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Key Economic Sector Nexus and their Granger Causality with Electricity in Tanzania

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Abstract

This thesis uses annual data from 1970 - 2014 to investigate Granger causality between electricity production and key growth contributors in Tanzania. The multivariate analysis is done using Autoregressive Distributed Lag (ARDL) to check for co-integration; the Vector Error Correction (VEC) and Vector Autoregressive (VAR) models are employed for co-integrated and non-co-integrated variables respectively. The sectors investigated are agricultural and manufacturing value addition while also including labour and capital stock as inputs beside electricity. The results show that electricity production does not significantly Granger Cause manufacturing value addition in both short and the long run. It is observed however to significantly Granger Cause agricultural value addition and capital formation in the long run. There is also significant two-way sectoral causality between agricultural and manufacturing value added in the short run. The results of this study suggest unidirectional flows from electricity to one of the growth supporting sectors and capital formation, this indicates energy dependency of this economy’s traditional sector and its stock of accumulated input. Therefore, in Tanzania the agricultural sector seems to be the main driver of this energy led growth hypothesis.

Keywords: multivariate, Augmented Dickey Fuller, Autoregressive Distributive Lag, Tanzania, Vector Error Correction Model, Vector Autoregressive, energy dependency.

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LIST OF ABBREVIATIONS& GLOSSARY

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criteria
AMR	Automatic Meter Readers
ARCH	Autoregressive Conditional Heteroscedasticity
ARDL	Autoregressive Distributive Lag
ARL	Average Run Length
CUSUM	Cumulative Sum Square
EWURA	Energy and Water Utilities Regulatory Authorities
GDP	Gross Domestic Product
I (N=0, 1…)	Integrated of Order 0, 1…
ICT	Information Communication Technology
KWh	Kilowatt hours
LUKU	Lipa Umeme Kadiri Utumiavyo
MEM	Ministry of Energy and Minerals
MIT	Ministry of Industry and Trade
MW	Megawatt
NBS	National Bureau of Statistics
OECD	Office of Economic Cooperation and Development
OLS	Ordinary Least Squares
R&D	Research and Development
SBIC/SIC	Schwarz Information Criteria
SPC	Statistical Process Control
TANESCO	Tanzania Electric Supply Company Limited
TFP	Total Factor Productivity
UNIDO	United Nations Industrial Development Organizations
V.A.	Value Added/Addition
VAR	Vector Autoregressive
VECM/ECM	Vector Error Correction Model/Error Correction Model
WDI	World Development Indicators

1: INTRODUCTION

Most developing countries in the world are concerned about ensuring the attainment of economic prosperity. However, the type of prosperity that is desirable is the one that ensures improvement of the quality of life among its citizens as a whole. This can be done through ensuring the availability of necessary infrastructures. This study considers electricity to be one of the most important infrastructure investments by developing economies, for with it comes opportunities for improvement in productivity, healthcare, communication, media, other social services such as street lights and the general supportive environment for R&D in institutions.

Tanzania is counted among such developing economies, it has been recently reported to grow at 7.1%, such high rate of GDP growth requires persistency if the country is to attain middle income status relatively quickly. One of the most important drivers or supporters of business environment is the availability of affordable commercial energy. This would not only attract private investments that create jobs but also is expected to ensure the smooth functioning of the economy through widening of the tax base as a result of the expanding business sector. This makes research into energy issues for the country an issue of concern for future planners.

This investigation can be summarised into two straightforward questions: - If the GDP is broken down into separate sectors, does the increase in commercial energy supply cause growth of each of the sectors? Or is it vice versa -that growth of these sectors increases energy supply? What is the direction of causality? These are valid questions and yet prudence must be exercised in tackling them. The first thing to remember is that at least for Tanzania the amount of energy supplied must all be consumed, that is in this study the assumption is that there is no such thing as excess electricity produced. This work is dedicated towards providing answers to the questions raised and it is segmented into 8 Chapters, below is a brief outline;

Chapter 2 constitutes the background, in it, the paper discusses about the motivation for the study highlighting a brief history about energy crises, their impact on growth, countries´ responses, the recent general international energy consumption trends and sustainability concerns. It also shows Tanzania's profile, performance, and the interlinkage of the traditional and modern sectors.

The literature review in Chapter 3 constitutes a brief overview on the research about Granger-causality between economic growth and electricity or commercial energy. Most of the analysis conducted is bivariate focusing on GDP and energy causality but not considering the impacts upon different sectors and other potential inputs that enter with energy that could influence their causality direction.

In Chapter 4, the study shows the theoretical foundation of this investigation and depicts how it is based upon a neoclassical production function by Solow & Swan. The section also highlights the possible challenges of estimating the traditional OLS model, and offers the solution as causality investigation to provide a map. The data used is time series, consisting of total electricity consumption in (kWh), labour input as working age population; these two were sourced from World Development Indicators-2015. The other set of data from UN statistical database which constitutes manufacturing value added, agricultural value added and gross capital formation. All the data used ranges from 1970 to 2014.

In Chapter 5, the method employed is Granger causality test; before conducting this test however, the paper first conducts unit root test using ADF. The aim of the unit-root test is to show whether the variables are integrated of order 0 i.e. I(0) or integrated of order1 i.e. I(1). Variables found to be of the same order of integration could indicate a long-run relationship, and such series if investigated for Granger causality irrespective of their co-integration status would lead to meaningless results. Therefore, for this reason, co-integration test of Autoregressive Distributed Lag (ARDL) is used, from it, if series are found to be co-integrated the Granger-Causality test will be done using Vector Error Correction Model (VECM) and if not so then Vector Autoregressive (VAR) method will be used.

Chapter 6 is a presentation of the empirical results of the study, this shall include also the results for the diagnostic tests conducted to check for the stability of the VECM estimation procedure, and Autoregressive Conditional Heteroscedasticity [ARCH(n)] process.

Chapter 7 presents the discussions about the results in consideration also of the previous literature and in light of policy implications.

Chapter 8, the final segment of this discussion, shall briefly display the conclusion of this study presenting challenges as well as way forward regarding future research in the line of energy research.

2: BACKGROUND

2.1. Motivation

The global oil crisis of 1973 attracted people's attention to energy supply shocks as this caused losses to oil importing countries. In the context of grid commercial energy however, pioneering works by indicated that there was an association between high electrification and social status in the post-world war II U.S.A. (Kraft and Kraft,1978) (as cited in Chontanawat el al.,2008 and Acaravci & Ozturk,2010)

This could have been attributed to the fact that electricity served as an indication of economic achievement, even though at the time this was highly marked by high government spending for rural electrification, and thus from then on it became interesting to find out the direction of causality between economic development and electricity consumption. (Supel,1978, p.2, Aschauer,1989, p.33)

A fairly recent survey done in 6 OECD countries has showed that in the year 2000 industry was responsible for 35% of primary energy consumption (Worrell et al.,2003).

Howbeit, the current affairs indicate concerns about air pollution and unsustainable processes of energy resource extraction. Global policy makers advocate for more sustainable energy production and distribution. This is expected to be achieved through limiting some forms of energy production such as non-renewables. The problem of coordination is dealt with through global agreements such as the recent 2015 United Nations climate change conference in Paris. The advocates lobbied for a multilateral commitment by nations to environmental protection standards that might influence choices of different nations.

However, the countries to be involved are not expected to respond similarly because of variations in aspects such as their global market positions and prior investments in energy infrastructure: suppliers of non-renewables, for example, might pre-empt the policy makers (carbon tax, non-pollutant technologies, carbon pricing agencies...) by flooding the market with their resource; while countries in the frontier of R&D may improve their efficiency in energy consumption and even come up with new technologies to counter such challenges in the long run (Zhang,2015).

To identify the impacts of such scenarios for a developing country like Tanzania it is imperative to know the direction of causality between energy and growth. This will display the degree of energy dependence. Herein the method proposed is Granger causality, and so far its implications upon growth and energy interactions are not yet universally understood in the policy world, this is so even within the context of the developed countries.

The gap in scientific knowledge is identified partly due to the fact that most of the investigation had focused mainly on the direction of Granger causality between commercial energy and GDP/GNP. It is understood theoretically that GDP/GNP is composed of output values from different sectors including also utilities such as water and electricity producers. This implies that a bivariate causality analysis on such composites with electricity could prove problematic because there is electricity production within them. When such analysis is conducted across economies it assumes away the structural differences between individual countries. These structural differences result from countries' distinguishable characteristics that influence main contributors to their economic growth i.e. positive increments in GDP/GNP. Such distinguishable characteristics may include resource abundance such as human capital/technology, land, physical capital stock etc.

Thus, when analysing countries with distinguishable characteristics a bivariate investigation is limiting in the sense that electricity causality on development may be augmented by other aspects important to economic growth especially if electricity supply is not reliable. Therefore, excluding such aspects in causality analysis makes the results less informative especially when studying countries at different levels of economic achievement.

It is for such a purpose that this work is prepared, using the Auto-Regressive Distributed Lag procedure to check for long run co-joined movements between select sectors for Tanzania and other key inputs including electricity. This is done in order to eventually perform the Granger tests appropriately i.e. using either VECM or VAR. The chief aim is to show how electricity consumption impacts economic growth through the selected sectors of manufacturing and agriculture taking into account also labour force and capital.

The research question is considered herein of relevance due to the following reasons;

First, energy sustainability issues as hinted previously present a potential trade-off for economies. As per results from a number of previous investigations, some countries are energy dependent while others are in a position of less energy dependence. Given the prospects of enforcement on limits to non-renewable energy production, countries that are energy dependent are therefore potentially worse off. This situation makes the research question important in answering an issue of strategic importance to both developed countries and developing ones.

Secondly, this investigation builds upon the works of previous researchers and seeks to extend the analysis. Ebohon (1996) and Odhiambo (2009) have indicated to an extent how the development of Tanzania is dependent upon electricity production, and thus a constrained energy sector could theoretically stunt economic growth. This research question brings something new to the table by further elucidating on how different sectors that contribute to economic growth interact with commercial energy. It is therefore expected that the study will be able to highlight how the different sectors of the economy might cause varied results among countries when studying electricity-growth causality.

Thirdly, the research question when answered will provide policy implications that inform public decisions. The question will indicate how the economic prosperity of farmers is influenced by electricity, how the workers in factories and owners of capital (machinery) gain altogether with respect to electricity and finally how the two sectors i.e. primary sector and modern sector interact for development.

There are however some limitations to this study: The study does not explicitly consider electricity outage; a common scenario in developing countries involves power interruptions that come without prior warning. Such situations result into losses of reputation and revenues especially for businesses that have strict commitments to clients; other losses may result from the malfunction of electrical equipment and their need for replacement as a result of unpredictable electricity loads. Tanzania is not exempt from such issues, however, this study focuses solely on Granger Causality between energy and growth and thus not considering unreliability. This is done because of a theoretical possibility for substituting electricity with other factor inputs in the sectors of interest especially when it is unreliable.

Related to that, this study does not take into account the varied energy efficiency of capital machinery but rather assumes homogenous input. The justification for such simplification is that, the study measures the stock of capital simply in monetary terms i.e. value of assets; this means that there is room for including all forms of capital machinery from the electronics based computers and automated production lines, buildings, to government sanctioned rural electrification power lines. This also means that such a classification provides level ground for studying the developed countries alongside the least developed.

2.2. Country Profile

Tanzania has an estimated population of about 50.8 million and increasing. As of 2013 the portion of land used for agriculture was 37.7% and 30.8% for forestry. Therefore, the economy depends on traditional sector to a great extent (WDI, 2015).

