	2.9910	3.84	6.51
6	144	-256.12385	0.08665			

Figure 4.1: Johansen Cointegration test results

When the trace statistic is smaller than the critical value, we accept the null hypothesis of no cointegration. From the table of Cointegration above we determine our series to have a cointegration rank of order five that is they are cointegrating equations since the trace statistics at r=5 of 2.9910 is less than its critical value of 3.84 at 5% critical value and 6.51 at 1% critical value we reject the null hypothesis. The results show that there is cointegrating vector and eventually there exist a long run relationship between the manufacturing performance and energy consumption. Hence a vector error correction model needs to be estimated.

4.3 Vector Error Correction Models (VEC)

Having determined that series are I (4) and the rank of five, in such a case the suitable action is to fit VEC models which will be able to capture both short-term and long-term relationships of the variables. At the long term we will examine the speed of convergence of each variable

Vector error-correction model

Sample: 1984 - 2019 — Number of obs = 36
AIC = 26.18362
Log likelihood = -322.3051 — HQIC = 28.47114
Det(Sigma_ml) = 2.407472 — SBIC = 32.73763

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_Manfuacturin~e	24	2.42067	0.7526	36.49642	0.0491
D_RenewableEne~n	24	1.02878	0.7877	44.5246	0.0066
D_Nonrenewable~n	24	1.01211	0.6954	27.40172	0.2861
D_EnergyPrice	24	4.3519	0.8836	91.05818	0.0000
D_TradeOpennes	24	16.7723	0.8341	60.32069	0.0001
D_RealGrossFix~l	24	1.0693	0.8681	78.96018	0.0000

Figure 4.2: Vector error-correction model results.

The results from the VEC estimation is that present values of manufacturing performance, renewable energy, energy prices, trade openness and capital are important in explain the relationship with their lagged values and performance of manufacturing sector performance. All the variables are statistically significant with a P-Value of 0.0000 except for non-renewable energy consumption which is not statistically significant with a P-Value of 0.2861

4.3.1.1 Short run coefficient results

At the short run, the lag of manufacturing performance, renewable energy and energy prices Trade openness and capital stock are statistically significant in explaining the relationship of manufacturing performance. This means that a change in renewable energy leads to a significant change in the manufacturing performance as indicated by the significant t-values and p-values at 5% critical value. The short run response of energy consumption on changes in the manufacturing sector VEC equation are presented below.

4.3.1.2 The long run result

In the long run all the variables are endogenous in the model, manufacturing sector also explains performance of itself through the lagged differences. The below table indicate the speed of cointegration and convergence toward equilibrium in the long run the results indicates that energy price will not converge in the future with a P value of 0.0346 against the 1% significant level but at 5% significant level it will converge showing causality between the manufacturing sector and energy prices.

Table 4.4: Johansen normalization restriction imposed

Beta	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
D2Manfuacturingperformance	1	.	.	.	.	
D2RenewableEnergy	-22.6376	1.544	-14.66	0.000	-25.6643	-19.611
D2Nonrenewableenergy	-4.6485	1.546	-3.01	0.003	-7.67956	-1.6174
D2EnergyPrice	-0.1670	0.8627	-0.19	0.846	-1.85796	1.5238
D2TradeOpennes	-0.1046	0.114	-0.91	0.361	-0.32911	0.1198
D2RealGrossFixedcapital	14.8813	0.599	24.83	0.000	13.70686	16.0558
cons	0.95406	.	.	.	.	

Table 4.5: Speed of Cointegrating equations

Beta	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
L._ce1	-5.084	0.786	-6.47	0.000	-6.624	-3.544	***
L._ce2	4.550	1.965	2.32	0.021	0.699	8.401	**
L._ce3	-2.299	2.023	-1.14	0.256	-6.265	1.667	
L._ce4	1.679	0.465	3.61	0.000	0.767	2.590	***
L._ce5	-0.421	0.111	-3.78	0.000	-0.640	-0.203	***

A unit change in renewable energy will increase the manufacturing sector changes by 22.6376 margins which is a statistically significant variable in explaining the casualty with a P- Value of 0.000 while nonrenewable energy is statistically significant with a P- Value of 0.003. Energy price, trade openness is both statistically insignificant with a p-value of 0.846 and 0.361, respectively. Further trade openness coefficient indicates that there will be less reliance of external commodities due to well performing manufacturing sector with a 0.88479 value. Thereafter, we perform post estimation analysis to check the fitness of the model.