This can also be evidenced by how much agriculture accounts for more than one quarter of GDP, providing 85% of exports, and employing about 80% of the total work force directly and indirectly. According to quarterly accounts GDP grew by 7.2 % in the first three quarters of 2014, major contributing sectors were services 47%; manufacturing 8.2%; agriculture, forestry and fishing 9.7 % of the growth. The growth is expected to remain strong, at least 7.1%, and above from 2015 onwards, spurred by continued investment in infrastructure and growing electricity generation. Part of the reason for growing electricity generation can be attributed to the recent sharp decline in oil prices, this is expected to boost further manufacturing activities and a recovery in exports. (NBS,2016)

2.3. National Electricity Supply

The financial situation of TANESCO[1], the sole distributor of electricity in the country, has improved noticeably following the 40.3 percent tariff increase in January 2012 and 40 percent in January 2014 coupled with a significant reduction in the cost of power generation. This reduction in cost was due to the completion and commissioning of the Mwanza 60 MW power plant by end of 2013 and utilization of hydro capacity, which allowed TANESCO to retire all but one emergency power plant by the end of 2014.

TANESCO has also managed to reduce technical losses and to improve revenue collection by introducing prepaid meters (LUKU), Automatic Meter Readers (AMRs), disconnecting non-paying customers and installing LUKU and AMR meters in government institutions. The EWURA automatic tariff adjustment formula, which adjusts electricity tariffs quarterly to reflect changes in the exchange rate, inflation and oil prices, will maintain tariffs at or above cost-recovery.

Tariffs were decreased by 2.3 percent in March 2015 to reflect the recent significant decline in global oil prices, which was partly offset by inflation and the depreciation of the shilling against the U.S. dollar. Going forward, TANESCO's financial position is expected to further improve, as the cost of power generation is projected to fall with the completion of a new gas pipeline

[1] A parastatal organization under the Ministry of Energy and Minerals (MEM) which commenced its operations in 1933.

and a gas-fuelled power plant. This activity registered a negative growth of 1.2 percent in the third quarter of 2015 compared to 14.2 percent in the corresponding quarter of 2014. The negative growth was due to low water levels at hydroelectric dams, rehabilitation of generation and distribution infrastructure. For the period of July – September 2015, total electricity generated was 1,550 Million kWh compared to 1,581 Million kWh in the corresponding quarter of 2014 (NBS,2016).

2.4. Manufacturing in Tanzania

Originally, manufacturing used to imply crafting of products that could be sold. However, this definition expanded with advancements in technology to the extent of no longer being labour intensive, rather capital intensive involving automated electronic machinery. Moreover, the complexity involved is now the transfer of raw materials through various processes until the finished product is obtained. In Tanzania this sector's prominent value added contributions are from food and beverages (48%), non-metallic mineral products (11%), furniture and manufacturing (10%) (UNIDO,2015).

Therefore, the raw materials are naturally sourced from agriculture, forestry, fishing, mining, quarrying as well as products of other activities such as packaging and chemical processing. With regard to its stage of industrialization, the country is considered among the least developed countries ranking 120th among 142 others in the world competitive industrial rank (UNIDO,2015).

Recent data show that the activity grew at the rate of 3.6 percent in the third quarter of 2015 compared to 6.3 percent in the third quarter of 2014. For the period of July - September 2015, there was slight decrease in the manufacturing activity compared to the corresponding quarter of 2014 due to a general decrease in the production of food, beverages and tobacco industries. There was also less production of textile and wearing apparel; chemicals and pharmaceuticals and rubber and plastic products during the third quarter of 2015 compared to a similar quarter of 2014 (NBS,2016).

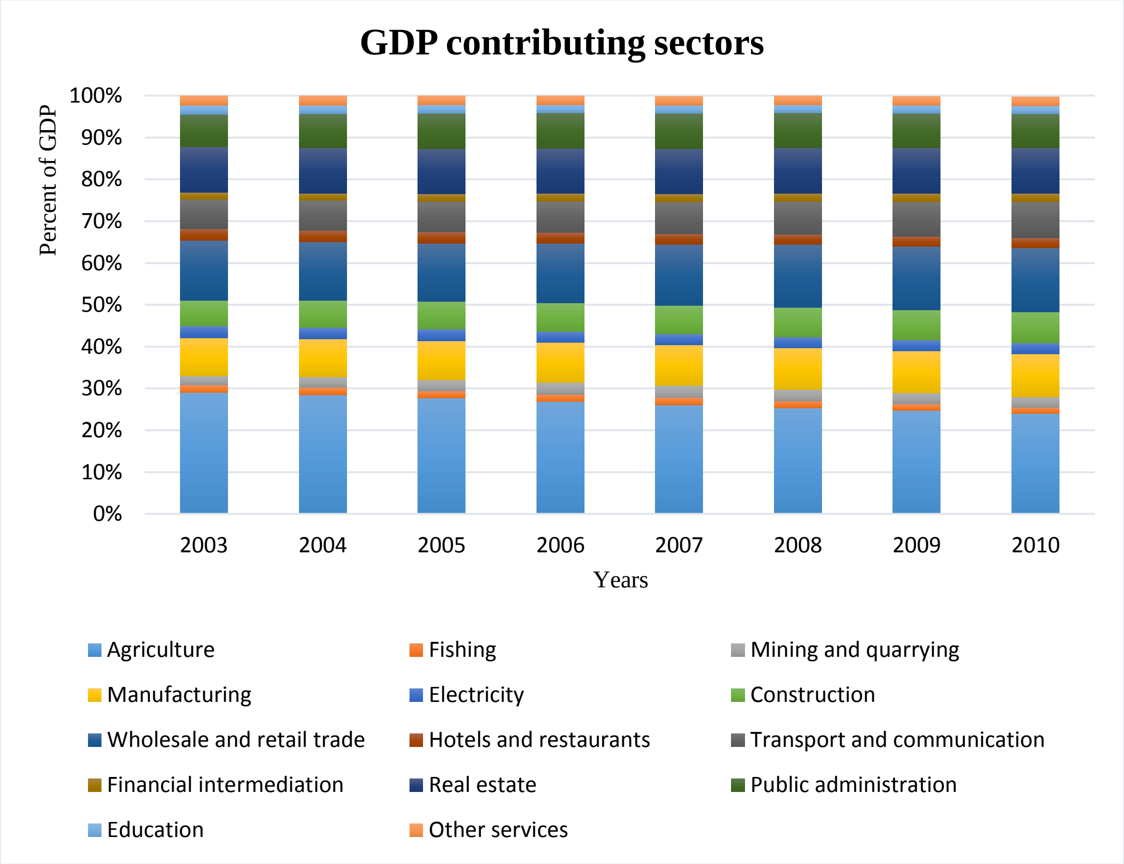
Official records show that the number of large industrial establishments operating in mainland Tanzania is 733. These are distributed among 30 regions with the highest concentration in Dar es Salaam followed by Arusha and Mwanza in order of their urbanization to the last one i.e. the more urban a region the more likely it is for industrial establishments to flourish[2]. The

[2] Rural Urban inequality is implied…indicating the dual sector model by Lewis (1954).

majority of these establishments (about 94 percent) consist of manufacturing employing a total of 105,568 workers (MIT,2012).

As per the previous discussions, it can be observed below that the manufacturing sector, though most desirable in policy as the driver of growth, is still weak compared to agricultural sector in Tanzania. This makes it difficult to exclude the primary sector in the upcoming analysis because the primary sector does have significant contributions to GDP. It can be seen in Figure 1 below that while the agricultural sector contributes on average 26.54% on economic growth, the sector of interest, manufacturing, only contributes about 9.65% of GDP growth on average.

Figure 1: Graphical depiction of Industrial contributions to Tanzania's GDP

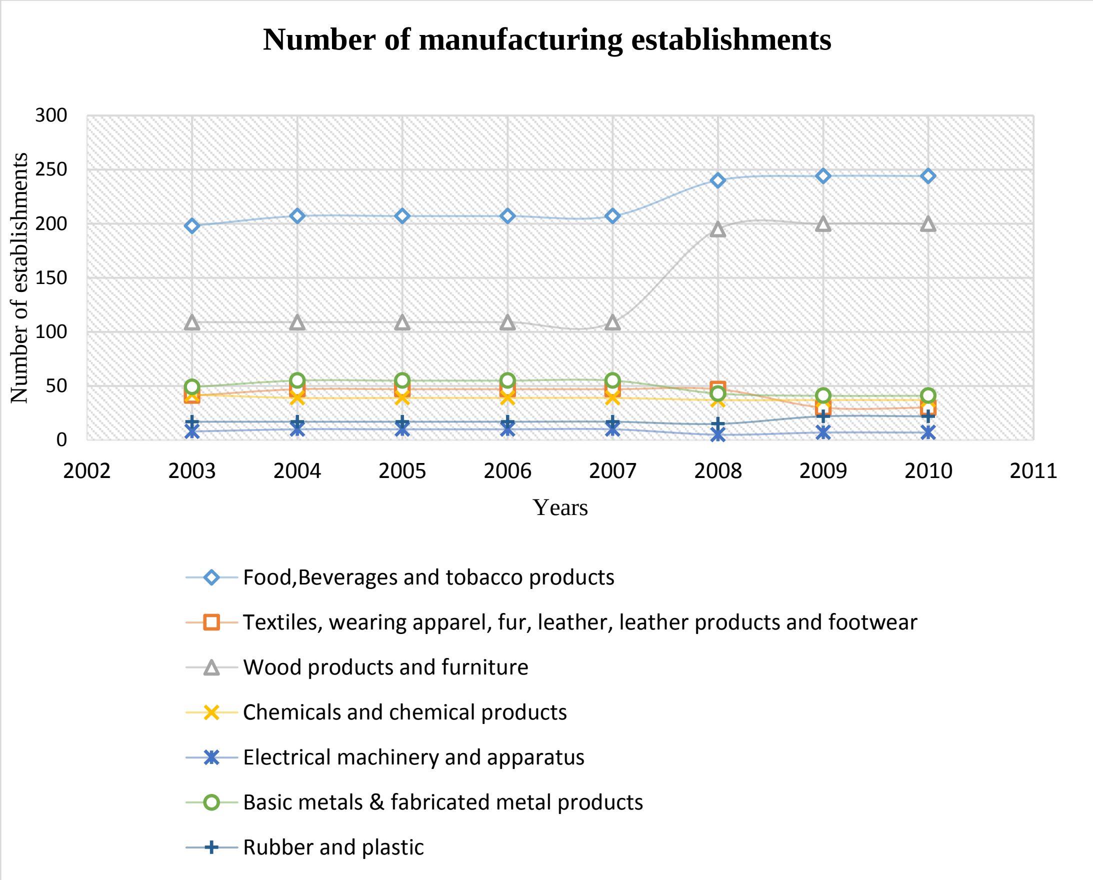


(Data Source: NBS,2016)

The two sectors, agriculture (coded blue) and manufacturing (coded yellow) are observed not to have visible changes in their contribution to GDP as the time progresses. However, underneath the seemingly unvarying columns there is an undercurrent movement with manufacturing contribution slyly increasing while that for agricultural sector is decreasing less slyly.

Figure 2 below depicts evidence on how the manufacturing sector is dependent on agricultural raw materials for its productivity. It can be seen that the majority of manufacturing establishments constitutes of those based on food stuffs, beverage and tobacco processing. It goes without saying that these factories depend upon output generated from the primary sector i.e. agriculture.

Figure 2: Different Manufacturing output classifications



(Data source: statistics UNIDO, 2015)

From above curves, a strong case can be made about how the agricultural sector really contributes into manufacturing value added.

3: LITERATURE REVIEW

The first recorded work for energy-growth phenomena was by Kraft and Kraft (1978) done in U.S.A. Their investigation is said to have implemented Sims specification to check for causality between electricity consumption and GNP. Using annual data for a period extending from 1947 to 1974, their method was based on the assumption of covariance stationarity of variables. It involved fitting an OLS regression model which is more likely to give spurious results especially when investigating macroeconomic variables. Their results indicated a unidirectional causality from GNP to electricity. Despite the potential shortcoming in estimation, the results could indicate a government that is pushing towards stimulating its economy through public expenditure. This public investment in the energy sector could make it seem like causality flows from GNP to electricity consumption.

Conversely for the same country Akarca & Long (1979), used the Granger method checking monthly employment and energy consumption data between January 1973 and March 1978. They specifically conducted the study by means of the Box- Jenkins procedure which uses Autoregressive Integrated Moving average models (ARIMA). This method is considered superior to that by Sims in that it is not based on exogeneity assumption of the right-hand side during estimation. The result of their study indicated that causality proceeded from energy consumption to employment negatively. Thus they concluded that constraints on energy consumption are expected to have a small incremental impact on employment levels. These results are quite interesting because according to Okun (1962), employment is associated positively with total output i.e. GNP; by this reasoning therefore the results by Akarca & Long are opposite those by the Krafts through implying that constrains on electricity raise employment and hence output. However, it can be argued that these results are a symptom of energy becoming administratively expensive relative to labour input, therefore employers seeking to minimize costs and ensure predictable output opt to more workers.

Yu & Hwang (1984) further built upon the two using both methods i.e. Sims and Granger improving also on the data from 1947 to 1979. They found no evidence for Granger causality between GNP and energy consumption, confirming the argument that the results by Kraft and Kraft could be spurious. The Sims results indicated a high degree of relationship between GNP and energy consumption through a high R^2, but this did not translate into causality. However, by the same method their study did indicate slight causality flows from employment to energy consumption which is opposite the results by Akarca & Long. Using the reasoning that total output is positively associated with employment it can be observed that indeed Yu & Hwang results are consistent with those by Kraft & Kraft. the monthly data from 1947 to 1979 to analyse by Granger method, the results showed no causality flows. The study performed the Chow test to check for suspect structural changes in the 1973, the results showed presence of such changes which explain the paradoxical results. This means that the results on energy-growth studies are to an extent highly influenced by structural conditions prevailing in an economy.

Aschauer (1989) argued that public expenditure on infrastructure facilities such as utilities, highways, bridges etc. are justifiable by their contribution to the quality of life and productivity in a particular jurisdiction. Though his argument tended to the side of Kraft and Kraft implications, the methodology employed to reach these results was quite different. He employs a qualitative approach by Terleckyj (1975) and the simulation method for yearly observation in periods of 1965-1985. The method had the advantage of scrutinizing using both the qualitative and quantitative offering a relatively balanced view of their investigation. However, some of the qualitative aspects considered were vague and may have as well had been attributed to a rise in critical mass of health awareness with time; aspects such as quality of air, reduced drug abuse and reduced viral infection. It is indeed difficult to prove that investment in roads, electricity, mass transit, law enforcement and waste management indeed had a positive impact on these aspects.

As for the simulation method the researcher tried to show the connection between such investments and the total output taking into account also labour input. Its model involved dividing the capital into public and private investment, thus it managed to show how the public infrastructure influences private activity. This dividing up however had the disadvantage of collinearity which the author did not account for, that is, aggregate private returns to investment may also get taxed to finance future public investments.

Majority of these first works on energy and economic growth were published in the U.S from the late 1970's to the early 1980's. From this time onwards other developed countries have followed suit, also some works have involved cross country analyses which have included a combination of both DC's and LDC's.

However, there has been a few recognizable studies conducted for individual African countries, Chontanawat et al. (2008); Wolde-Rufael (2005) and Ebohon (1996) are some of the works that conducted a cross sectional study while Jumbe (2004); Odhiambo (2009) and Solarin (2011), investigated individual countries.

Chontanawat et al. (2008) investigated 30 OECD and 78 non OECD countries which also included a number of African countries. The Hsiao Granger method which incorporates Akaike Final Prediction Error criteria was the method used. Their findings indicated a stronger causal relationship among developed countries than in the developing ones. They further used Human Development Index to classify countries into the developing and the developing ones. The reasons for causality strength of the results favouring developed over developing countries were not explicitly shown nor suggested. But Wolde-Rufael (2005) on the other hand used Toda and Yamamoto approach and found mixed results for 19 African countries. The results were attributed to factors that are unaccounted for that influence economic structure of the countries. However, there was no explicit indication of such factors and how they cause a difference of results across countries. Ebohon (1996) examined Nigeria and Tanzania and observed two-way causality for both of them, he obtained these results using VAR granger method. In this study it was observed that the two countries have similar structure and therefore the study brought analogous results. Therefore, it can be seen in these exemplified works that apart from individual country exogeneity there is no consensus about the methodology put to use. This partially explains why the causality results differ from one researcher to the next.

Studies that focused on individual African countries such as Jumbe (2004) who used Co-integration and Error correction procedure, investigated energy growth causality for Malawi. He uses data from the time periods of 1970 to 1999 and finds two-way causality for the standard GDP, agricultural and non-Agricultural GDP. This study implicitly indicated that different sectors contributing to economic growth could have an important implication to causality direction. However, his results showed that electricity did not significantly granger cause agricultural GDP even though it is the dominant sector. But such results could be obtained because there is no data that indicate agricultural value addition which needs a set of inputs including electricity.

Odhiambo (2009) used the dynamic model (ARDL) bounds test to check the direction of causality; in his study there were two proxies for energy-growth study, the first was per capita energy consumption and the other was electricity consumption per capita. Even though the two proxies are different, the results did not show any significant variation. The study found that generally consumption of more energy is expected to spur economic growth. But the proxies difference was supposed to have significant implication in this study, because energy consumption incorporates grid and off grid electricity, thermal energy from wood, coal and charcoal some of which is not accounted for in the national records. Therefore, chances are that there were no enough records to justify the use of energy as a proxy in and of itself. For, per capita energy consumption refers to the average civilization's expenditure on renewable and non-renewable energy resources. These include the naturally radiant (sun), chemical (all fossil fuels including firewood and charcoal, others such as biofuels, uranium…), potential (waterfalls) and kinetic energy resources (wind, water and other free moving elements). While electricity consumption per capita is the amount of electricity used by average household, for the case of Tanzania this is supplied by the national grid after the most dominant energy resource in a particular location has been processed by power plants.

Therefore, by virtue of their definitions these two i.e. per capita energy consumption and electricity per capita cannot be equal nor have similar impacts to the economy.

The above results from Odhiambo (2009) are confirmed by Solarin (2011) even though he uses a different method of co-integration for Botswana and performs a trivariate investigation unlike the former who uses a bivariate method. In his study Solarin included also capital as one of the important inputs to real GDP, and using the production function framework he suggests a certain degree of substitutability between electricity consumption and capital input.

In this paper the interest is not so far from the previous researchers that is; to provide more information for policy making using Tanzania as a case study. The analysis extends what has already been done by Ebohon (1996); Odhiambo (2009) and Solarin (2011) by further subdividing GDP into sectors. Key issues include the choice of input allocation unto select sectors to spur economic growth, this is to be done considering also that these chosen sectors interlink through input-output mechanisms.

The results will be valuable to the public policy maker by indicating, as Jumbe (2004) among others have argued that if causality runs from energy production to GDP, then more electricity generation would significantly contribute to economic growth via a specified sector. Such a hypothesis confirming result would imply that there is a need for more electricity generation to attain desirable growth levels through its key productive sector/s.

While Masih and Masih (1997) argued that energy tightening policies could be implemented without adverse effects, meaning a country could focus less resources to electric power generation for industry. The results of a study that could support this argument would indicate a sector which is less dependent on electricity production. Thus, it is crucial for countries to first have an understanding of which side they stand with respect to these two trains of thought. From that point, an understanding of which sectors needs relatively more is a reasonable step. And such is the gap that this work intends to cover.

When investigating a country's Granger causality between electricity and growth four hypotheses can be identified (Acaravci & Ozturk,2010):

The first is no causality between GDP and energy consumption {this is the neutrality hypothesis}: In this hypothesis scholars such as Stern (2013) have found using a meta-analysis of the literature on Granger causality between energy consumption and growth that there is no evidence to support genuine causal effects. Asafu-Adjaye (2000) shows no granger causality in the short-run for India and Indonesia however in the long-run causality runs from energy to economic growth.

The second is unidirectional causality from growth to energy {the conservation hypothesis}: This hypothesis is supported by a number of studies such as Kraft & Kraft (1978); who used the granger causality test developed by Toda & Yamamoto (1995) and found that it was rather economic growth that promoted energy consumption consistent with others such as Ghosh (2002); Mehrara (2007); Soytas & Sari (2003) who also found unidirectional causality supporting conservation hypothesis. Aqeel & Butt (2001) also found the same using co-integration and Hsiao's version of Granger causality in a study conducted in Pakistan. However, this economic growth was observed to impact positively petroleum consumption with no direction of causality from natural gas. While the electricity supply is seen to have a positive causality on growth with no feedback. Therefore, showing "conservation hypothesis" on petroleum consumption and "growth hypothesis" on electricity and natural gas consumption.

The third is unidirectional causality from energy to economic growth {the growth hypothesis}: scholars who subscribe to this hypothesis are Aschauer (1989); Zaman et al. (2011) did their study in Pakistani using 36 annual observations (1975 – 2011) for nuclear, fossil fuels and electricity against industrial sector particularly beverages and cigarettes. The former approached the argument from the demand side while others such as Cantore (2011) examined it from the supply side by examining how total factor productivity is influenced by rising energy prices. They found that rising energy prices have negative impact on TFP except when interacted with research and development which leads to increased energy efficiency. Lean & Smyth (2010) did the same for Malaysia using augmented production function and disaggregated energy consumption and found unidirectional causality by non-renewable energy sources to economic growth regardless of the negative environmental costs. Odhiambo (2009) examined energy and electricity impacts on growth for Tanzania and also obtained similar deductions. In his work the recently developed method of Autoregressive Distributed Lag model was used. Its chief advantage being its ability to not be influenced by less large yearly observation range makes it useful for countries that do not yet have extensive records.

Lastly, bidirectional causality between energy and growth {this is the feedback hypothesis}: Scholars subscribing to it are such as Lise & Montfort (2007), who tried to examine energy consumption and GDP causality in Turkey using co-integration relationship. Huang et al. (2010) used different energy consumption raw materials (coal, oil, gas and electricity) to test for causal relation in Taiwan and the results show different directions of Granger causality. Oh & Lee (2004) also study data in Korea besides energy, labour and capital which are also considered to be important factors generating GDP and they also conclude a bi-directional causality.

As noted earlier on the importance of deducing the causality, Jumbe (2004) among others, has argued that if causality supports the "growth hypothesis" then an economy is energy dependent and any policy that negatively influences energy consumption will lead to a fall of income and employment. On the other side Masih & Masih (1997) have shown that if it supports the "conservation hypothesis" this implies an economy is not energy dependent and therefore it is possible to implement energy conservation policies without serious negative repercussions.