4.4. Post estimation analysis

Post estimation analysis to check for robustness of the model in modeling the relationship between the manufacturing performance and energy consumption is conducted. First, we check for autocorrelation in residuals of VECM using the Langrange multiplier test.

4.4.1 Autocorrelation test

Table 4.6: Langrange multiplier Autocorrelation test results

Lag	Chi2	df	Prob>Chi2
1	95.8674	36	0.00000
2	91.5159	36	0.00000

H_0 : no autocorrelation at lag order.

The p-value at lag one and two is less than 0.05. We accept the null hypothesis of no autocorrelation at lag order 1 and 2.

4.4.2 Normality test

Table 4.7 Jarque-Bera Normality test

Equation	Chi2	df	Prob>Chi2
D_D2Manfuacturingperformance	2.968	2	0.22677
D_D2RenewableEnergy	5.248	2	0.07252

D_D2Nonrenewableenergy	5.345	2	0.06909
D_D2EnergyPrice	3.435	2	0.17953
D_D2TradeOpennes	0.911	2	0.63410
D_D2RealGrossFixedcapital	1.152	2	0.56228
ALL	19.057	12	0.08716

All probabilities are above 5% significant level hence we reject Ho. And conclude that all the series all the equations are normally distributed.

4.4.3 Eigen Stability Condition

Then stability condition of VECM estimates is checked. After fitting a VECM, it is required that variables be covariance stationary. VAR does not satisfy stability condition. Because the modulus of each eigen value is not strictly less than one, the estimated VAR is unstable as show in the table below.

Table 4.8: Check Stability of Variance

Eigen value	Modulus
-.5269968, + .9391426i	1.0769
-.5269968, - .9391426i	1.0769
-.8881017, + .5735724i	1.05722
-.8881017, - .5735724i	1.05722
.2244707, + .9969588i	1.02192
.2244707, - .9969588i	1.02192
-.9933965, + .1776803i	1.00916
-.9933965, - .1776803i	1.00916
1	1
1	1
1	1
1	1
1	1
-.3708267, + .8483937i	0.925896
-.3708267, - .8483937i	0.925896
-.7311275, + .4210312i	0.843691
-.7311275, - .4210312i	0.843691
-0.7837139	0.783714
-.4123421, + .6410742i	0.762235
-.4123421, - .6410742i	0.762235
.3176481, + .5949094i	0.674402
.3176481, - .5949094i	0.674402
-.1793372, + .4688247i	0.501955

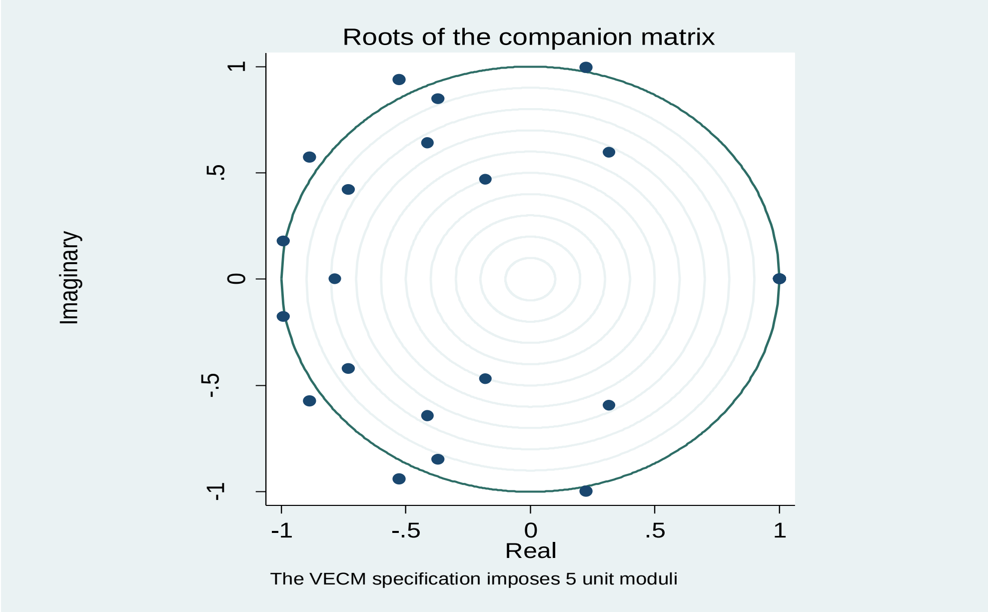

Figure 4.3: Root of the companion matrix stability of the model

5-unit moduli and eigen values lie inside outside the unit circle thus VECM is unstable. The impulse response functions cannot be estimated since the model is unstable which will result to unknown interpretations.