Thus, from previous discussions it has been apparent that the causality direction between energy and growth is still an enigma among scholars. On this argument, it can be safely deduced that the results are test and country specific and therefore it calls for scrutiny of individual countries' sectoral performance. This is done with an understanding of varying energy resource requirements, a characteristic structure that makes countries unique and therefore it is expected to influence the direction of causality on the whole.

Provided that the previous works in Tanzania by Ebohon (1996) using instantaneous Granger causality and Odhiambo (2009) who used ARDL and VAR gave conflicting results (with the former proposing dual causality while the latter supporting the growth hypothesis). This study extends the analysis by taking an approach that involves the breaking down of GDP growth into value added contributions from agriculture and manufacturing. The aim is to be able to clearly show the direction of causality between electricity production and the different sectors of the economy. Like Oh & Lee (2004), this study takes into account the other variables considered to influence the GDP which are labour and gross capital formation.

4: THEORETICAL FRAMEWORK

4.1. Theoretical aspects

This section highlights the theoretical underpinnings of the study. The inquiry into existing relationships between electricity production and economic growth is based on the neo-classical production function proposed by (Solow& Swan,1956).

For this analysis however, manufacturing is theoretically considered the sector of interest. The argument for such choice is based on the industrial classification of activities, where manufacturing is classified as a secondary industry while the agricultural sector is classified as primary industry[3]. Also, when considering the Solow & Swan model having its long-run assumption of growth driven by technological progress, it clearly reflects the situation in developing countries where growth in manufacturing sector is more or less stagnant, case in point Tanzania's manufacturing sector.

The general thrust of this inquiry is based upon the argument proposed by Kraft & Kraft (1978), Aschauer (1989) who suggested improvement of a society's developmental capacity as a result of public investment in its infrastructure. The infrastructure considered herein is electricity production which is a proxy for commitment by the responsible government or agencies to ensure energy security. The other aspect of investment is expected to be explained by gross capital formation. The analysis is founded upon a standard production function generically presented as:

$$MVA_t = f(CAP_t, ELPR_t, AGR_t, LABOUR_t) \text{---------------------------------------(i)}$$

Where "MVA" represents manufacturing value added, "CAP" represents gross-capital formation, "ELPR" represents total electricity production in kWh, "AGR" represents agriculture value added, "LABOUR" represents the labour input in terms of employable age population, all measured yearly. The study uses per capita values obtained by dividing this labour quantity against the rest:

$$\frac{MVA_t}{LABOUR_t} = f\left(\frac{CAP_t}{LABOUR_t}, \frac{ELPR_t}{LABOUR_t}, \frac{AGR_t}{LABOUR_t}, constant\right) \text{---------------------------------------(ii)}$$

Letting the constant value equal k, and the small caps to represent per-labour input values the generic expression becomes:

$$mva_t = f(cap_t, elpr_t, agr_t, k) \text{---(iii)}$$

---

[3]In this study for simplicity the primary industry will not include mining activities in Tanzania

Assuming also a Cobb-Douglas production function specification; as shown below, it is to be understood as the manufacturing sector productivity determined by gross capital formation, electricity production and output from the primary sector/agriculture- all values per working age population. The constant “k” may be thought of as not just a constant but a proxy of the overall industrial productivity of a country.

$mva_t = k \cdot cap_t^{\delta} \cdot elpr_t^{\tau} \cdot agr_t^{1-\delta-\tau}$--(iv)

For simplicity from this point onward "η" shall represent $(1 - \delta - \tau)$.

When natural logarithms are applied so as to transform the variables of the overall equation into linear logarithmic form, the following is the resulting expression:

$\ddot{mva}_t = \alpha + \delta \cdot \ddot{cap}_t + \tau \cdot \ddot{elpr}_t + \eta \cdot \ddot{agr}_t$; where "$\alpha$" $= \ln(k)$----------------------------(v)

Here the double dots accents imply the logged per-working age population values of the previously specified[4]. The to-be-obtained coefficients of inputs stand for individual input-elasticities of output with a restriction that they all must sum up to one. However, production functions have been observed to include an element of dynamic evolution particularly in technology, as such the speed of growth caused by the change of individual factors of production per worker significantly varies exogenously with context as suggested by (Solow & Swan,1956; Brown,1975).

Moreover, the variables included in the above production function are expected to interact with each other provided that this analysis is based upon macroeconomic parameters. These variables are also known to be subject to interdependence through input-output mechanisms, (Daly,1972; Agarwal,1996).

Such conditions challenge the standard OLS specifications rendering them less credible i.e. spurious regressions with unrealistic R^2 and most likely violating the asymptotic assumptions; where the t-statistic does not follow its expected distribution restricting the ability to confidently make statistical inference.

At this juncture it becomes necessary to consider causality tests so as to first map out the relationships between the variables of interest. This study uses the Granger method to further deduce the degree of causality between the two different yet interlinked sectors with electricity

[4]Individuals of working age i.e. 15-64 years

by means of a multivariate analysis. This is done so as to disentangle the utility sector found in the GDP accounts.

From the above linear-log setting, manufacturing sector is expected to take in output from the agricultural sector and electricity generation as inputs. However, the agricultural sector is itself expected to take in some material input from the manufacturing sector and electricity. Both sectors are also expected to take in gross capital formation as inputs. Also, it can happen that gross capital formation is influenced by activities in the manufacturing, agricultural sector and electricity consumption. Or that all these variables by virtue of their operational demand impose an impact on electricity consumption, such that the results would indicate causality flows to electricity.

This investigation therefore uses Granger Causality test and employs four procedures which are explained in the next chapter.

5: EMPIRICAL FRAMEWORK

Augmented Dickey-Fuller (ADF), a basic unit root test, is employed as the first step, the aim is to test stationarity of specified variables and at the same time control for autocorrelation of the residue term which would not be dealt with by the traditional Dickey Fuller. If the data is found to be stationary at levels i.e. not having unit root, the OLS estimation could be used; however, due to the model set up and the nature of parameters this strategy is not pursued. Conversely, the first differences are taken so as to transform the non-stationary data into stationary series. Second step involves the optimal lag length selection, this is determined so as to limit the error as much as possible when employing the Granger causality test and it is also useful for the bounds test. Third step involves an Autoregressive Distributed Lag model (ARDL), this co-integration test[5] is used for determining the short-run and long-run equilibrium relationships of the variables. The final step involves the Granger causality test which will show the direction of causality between the interlinked sectors of interest which are agricultural and manufacturing value addition versus electricity and capital input[6].

5.1. Augmented Dickey Fuller

Prior to using Granger-causality tests, a unit root test is employed, the aim is to determine the order of integration I(d). The test implemented in this study is used as a classification mechanism for discerning whether a variable is stationary or non-stationary. This classification is important for clarity since most time series data are known to be non-stationary, and such data when used tend to have meaningless regressions. Also, if the test results indicate presence of variables with the same order of integration, it can be considered as a sign that these are co-integrated. Such co-integrated variables are also known to have nonstandard distributions, and hence contribute to spurious regression results. The ADF test also informs on the order of integration in this study where the ARDL method is implemented to check for co-integration. It is important to remember that for it to be valid it is required that none of the variables be integrated of order two i.e. I(2). This is because the method of ARDL is said to be functional when the variables of interest are either all integrated of order 0 or of order 1 or both.

This method of testing for unit root (ADF) proposes three models, the main focus of the test is whether the coefficient of a lagged variable in this case θ_0 equals zero. If such a condition is fulfilled, then the specified variable is said to follow a stochastic process. The alternative to

[5] The method is put to use due to ADF not providing conclusive results on their tests as one non-stationary and another stationary parameter may have stationary co joined movements

[6] Labour is included as working age population as highlighted in the theoretical framework

this condition is that the coefficient θ_0 be less than nought, when this is fulfilled the variable of interest is considered stationary. In the equations below "Y_t" will generically stand to represent each one of the variables under study i.e. $\{m\ddot{v}a, el\ddot{p}r, c\ddot{a}p, a\ddot{g}r\}$; ΔY_t; will represent the first difference of the original "Y_t". While 'μ' represents intercept, 'T' is time trend, "p" represents the optimal lag at which the lagged value of a variable is significant; "ε_t" is the residual of the time series. The paper therefore applies ADF for all four series of variables as specified above. Each of these testing models has its assumption which all together constitute the ADF unit-root test, details on the assumptions and their hypotheses are specified below;

Model 1: Assumption -Neither intercept nor trend/Plain random walk

$\Delta \mathbf{Y}_t = \theta_0 \mathbf{Y}_{t-1} + \sum_{t=1}^{p} \theta_t \Delta \mathbf{Y}_{t-1} + \varepsilon_t$---(vi)

Null hypothesis (H_0): Is that "Y_t" follows a random walk process such that [θ_0=0];

Alternative hypothesis (H_1): proposes that "Y_t" follows a stationary process such that [θ_0<0]

Model 2: Assumption -Intercept only/Random walk around a drift

$\Delta \mathbf{Y}_t = \mu + \theta_0 \mathbf{Y}_{t-1} + \sum_{t=1}^{p} \theta_t \Delta \mathbf{Y}_{t-1} + \varepsilon_t$---(vii)

H_0: "Y_t" follows a random walk around a drift i.e. [θ_0=0, μ≠0];

H_1: follows level stationary process i.e. [θ_0<0, μ≠0]

Model 3: Assumption -Intercept and trend/Random walk around a trend

$\Delta \mathbf{Y}_t = \mu + \theta_0 \mathbf{Y}_{t-1} + \beta T + \sum_{t=1}^{p} \theta_t \Delta \mathbf{Y}_{t-1} + \varepsilon_t$---(viii)

H_0: "Y_t" follows a random walk around a trend i.e. [θ_0=0, β≠0]

H_1: "Y_t" follows a trend stationary process i.e. [θ_0<0, β ≠0]

Observe also how all the tests conducted are one tailed; according to the ADF specification $\theta = (1 - \rho)$so that when"ρ" equals 1, the variable is said to have unit root i.e. non stationary while when $\rho < 1$ the variable is said to not have unit root and hence stationary. Under the null it is understood that $\hat{\theta}$ is biased downward, it is also for this reason that the tests are one tailed (Greene,2008).

5.2. Autoregressive Distributive lag model

After the unit root test (ADF) has been employed whose null hypothesis I(1) is tested against I(0), the end results will determine which series are stationary and which ones are not. Due to the fact that a stationary process signals the existence of a long-run relationship among the variables of interest[7] and that such a co-integrated relation is potentially plagued with nonstandard distributions considered harmful to empirical analysis. A co-integration test is thus used to confirm the presence or absence of it. This is done so as to avoid treating variables with long run co-joined movements as ones not having it within the Granger causality test framework. The test of choice in this study is ARDL, this method is preferred because it can be used to analyse the co-integration relation between variables that are I(1), I(0) or when used in combination.

5.2.1. The optimum lag selection

In order to select the desirable lag for our next procedure the Autoregressive Distributive lag model one ought to employ a lag selection criterion. In this study Akaike's information criterion (AIC) Akaike (1969) and the Schwarz's Information Criterion (SIC) Schwarz (1978) are put to use. Their formulae are presented below;

I. SIC = ln |Ǹ| + ln N/T (number of freely estimated parameter) --------------------(viii)

II. AIC = ln |Ǹ| + 2/N (number of freely estimated parameter): -----------------------(ix)

Whereby, Ǹ is the estimated covariance matrix and N is the number of observations. These two methods are known to give consistent results however, SIC is prioritised in this study; because according to Monte Carlo experiments it has been argued that SIC offers potentially more useful combination approach. This provides enough justification for this study to base its empirical scrutiny upon it. Provided that a linear combination of two or more non-stationary series may be stationary, and if it so happens in this investigation the series will be considered to have a long-run equilibrium relationship i.e. Co-integrated. (Engle & Granger,1987)

To investigate presence of such long-run relationships between electricity and the other variables under our consideration, the bounds test for co-integration within ARDL (the Autoregressive Distributed Lag) modelling approach is adopted as the next step. The model was developed by Pesaran et al. (2001) and can be applied irrespective of the order of integration of the variables (irrespective of whether the variables are purely **I**(0), purely **I**(1) or mutually co-integrated). This method has the advantage of being consistent even with limited time series observations, this is convenient for a country with limitations on data availability

[7] Even for nonstationary series the assumption of co-integration is not readily rejected without a test

5.2.2. The ARDL bounds test

Before conducting Granger Causality analysis on the variables manufacturing, agriculture, electricity and gross capital formation first it must be determined whether or not any of the variables are co-integrated. This is because co-integrated variable….

The hypothesis examined with ARDL co-integration test is applied as follows;

H_0: The null hypothesis is that there is no co-integration relationship between the variables

H_1: There is co-integration relationship

Particularly;

i. Accept H_0 if and only if |F-test statistics|<|Lower bounds F-critical value|
ii. Reject H_0 if |F-test statistic|>|Upper bounds F-critical value|
iii. Inconclusive results if |Lower bound value|<|F-statistic|<|Upper bounds value|

Based on the above decision rule, the rejection of H_0 implies there is co-integration and in fact the series are expected to move together in the long-run. The following are their testing equations:

$$\Delta m\ddot{v}a_t = \alpha_0 + \sum_{i=1}^{n}\alpha_{1i}\,\Delta m\ddot{v}a_{t-i} + \sum_{i=1}^{n}\alpha_{2i}\,\Delta el\ddot{p}r_{t-i} + \sum_{i=1}^{n}\alpha_{3i}\,\Delta c\ddot{a}p_{t-i} + \sum_{i=1}^{n}\alpha_{4i}\,\Delta a\ddot{g}r_{t-i} + \alpha_5 m\ddot{v}a_{t-1} + \alpha_6 el\ddot{p}r_{t-1} + \alpha_7 c\ddot{a}p_{t-1} + \alpha_8 a\ddot{g}r_{t-1} + \varepsilon_{1t} \text{------------ [1]}$$

$$\Delta el\ddot{p}r_t = \beta_0 + \sum_{i=1}^{n}\beta_{1i}\,\Delta el\ddot{p}r_{t-i} + \sum_{i=1}^{n}\beta_{2i}\,\Delta m\ddot{v}a_{t-i} + \sum_{i=1}^{n}\beta_{3i}\,\Delta c\ddot{a}p_{t-i} + \sum_{i=1}^{n}\beta_{4i}\,\Delta a\ddot{g}r_{t-i} + \beta_5 el\ddot{p}r_{t-1} + \beta_6 m\ddot{v}a_{t-1} + \beta_7 c\ddot{a}p_{t-1} + \beta_8 a\ddot{g}r_{t-1} + \varepsilon_{2t} \text{------------ [2]}$$

$$\Delta c\ddot{a}p_t = \gamma_0 + \sum_{i=1}^{n}\gamma_{1i}\,\Delta c\ddot{a}p_{t-i} + \sum_{i=1}^{n}\gamma_{2i}\,\Delta el\ddot{p}r_{t-i} + \sum_{i=1}^{n}\gamma_{3i}\,\Delta m\ddot{v}a_{t-i} + \sum_{i=1}^{n}\gamma_{4i}\,\Delta a\ddot{g}r_{t-i} + \gamma_5 c\ddot{a}p_{t-1} + \gamma_6 el\ddot{p}r_{t-1} + \gamma_7 m\ddot{v}a_{t-1} + \gamma_8 a\ddot{g}r_{t-1} + \varepsilon_{3t} \text{------------- [3]}$$

$$\Delta a\ddot{g}r_t = \delta_0 + \sum_{i=1}^{n}\delta_{1i}\,\Delta a\ddot{g}r_{t-i} + \sum_{i=1}^{n}\delta_{2i}\,\Delta c\ddot{a}p_{t-i} + \sum_{i=1}^{n}\delta_{3i}\,\Delta el\ddot{p}r_{t-i} + \sum_{i=1}^{n}\delta_{4i}\,\Delta m\ddot{v}a_{t-i} + \delta_5 a\ddot{g}r_{t-1} + \delta_6 c\ddot{a}p_{t-1} + \delta_7 el\ddot{p}r_{t-1} + \delta_8 m\ddot{v}a_{t-1} + \varepsilon_{4t} \text{------------ [4]}$$

In the equations [1] through [4] Δ is the first difference operator; $\{m\ddot{v}a_t, el\ddot{p}r_t, c\ddot{a}p_t, a\ddot{g}r_t\}$ stands for the natural log of per-capita manufacturing value added, electricity production, capital formation and agricultural value added respectively. On the other side $\{\epsilon_{1t}\epsilon_{2t}\epsilon_{3t}\epsilon_{4t}\}$ are assumed to be serially independent random errors with mean zero and finite covariance matrix for equation 1 through 4 respectively.

Again in these equations [1-4], the F-test is used for investigating long-run relationships. In the case of one or more long-run relationships, the joint F-test on above [1-4] equations is done under the null hypotheses of none existing co-integration. They are presented in their respective order as H_0: $\alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = 0$: $\beta_5 = \beta_6 = \beta_7 = \beta_8 = 0$: $\gamma_5 = \gamma_6 = \gamma_7 = \gamma_8 = 0$: $\delta_5 = \delta_6 =$

$\delta_7 = \delta_8 = 0$. The F-test is considered in determining whether a long-run relationship exists among the variables through testing the significance of lagged levels of the variables. As previously hinted if the computed F-statistic exceeds the upper critical value there is co-integration; if the F-statistic falls within the two bounds of critical values then the test becomes inconclusive and finally, if the F-statistic is below the lower critical value, it implies no co-integration. In the case of existing co-integration based on the bounds test, the Granger causality test will have to be done under Vector Error Correction Model specification (VECM). By doing so, the short-run deviations of series from their long-run equilibrium path are also captured by including an error correction term otherwise the study uses Vector Auto Regressive Granger causality test (VAR).

5.3. The Vector Error Correction Model

Since there is a chance from the ARDL test above, of some variables having co-joined interactions in the long-run, a method is available for analysis of intertemporal Granger causality, and the method is VECM. (Granger,1988).

The model estimation in this study is done basing on a proportional long run relation of the form:

$$M_t \propto E_t * A_t * C_t$$

Where M stands for Manufacturing, E for electricity, A for agriculture and C for capital formation all measured per workers in this investigation.

Assuming the equilibrium long run relation (Keele & De Boef,2004);

$M_t = Z * E_t * A_t * C_t$---(x)

After taking natural logs, the equation becomes;

$m_t = z + e_t + a_t + c_t$--(xi)

Trying to get the general dynamic relation between manufacturing and the other variables;

This leads to a regression between the choice variable against its own lag of one period together with the explanatory variables at time t and their respective single lags.

$m_t = \alpha_0 + \alpha_1 e_t + \alpha_2 e_{t-1} + \alpha_3 a_t + \alpha_4 a_{t-1} + \alpha_5 c_t + \alpha_6 c_{t-1} + \lambda_1 m_{t-1} + \mu_t$-----------(xii)

To make this dynamic equation correspond to the long run equilibrium as specified in the previous equation (xi) above, all time variant factors together with the stochastic error term are averaged out so that;

$m_t = \overline{m}_t;\ e_t = \bar{e}_t;\ a_t = \bar{a}_t;\ c_t = \bar{c}_t;\ \mu_t = 0$

The dynamic model then becomes;

$$\overline{m}_t = \alpha_0 + \alpha_1\bar{e}_t + \alpha_2\bar{e}_t + \alpha_3\bar{a}_t + \alpha_4\bar{a}_t + \alpha_5\bar{c}_t + \alpha_6\bar{c}_t + \lambda_1\overline{m}_t$$

After simplification collecting like terms and factoring out;

$$(1-\lambda_1)\overline{m}_t = \alpha_0 + (\alpha_1+\alpha_2)\bar{e}_t + (\alpha_3+\alpha_4)\bar{a}_t + (\alpha_5+\alpha_6)\bar{c}_t$$

Dividing through by the multiplicative factor of $\overline{m}_t$

$\overline{m}_t = \frac{\alpha_0}{(1-\lambda_1)} + \frac{(\alpha_1+\alpha_2)}{(1-\lambda_1)}\bar{e}_t + \frac{(\alpha_3+\alpha_4)}{(1-\lambda_1)}\bar{a}_t + \frac{(\alpha_5+\alpha_6)}{(1-\lambda_1)}\bar{c}_t$---------------------------------------(xiii)

If this above equation corresponds to equation (xi), which is the long run equilibrium then;

$$\frac{\alpha_0}{(1-\lambda_1)} = z$$

And

$$\frac{(\alpha_1+\alpha_2)}{(1-\lambda_1)} = \frac{(\alpha_3+\alpha_4)}{(1-\lambda_1)} = \frac{(\alpha_5+\alpha_6)}{(1-\lambda_1)} = 1$$

For the above to be valid we further assume that;

$$(\alpha_1+\alpha_2) = (\alpha_3+\alpha_4) = (\alpha_5+\alpha_6) = (1-\lambda_1)$$

Introducing now the error correction term coefficient as the Greek letter – phi:

Let $\phi = (1-\lambda_1)$, so that $\alpha_2 = \phi - \alpha_1; \alpha_4 = \phi - \alpha_3; \alpha_6 = \phi - \alpha_5$ & $\lambda_1 = 1 - \phi$

Then equation (ii) becomes

$$m_t = \alpha_0 + \alpha_1 e_t + (\phi - \alpha_1)e_{t-1} + \alpha_3 a_t + (\phi - \alpha_3)a_{t-1} + \alpha_5 c_t + (\phi - \alpha_5)c_{t-1} + (1-\phi)m_{t-1} + \mu_t$$

After manipulation and collection of like terms;

$\Delta m_t = \alpha_0 + \alpha_1\Delta e_t + \alpha_3\Delta a_t + \alpha_5\Delta c_t - \phi[m_{t-1} - e_{t-1} - a_{t-1} - c_{t-1}] + \mu_t$-----------(xiv)

In this model $[m_{t-1} - e_{t-1} - a_{t-1} - c_{t-1}]$ is the error correction term and ϕ its coefficient. This model relates changes in one variable against changes in others, while taking into account the gap in the estimations of the immediate previous time.

This error correction coefficient is expected to be negative in this study because it corrects the degree to which the dependent variable exceeds the previous year's estimation.

The results from this test are expected to indicate how Granger-causality is observed among the variables of interest at different time dimensions i.e. at the short-run and the long-run. From the previous bounds test the study proceeds by the appropriate choice for the causality test, as highlighted above if the bounds test results imply a decision rule to reject the null hypothesis then the Granger model is to be estimated under the unrestricted error correction specification.