V. Discussion and Conclusion

5.1 Summary of finding

A Vector error correction model with four lags was estimated and results analyzed. The empirical results established that for manufacturing firm utilize more of renewable energy than non-renewable. This is backed by the production process is capital intensive and efficiency which increases but the incremental energy consumption decreases for both renewable energy and non-renewable energy. However, the energy price is statistically insignificant for both short term and long run implying the energy market is inefficient characterized by may distortions which include international fuel prices, imports and exports regimes policy for energy, immobility of energy resources such as hydro, solar, and tidal waves. This is contrary to common knowledge that energy consumption increases with increase in production as opposed to efficiency in energy technology deployed.

The positive response of renewable energy to a shock on the manufacturing sector performance could be because of the advocacy on the green energy debates and current international clean energy subsidies. Kenya was awarded 100 Million energy credit incentive program by United Nation for promotion of the renewable energy mix being higher than non-renewable thus reduction of pollution. Such environmentally friendly generation have positive impact directly to the manufacturing sector performance on the sustainability reporting on the individual firm financial statement. The trend of renewable energy has been incremental over time but very stable. (Mwakubo et al., 2007) renewable growth is characterized by rising demand, increased electricity prices, increasing global fossil fuel costs, and environmental activism.

The study established a weak positive linkage between trade openness and manufacturing performance of firms. Imports destroys domestic firm while increased competitiveness is eanested by increased exports. Such that in energy efficiency nation and well-developed energy market, manufacturing firms thrives and the country product competitiveness increases. The finding was also supported by Kahia, Aïssa and Charfeddine (2016) exhibited short-run also long-run bidirectional and unidirectional causality from economic growth to renewable energy use respectively.

Energy price trends are incremental over time and series is recursive. Further analysis of the model result to instability as indicated by the unit circle and a module of more than one. In depth insight still reveals at long run the speed of cointegration is divergence hence no equilibrium thus implying volatility and instability of the energy market. This problem will be addressed by policy change in electricity pricing tariff in Kenyan energy sector and liberalization of the sector from monopoly to perfect competition model with market force free mechanism determining the energy tariffs and pricing.

5.2 Contribution to Knowledge

In this study, we investigated the relationship between energy consumption and manufacturing sector performance in Kenya using time series data. First, we applied the unit root test to establish stationarity of the data series. Results indicate that the data of the variables are non-stationary and integrated of order four. Then we applied the Johansen Cointegration test to determine the long run relationship between the two variables. Results show that there is cointegrating relationship, that is there is long-term co-movement between the study variables. In the presence of a long run relationship, we employed the VECM test to determine the causal relationship between energy consumption and manufacturing sector performance.

Results indicate that renewable energy had bidirectional relationship with manufacturing performance both in short run and long run This implies that their performance of manufacturing sector can be determined by the efficiency technology deployed that utilized the renewable energy. Lastly, we sought to investigate the response of non-renewable energy to a standard deviation shock on the manufacturing sector performance using the VECM model. Results indicate a weak positive relationship between energy prices and trade openness in the model depicting energy and commodity markets inefficiency, while a very strong long run relationship between renewable and capital with manufacturing performance sector.

5.3 Policy Implications:

The key policy intervention to alleviate the challenges facing energy markets in term of fluctuation of supply as shown in the trends. Renewable energy instability needs investment and deployment of storage technology especially during excess energy supply and smart grid system to regulate supply and demand at point of metering.

Furthermore, results demonstrate bidirectional causality between the consumption of non-renewable energy and production performance both in the short and long run. In addition, there are several measures and policies that need to be implemented by the authorities to advocate usage of clean and sustainable energy, such as the establishment of several important regional institutions and cooperation, renewable energy generation tax credits and rebates.