Here below are the actual models used for its estimation;

$$\Delta mva_t = \alpha_0 + \sum_{i=2}^{p} \alpha_{1i}\, \Delta mva_{t-i} + \sum_{i=2}^{p} \alpha_{2i}\, elpr_{t-i} + \sum_{i=2}^{p} \alpha_{3i}\, \Delta cap_{t-i} + \sum_{i=2}^{p} \alpha_{4i}\, \Delta agr_{t-i} + \theta_1 ECT_{t-1} + \varepsilon_{1t} \text{-- [5]}$$

$$\Delta cap_t = \gamma_0 + \sum_{i=2}^{k} \gamma_{1i}\, \Delta cap_{t-i} + \sum_{i=2}^{k} \gamma_{2i}\, \Delta elpr_{t-i} + \sum_{i=2}^{k} \gamma_{3i}\, \Delta mva_{t-i} + \sum_{i=2}^{k} \gamma_{4i}\, \Delta agr_{t-i} + \theta_2 ECT_{t-1} + \varepsilon_{2t} \text{-- [6]}$$

$$\Delta agr_t = \delta_0 + \sum_{i=2}^{j} \delta_{1i}\, \Delta agr_{t-i} + \sum_{i-2}^{j} \delta_{2i}\, \Delta cap_{t-i} + \sum_{i=2}^{j} \delta_{3i}\, \Delta elpr_{t-i} + \sum_{i-2}^{j} \delta_{4i}\, \Delta mva_{t-i} + \theta_3 ECT_{t-1} + \varepsilon_{3t} \text{ -- [7]}$$

ECT_{t-1} Represents the lagged error correction term derived from the long-run co-integration model. Finally, according to the ECM for causality tests, having negative coefficient and statistically significant F and t-ratios for ECT_{t-1} in equations (5) to (7) would be enough condition to indicate long-run Granger causality.

If the null hypothesis of the bounds test is not rejected the Granger causality test is to be done basing on standard VAR model which is identical to the already specified above with exception of its non-inclusion of the error correction term (ECT). The letters “p”, “k” and “j” stand for the optimal lags for each of the variables as obtained in step (II) of lag selection prior estimating the ARDL; “t” represents the time periods and α, γ & δ are coefficients for each of the variables’ estimated parameters respectively. In the final results table, they are reported as short-run and long-run vales each depending on the specification of the model; θ denotes the coefficient of ECT, it should have negative sign in order for co-integration to exist which would confirm long-run causality relationship.

Right here below is a presentation of the VAR specification for electricity:

$$\Delta elpr_t = \beta_0 + \sum_{i=1}^{q} \beta_{1i}\, \Delta\, mva_t + \sum_{i=1}^{q} \beta_{2i}\, \Delta cap_t + \sum_{i=1}^{q} \beta_{3i}\, \Delta agr_t + \sum_{i=1}^{q} \beta_{4i}\, \Delta elpr_{t-1} + \varepsilon_t \text{---[8]}$$

In the results table what shall be reported are the Wald test results which indicate Granger causality as per the above specification.

Thus, these equations are used with intent to capture Granger causality between the two sectors manufacturing value added and agriculture value added together with gross capital formation (observed to significantly contribute Tanzania’s economic performance) vis-à-vis electricity production. In addition to that these models [5] through [8] have been presented as a final granger causality examination after knowing which variables are co-integrated and which ones are not (the non-co-integrated variable is electricity while the rest are co-integrated)

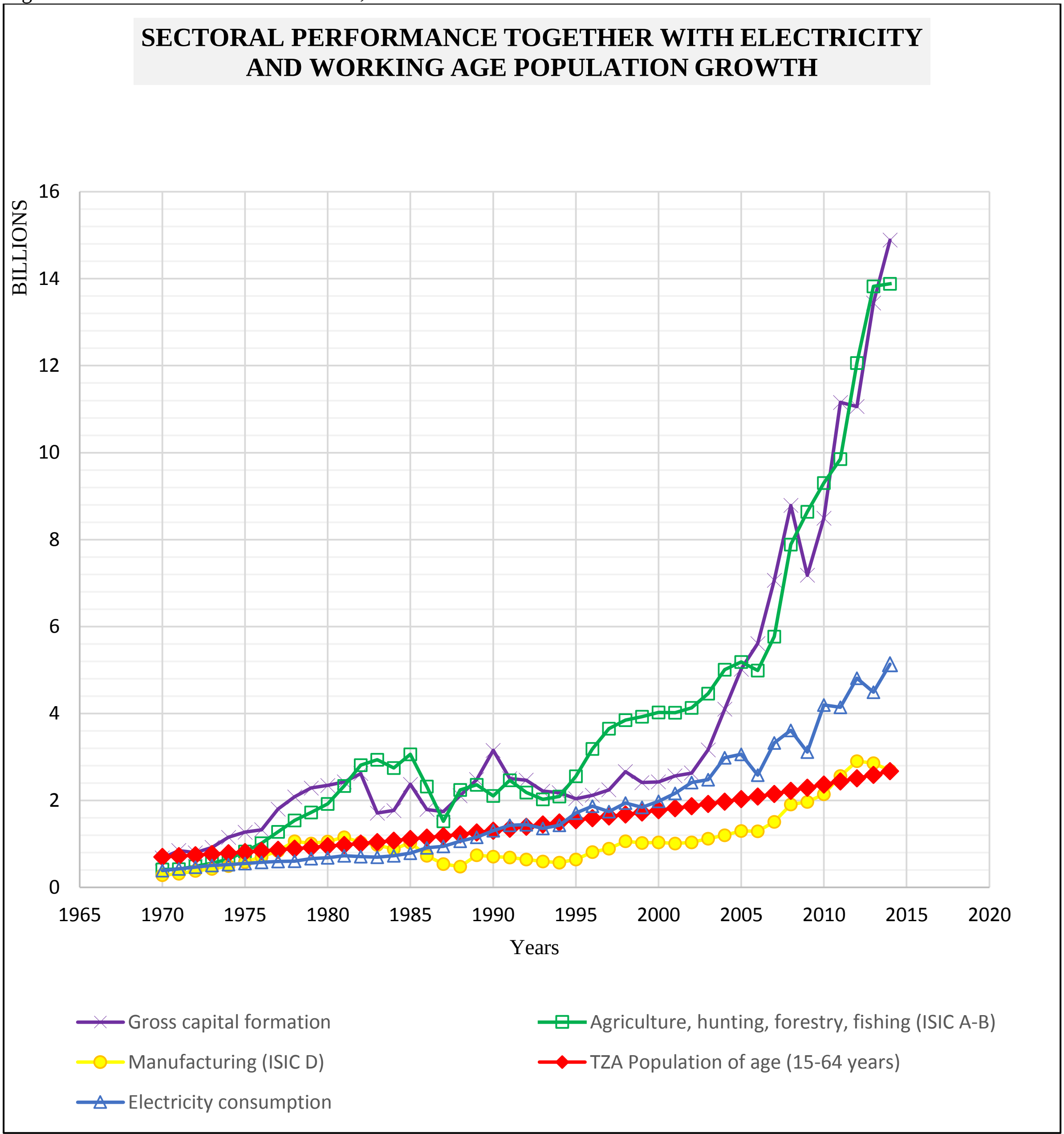
5.4. Data

The study uses time series data from 1970 to 2014, during this period of time Tanzania has undergone significant changes due to varied political environment. The specific series are total electric power consumption measured in Kilowatt-hours (kWh), labour input obtained as a product of the percent of individuals in range of 15 to 64 years and the total population in a specified year. These first two data series were obtained from the World Bank Development Indicators (WDI,2015).

The following last three data series have been measured in 2015 US$, sourced from United Nations Statistical database for the same range (from 1970 to 2014) as the previous; these are manufacturing value added, gross-capital formation, which here-in to a certain extent is acknowledged to proxy for public investment in infrastructure as proposed by Aschauer (1989), however this type of reasoning could also be true for electricity production. The final of the three is agricultural value added which includes above the traditional crop cultivation and animal husbandry- hunting, forestry and fishing.

Figure 3, below is a time series plot of the described data before their transformation into per working population log values;

Figure 3: SECTORAL PERFORMANCE, WORKING AGE POPULATION AND ELECTRICITY CONSUMPTION



(Data source: WDI, 2015 & UN statistics, 2015)

The motive behind inclusion of manufacturing and agricultural sector output as value added are so as to specifically avoid pitfalls brought about by the following issues;

Firstly, double counting of electricity generation; majority of previous studies have used GDP values which are considered the sum of value added in a given year. Under such considerations, the GDP also includes the value added by utilities wherein there is electricity production the variable of interest. This puts electricity among the groups considered as intermediate sectors. Therefore, this paper proposes that individual sectors such as manufacturing and agricultural value added could provide more information about the direction of causality than previously investigated if independently studied with electricity production.

The second issue is Collinearity; it follows naturally that some sectors feed each other in the form of input-output matrix, by separating each sector in accordance to its addition to final output value it becomes more feasible to get wiggle room for reliable statistical examination of their relationships with the absence of noise from the connective sectors.

As for the choice of manufacturing instead of GDP or GNI, it is because the author believes that in such investigations country's national income only tell half the story. In order for one to clearly show how commercial energy impacts economic growth one has to first understand how the growth contributing sectors are themselves influenced by electricity. And therefore, a vibrant manufacturing sector indicates the extent of productive organisation and their supportive institutions in place such as property rights, enforceable contracts and patents creation and protection as discussed by (Djankov et al.,2003).

Regarding the data and statistics put to use in this study, it is important that they be interpreted with discretion, this is due to the history of Tanzania as a country and its relations with other foreign nations more advanced than it.

It has been shown historically that ever since its independence from the British rule in 1961 Tanzania had become one of the favourite recipients in the international aid community. This extended from the period 1962 to 1983 and involved funding aggressive socialist ideology in the form of Ujamaa policy (Edwards,2014).

The policy called for a controlled agglomeration of productive forces in villages called Ujamaa villages (which is Swahili word for oneness of a people/being related). At the time all households which ideally represented clusters of nuclear families had to reside in select villages where social services could easily be provided by the government and their labour force put to the task for the development of the nation as a whole. The chief characteristic of this policy was that it called for unity and an environment of egalitarianism. (Boesen,1976)

Though considered unpopular in the west this system managed to instil a sense of belonging to the heterogeneous tribes of the region and called for a oneness of purpose to achieve economic development. It has however been criticised for not having directly showed improvement of productivity and for not having a long term strategy but rather responding to the needs of the proletariat. Nevertheless, an analogous system was in place earlier on in the state of Israel under the name Kibbutz and has survived till this new age of advanced technology.

There is evidence however that the aid that came from the Nordic countries at that time might have distorted the incentives and provided a breeding ground for corruption. Some have also argued that the IMF used aid to incentivise the Tanzanian economy away from committing to its ideology in the 1980s through structural adjustment programs. Other aspects also suspected for its failure include the war against Iddi Amin in the 1978, drought of the 1974 - 1975 together with the oil price shocks of the 1973 and 1979. All these had their share impact on the Tanzanian economy at the time. (Edwards,2014)

When it became apparent that the Socialist policy has failed in the 1986 the next administration (after Mwalimu J.K. Nyerere) embarked on economic liberalization. This constituted also abiding by the stipulated conditions by the IMF such as breaking down some of the parastatals, reduction of deficit spending and devaluation of the Tanzanian shilling. This was further incentivised by increased grants up to 96% per capita values more than in the previous years before the reforms. Also there is evidence that the country has always been donor dependent getting financial support through program and budget support even up to the late 2011 (Edwards,2014)

This means that the data that is used in this study i.e. from 1970 to 2014 provided that it falls within this time period, is bound to be distorted by the windfall gains of the Official development assistance. And therefore an argument can be put forward that it may be difficult to statistically measure the actual sector's performance during these years especially late 1970s to the early 1980s where significant reforms were made.

Also, the constant change of the political environment ensures that the previous investments that were prioritised by the passing administration are either ignored or replaced by the new ones that ensure legacy of the incumbent. This is symptomatic for lack of a long term Tanzanian economic strategy from which the different administrations must adhere to.

However, this analysis is not focused on the drivers or sources of funding for various public investments. The investigation rather seeks the perspective of what's been available i.e. tax revenues or budget assistance and with it paints a long-run picture of how resources have been allocated. Also, the manufacturing and agricultural sectors which both involve to a larger extent the private sector at least recently offer a view about how the public investment has created an environment suitable for the private sector to flourish as it generates value.

In this investigation the four variables observed in previous Figure 3 above i.e. manufacturing, electricity consumption, agriculture and capital formation are transformed through dividing by specified labour input to obtain values relative to the working age population.

5.5. Diagnostics

Residue plots are used in this study with a target of giving a visual impression about the randomness of the error terms. If the error term is relatively less random then this will indicate a certain level of non-stochastic process in the residue which is supposed to be stochastic.

From the residue plots some of the variables may indicate non-random distribution. In order to determine the source of this non- stochastic distribution the Autoregressive Conditional Heteroscedasticity (ARCH) test for conditional heteroscedasticity is implemented to check first the existence of this condition as illustrated below (Greene,2008);

Provided a standard OLS specification:

$Y_t = \beta' X_t + \varepsilon_t$--(xv)

It can happen for a select lag length q that;

The residue is a function of its autoregressive function up to lag q and a certain random variable h. Thus: -

$\varepsilon_t = h_t \sqrt{\alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \varepsilon_{t-2}^2 + \cdots + \alpha_q \varepsilon_{t-q}^2}$------------------------------------(xvi)

Whereby h_t is normally distributed having a mean 0 and a variance of 1

$h_t \sim \mathrm{N}(0,1) \wedge \mathrm{E}[\varepsilon_t | X_t, \varepsilon_{t-1}] = 0 \leftrightarrow \mathrm{E}[\varepsilon_t | X_t = 0 \wedge \mathrm{E}[Y_t | X_t] = \beta' X_t$

This is a classic regression model; however,

$$Var[\varepsilon_t | \varepsilon_{t-1}] = \mathrm{E}[\varepsilon_t^2 | \varepsilon_{t-1}] = \mathrm{E}\{\left[h_t \sqrt{\alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \varepsilon_{t-2}^2 + \cdots + \alpha_q \varepsilon_{t-q}^2}\right]^2\}$$

$\therefore \ Var[\varepsilon_t | \varepsilon_{t-1}] = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \varepsilon_{t-2}^2 + \cdots + \alpha_q \varepsilon_{t-q}^2$--------------------------(xvii)

This last equation means that the disturbance term of the estimation ε is heteroscedastic with respect to ε_{t-1} and not with respect to the independent variables as usual. This will be performed because the estimated Error Correction Model was done under the assumption of homoscedastic variances. However, provided that this is a time series study, if heteroscedasticity is at all detected then it is not likely to be unconditional (Weiss,1986).

If the test indicates the presence of such a condition the model will be re-estimated taking into account, the ARCH (q) effects (Greene,2008).

What the re-estimation does, is to report the above last model of the conditional variance up to the select lag length where the ARCH effect has been observed to be present. The results table will also show the re estimated coefficients with the dependent and independent variables as before the re estimation.

In testing for the stability of the process used to obtain the ECM estimates, the study utilised the Brown, Durbin and Evans (1975) test popularly known as the minimax sequential probability test aptly known as (**CUSUM**). Its results are based on the recursive regression residuals squares summation. According to Chatterjee & Qiu (2009) it is one of the dominant statistical process controls (SPC); in this scenario it is used to ensure that the error terms follow an "in control distribution" which in this case is assumed to be normally distributed. The points are updated recursively and plotted against the model's break point which is the average run length (ARL). In this study the ARL is set as the probability of Type 1 error. Thus, the coefficients of a given regressions are stable if the plots of the statistics fall within critical bounds of 5% significance; otherwise they are considered to not follow the "in control distribution" which renders the estimates generated by them unstable (Tartakovsky,1995).

This will raise a question of how trustworthy can these results be for policy and effective strategy.

Ramsey reset test is also employed to check for the specification of the Error Correction Model. What is done is to estimate an auxiliary regression and reporting whether or not the added variables proved significant. If found significant then the specification could be inferred to be incorrect (Gujarati,2003).

The investigation also conducts a check for whether or not the estimated model satisfies the normality assumption, the tests employed is the Doornik & Hansen test. The justification for the use of it, is to be able to control for size and power of the test i.e. could provide results even for small samples, as small as 10 observations having the test statistic with a Chi-square distribution (Doornik & Hansen,2008).

6: RESULTS

6.1. Augmented Dickey Fuller Test

Augmented Dickey Fuller unit root test is the first step to be performed in order to test the stationarity of the variables of interest; manufacturing value added, gross capital formation, electricity consumption and agricultural value added i.e. mva, cap, elpr and agr respectively.

Table 1: Unit root test using Augmented Dickey Fuller

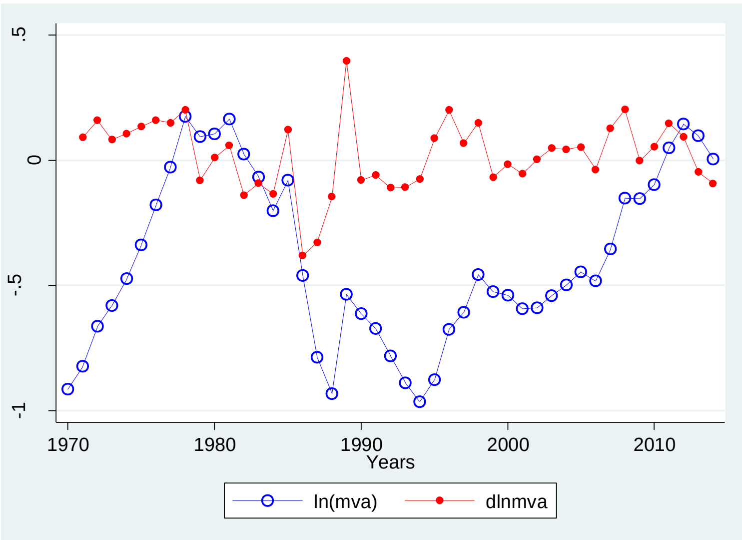
	$m\ddot{v}a_t$			$c\ddot{a}p_t$			$el\ddot{c}n_t$			$a\breve{g}r_t$		
Z(t)-ADF model No.	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Level	-1.8	-1.6	-1.5	N.A	-0.6	-1.1	-0.7	-0.6	-4.2**	N.A	-1.5	-1.8
1st Diff.	-4.8***	-4.8***	-4.8***	-6.2***	-6.4***	-6.5***	-8.6***	-9.7***	N.A	-4.9***	-5.4***	-5.3***
Conclusion	**I(1)**	**I(1)**	**I(1)**	**I(1)**	**I(1)**	**I(1)**	**I(1)**	**I(1)**	**I(0)**	**I(1)**	**I(1)**	**I(1)**
Null Hypothesis is that there is a unit root												

*, **, *** Imply stationarity at 10%, 5%, and 1% level of significance respectively.

The above table illustrates the results of ADF unit root test. It indicates that all variables tested stationary at first differences I(1) with exception of electricity production at Model specification 3. These variables observed to be integrated of order one in all three model specifications imply to have no unit root at first difference. Therefore, from the results we can comfortably reject the null hypothesis of non-stationarity for all other variables with exception of electricity production.

Right below is a graphical description of the four variables at level and at first differences;

Figure4:MANUFACTURING VALUE ADDED AT LEVELS AND AT FIRST DIFFERENCE

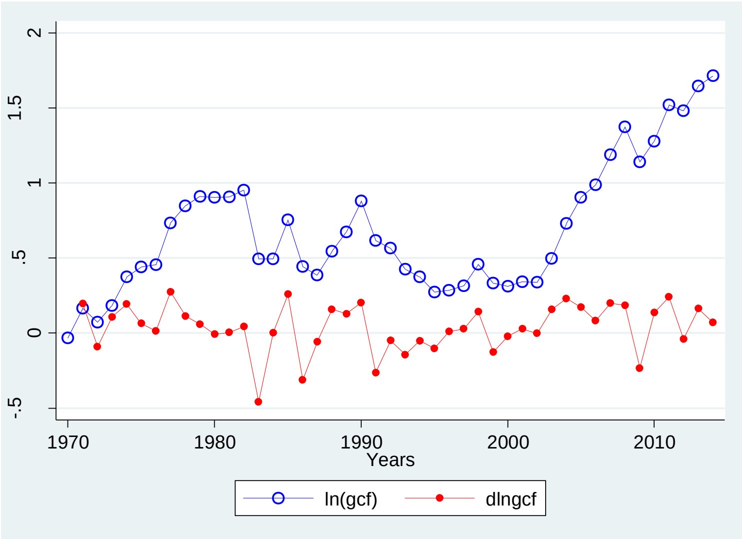


The variables understudy are natural logs of the original data series

(Data Source: UN statistics, 2015)

Where the blue line with hollow circular mark depicts the natural log of manufacturing value addition per worker population for Tanzania at levels, the red line together with full dot present the same values at first difference. Observe that unlike at levels the values at first difference seem to vary but not far from the value 0; this can be considered the mean value of the distribution, and thus if a series does change signs along its mean value then it is considered stationary.

Figure 5: GROSS CAPITAL FORMATION AT LEVELS AND AT FIRST DIFFERENCE

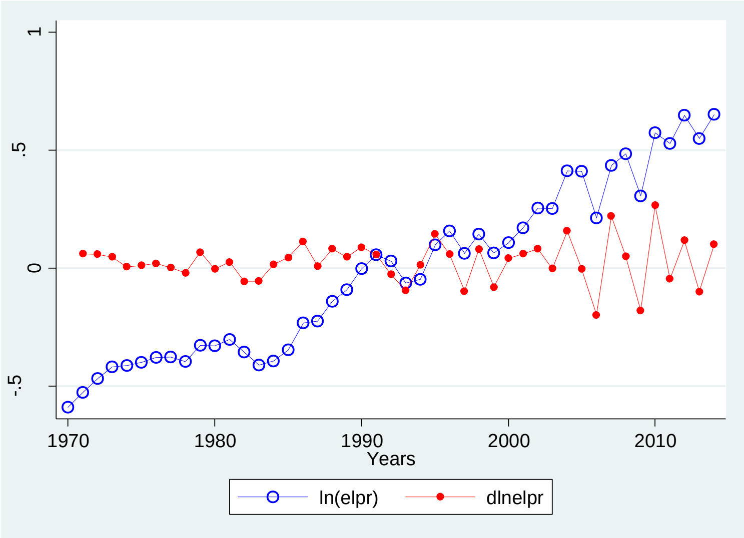


The variables understudy are natural logs of the original data series

(Data Source: UN statistics, 2015)

As in the previous graph; the blue line represents gross capital formation per workers' population in Tanzania at levels while the red line represents the same but at first difference. The values at levels are observed to be increasing from the 0 line which is analogous to the mean of the distribution. However, the values at first difference are seen to fluctuate and change signs but not far from the 0 line this is an indication that this data is stationary at first difference.