5.4 Areas for Further Research

However, based on the findings of this study the variables are predictable based on past values of the other variables. Therefore, there is a chance of improving the manufacturing performance by consumption of renewable energy in a more efficiency manager using a capital-intensive technology. The study makes recommendations to researcher to look at firm level to investigate implication of renewable energy on total output productivity factor. In addition, suggested areas for further research include identification of other factors such as energy storage influence on demand and supply of renewable energy for future generation. Also changing tends on investment and financing models deployed in energy sector.

References

[1]. Kenya Association of Manufacturers. (2019). Developing Circular Economy: Global perspective. India: Springer.
[2]. B, I. (1993). Estimating Long run relationships in Economics: A comparison of different Approaches. Journal of Econometrics.
[3]. Chang, C.-C. (2010). A multivariate causality test of carbon dioxide emissions, energy consumption and economic growth in China. Applied Energy, 87(11), 3533–3537.
[4]. Ghosh, S. (2002). Electricity consumption and economic growth in India. . Energy Policy, 30(2),, 125–129.
[5]. Gitone, I. (2014). Determinants of adoption of renewable energy in Kenya. . Unpublished Thesis, University of Nairobi.
[6]. Gujarati, .. (2003). Basic Econometrics. India: McGraw Hill Education.
[7]. Hendry, D. (1995). Dynamic Econometrics. United Kindom: Oxford University Press.
[8]. Kahia, M. A. (2016). Impact of renewable and non-renewable energy consumption on economic growth: New evidence from the MENA Net Oil Exporting Countries (NOECs). . Energy, 116,, 102-115.
[9]. Kasae, P. (2014). Energy Efficiency and Operational Performance of Manufacturing Firms in Kenya. Journals in Business & Management, 2(3), , 15 -24.
[10]. Kimuyu, P. M. (2012). The role of energy in economic development: African Perspective. IEE.
[11]. Kiplagat, J. K. (2011). Renewable energy in Kenya: Resource potential and status of exploitation. . Renewable and Sustainable Energy Reviews, 15(6, 2960-2973.
[12]. Kiplagat, J. W. (2011). Renewable energy in Kenya: Resource potential and status of exploitation. . Renewable and Sustainable Energy Reviews, 4 (15), 45 - 90.
[13]. Kotze, D. J. (1970). The analysis of the energy economy of South Africa with special reference to its forecasting. South Africa.
[14]. Love, P. (2014, November 23). Not just for the rich: Green growth and developing countries. . Retrieved from OECD Insight : www.OECDInsight.org.
[15]. Miranga, B. O. (2011). Environment and energy sources: a study of domestic energy choices in Kasarani, Westlands and Makadara divisions in Nairobi, Kenya. Doctoral dissertation.
[16]. Mwakubo, S. (2007). Strategies for securing energy supply in Kenya. Nairobi: Kenya Institute for Public Policy Research and Analysis.
[17]. Ntanos, S. S. (2018). Renewable energy and economic growth: Evidence from european countries. . Sustainability, 10(8), , 2626.
[18]. Odhiambo, W. (2011). The manufacturing sector in Kenya: an empirical analysis. Doctoral dissertation.
[19]. Onuonga, S. M. (2008). An Econometric Analysis of Energy Utilization in the Kenyan Manufacturing Sector. Doctoral dissertation, Kenyatta University.
[20]. Raza, S. A. (2016). Electricity Consumption and Economic Growth in South Asia. . South Asia Economic Journal, 17(2), 200–215.
[21]. Silva, S. S. (2012). The impact of renewable energy sources on economic growth and CO2 emissions-a SVAR approach. European Research Studies, 15,, 133.
[22]. Tiwari, A. K. (2011). Comparative performance of renewable and nonrenewable energy source on economic growth and CO2 emissions of Europe and Eurasian countries: A PVAR approach. Economics Bulletin, 31(3), 2356-2372.
[23]. Varian, H. R. (2006). Intermediate Microeconomics: A Modern Approach 7th edition. w w norton.
[24]. Wang, S. S. (2011). CO2 emissions, energy consumption and economic growth in China: a panel data analysis. ,. Energy Policy, 39(9), 4870–4875.
[25]. Wanjiru, H. &. (2013). Underpinning Factors for the Development of a Commercialization Strategy for Small Wind. 904–910.

Edwin Gwaro Ototo, et. al. “Energy Consumption and Performance of Manufacturing Sector in Kenya.” *IOSR Journal of Economics and Finance (IOSR-JEF)*, 12(1), 2021, pp. 23-36.