Figure 6: ELECTRICITY CONSUMPTION AT LEVELS AND AT FIRST DIFFERENCE

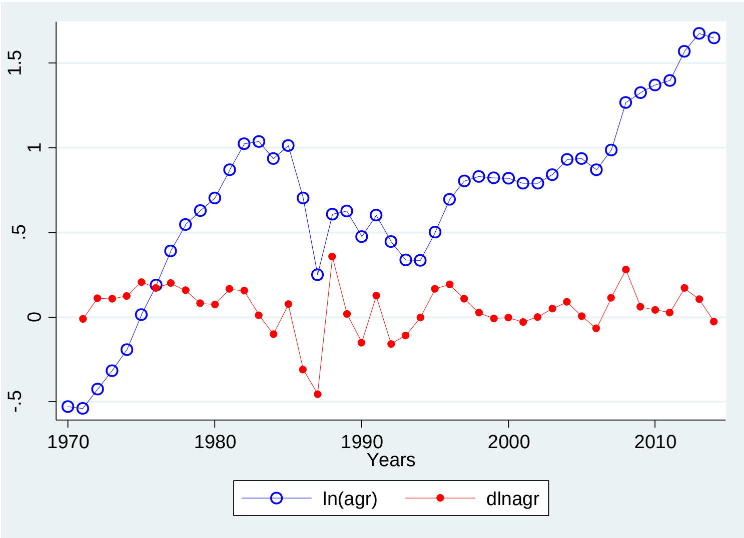


The variables understudy are natural logs of the original data series

(Data Source: WDI,2015)

The data for electricity consumption per working population in Tanzania at levels (coded blue) is observed to have a random process that is also accompanied by a trend. However, when it is first differenced (coded red) it is observed to vary close to the 0 line, the interesting case is found between the years 2000 and 2010 where there is an observable randomness along the 0 line. This could also partly explain why the Augmented Dickey Fuller test indicated it to be stationary at levels around a trend.

Figure 7:AGRICULTURAL VALUE ADDED AT LEVELS AND AT FIRST DIFFERENCES



The variables understudy are natural logs of the original data series

(Data Source: UN statistics, 2015)

The two line graphs depict the natural logs of agriculture value addition per working population with the blue line representing values at level while the red line represents the first difference. Indeed, after first differencing the graph seem not to vary away significantly from the 0 line, this indicates that this procedure did reduce non stationarity that was found in the original series. Thus, this variable is stationary at first difference which implies it is integrated of order one. i.e. I (1).

6.2. Autoregressive Distributive Lag Model - Optimum Lag Selection

Optimal lag length is necessary to define autoregressive time series and a residual in the next test of co-integration. Therefore, the table below illustrates the optimal lag length criteria for the four variables and their statistics. The lowest value of the statistic determines the optimal lag and an asterisk is used to mark the choice.

Table 2: The optimal lag length (AKAIKE & SCHWARS)

	AIC	**SBIC**	**AIC**	**SBIC**	**AIC**	**SBIC**	**AIC**	**SBIC**
Lag:	$m\ddot{v}a_t$		$elpr_t$		$c\ddot{a}p_t$		$a\breve{g}r_t$	
0	0.7037	0.7455	0.7056	0.7474	1.0595	1.1013	1.1080	1.1498
1	-0.9829	-0.8993	-1.8422	-1.7586	-0.7415*	-0.6579*	-0.9744	-0.8908*
2	-1.0405*	-9.1515*	-1.9699	-1.8445	-0.6965	-0.5711	-0.9698	-0.8444
3	-0.9945	-0.8273	-2.0137*	-1.8465*	-0.6582	-0.4911	-0.9355	-0.7683
4	-0.9467	-0.7377	1.9669	-1.7579	-0.7292	0.5202	-1.031*	-0.8217
Choice	**Optimal lag=2**		**Optimal lag=3**		**Optimal lag=1**		**Optimal lag=1**	

As hinted above the asterisk sign (*) marks the optimal lag statistic.

The optimal lags selected for manufacturing, capital, electricity and agricultural sector are 2, 1, 3 and 1 respectively. In the last case for agriculture the two criteria Akaike & Schwarz do not match. Since in this study we already expressed preference for Schwarz information criteria it follows that in this case its value takes precedence.

6.3. Autoregressive Distributive Lag Model - Bounds Test

Table 3 below depicts the statistical values as estimated in Pesaran et al. (1997) with Critical values of 0.1-0.01 having also the lower bounds assumed to be I(0) and upper bound as I(1).

Table 3: ARDL Bounds test result tables

	Significance Level	10%		5%		1%		Decision rule
Model	**F-statistic**	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**	H_0: no co integration
[1]mva	15.77***	3.17	4.14	3.79	4.85	5.15	6.36	Reject
[2]elpr	1.47	2.72	3.77	3.23	4.35	4.29	5.61	Not reject
[3]cap	10.18***	4.04	4.78	4.94	5.73	6.84	7.84	Reject
[4]agr	15.64***	4.04	4.78	4.94	5.73	6.84	7.84	Reject
The null hypothesis is that there is no co-integration								

*, **, *** Imply 10%, 5%, and 1% level of significance respectively.

The critical values are for the model with intercept but no trend as specified in the empirical strategy, contained in case (iii) of Pesaran and Pesaran (1997).

The results of the bounds test for co-integration, together with critical values of Pesaran and Pesaran (1997) are reported in Table 3 above. These results indicate that there is a co-integration relationship with 1% significance level for three of the tested variables. Therefore, the null hypothesis of no co-integration is rejected when considering manufacturing, capital formation and agriculture; the only exception is electricity production (elpr). The existence of co-integrating relationships among manufacturing value added (mva), capital formation (cap) and agricultural value added (agr) suggest that there must be Granger causality in at least one direction, but it fails to signify the direction of temporal causality among these variables. This necessitates the use of a method that takes into account the different time dimensions of the Granger causality and hence the Vector Error Correction Model.

6.4. Vector Error Correction Model/Vector Autoregressive

The long run steady states that have been investigated here are a result of an indication from previous test that there is co-integration. Right here below short run estimates are presented alongside long run steady states which are: for manufacturing value addition [5] mva = -0.53elpr + 0.39cap + 0.33agr; Capital formation [6] cap = 1.52elpr + 1.46mva + -0.67agr and agricultural value added [7] agr = 0.89mva + 0.89elpr + 0.08cap. These are presented in Table 4 below in greater detail;

Table 4: Error correction Granger causality model results

Model	Short run estimates				Long run estimates				
Variable	$\ddot{mva}_{t-i}$	$\ddot{elpr}_{t-i}$	$\ddot{cap}_{t-\iota}$	$\ddot{agr}_{t-\iota}$	$\ddot{mva}_t$	$\ddot{elpr}_t$	$\ddot{cap}_t$	$\ddot{agr}_t$	ECT(-1)
[5] $\Delta\ddot{mva}_t$	0.23	0.03	0.21	0.43***	-	-0.53	0.39	0.33	-0.24*
[6] $\Delta\ddot{cap}_t$	0.14	0.12	-	0.09	1.46**	1.52**	-	-0.67	-0.25**
[7] $\Delta\ddot{agr}_t$	0.33*	-0.08	-0.08	-	0.89**	0.89**	0.08	-	-0.27***

*, **, *** Imply 10%, 5%, and 1% level of significance respectively.

From Table 4 above, a negative and significant Error Correction Term coefficient signifies a long-run Granger causality from at least one of the specified independent variables. Only three models are reported i.e. manufacturing, capital and agriculture; electricity is not included in this Error Correction estimation because there is not enough evidence to rule out its non-stationarity and non-co-integration.

In Model [5] manufacturing value added as the dependent variable: Granger causality in the short-run is seen running from agricultural value added, with a 100% increase in value addition leading to manufacturing value addition improvement by only a significant 43% absent previous time disequilibria to correct. In the long run however, agricultural value addition has positive but non-significant elasticity of about 33% for every 100% increase. And thus among the sectors considered in the short-run and long run only agriculture significantly contributes to manufacturing at 1% level of significance only in the short run. In the short run also the other sectors, electricity consumption and capital formation have positive insignificant elasticities of 3 and 21% respectively. While in the long run electricity consumption and capital formation still have insignificant elasticities having -53% and 39% respectively. It is observed that in the short run electricity has a small positive elasticity of 3% on manufacturing for each 100% increase, while in the long run this same input has a decreasing effect of about 50%. Such smaller impact in the short run in conjunction with the bigger negative impact in the long run though not statistically significant may indicate challenges within electricity consumption as an input.

The coefficient for the ECT in this model is negative and significant at 10% level while individual variables are not observed to have significant long-run Granger causality. The negative ECT signifies long run convergence in the specified model even though the individual variables estimates prove nonsignificant. The point estimate of the ECT coefficient indicates that the adjustment for previous disequilibria at the current time is only 24%. Given that this estimate is quite distant from 100%, one can surmise that the long run equilibrium though significant, it still exhibits a slow reaction to adjust for the short run changes in variables.

In Model [6] where gross capital formation is the dependent variable; estimated coefficient for ECT is negative and significant at 5% level which is more than the previous model. Furthermore, this confirms long run Granger causality observed from both manufacturing value added and electricity consumption at 5% significance levels. Their respective elasticities are 146% and 152% respectively; electricity seems to have the higher elasticity on gross capital formation which signifies its importance in wealth accumulation. Their elasticities are observed to be highly reactive indicating that in the present 100% increments in manufacturing or electricity consumption have more that 100% impact on gross capital formation in the long run.

What this implies is that, in order for Tanzania's economy to succeed in increasing its stock of capital the manufacturing sector and its supporting infrastructure i.e. electricity cannot be ignored. These two are also observed to have positive but not statistically significant elasticity coefficients in the short run, with manufacturing having 14% and electricity having 12%.

Agricultural value addition is observed to have an elasticity of 9% in the short run and -67% in the long run both without statistical significance. The negative sign indicates that this sector is probably the net consumer of capital assets accumulated in the economy when considering the long run. In the short run however, the positive sign could indicate the extent of capitalization whereby the economy makes a conscious choice to import machinery so as to aid the sector.

In Model [7] agricultural value added is the dependent variable; the coefficient for ECT is negative and significant at 1% indicating presence of long-run Granger causality. Under this specification, the manufacturing value added and electricity consumption Granger cause agriculture value addition at 5% level of significance according to long-run estimates. Manufacturing value addition seems to have impacts both in the short and the long run, in the short run it has an elasticity of 33% significant at 10% while in the long run it has a higher more significant elasticity of 89% at 5% level of significance. This implies that manufacturing sector has strong causal effect on agricultural value addition. On the other side electricity consumption in the short run is observed to have a negative and nonsignificant elasticity on agricultural value addition of about 8%. While in the long run it is significant and a positive 89% at 5% level of significance; this indicates that while in the short run electricity might be a drag to agricultural development in the long run it has a positive impact perhaps accentuated by its contributions in manufacturing and gross capital formation. When capital formation is observed; in the short run it seems to have a negative and insignificant elasticity of 8% while in the long run it is positive and still insignificant taking the same value of 8%. This indicates that of the two, i.e. manufacturing and capital formation it is manufacturing that mostly impacts agriculture together with electricity input in the long run.

6.5. Vector Autoregressive (VAR)

Table 5 below displays the results of Vector Autoregressive Granger causality test from select sectors unto electricity. The aim of this test is to diagnose reverse causality that runs from either sectors or capital formation, the results are presented below;

Table 5: Vector Autoregressive (VAR) Granger causality for electricity

Equation	Excluded	Chi2	D.F.	Prob>Chi2
$el\ddot{p}r_t$	$m\ddot{v}a_t$	2.1948	3	0.533
$el\ddot{p}r_t$	$g\ddot{c}f_t$	0.60814	3	0.895
$el\ddot{p}r_t$	$a\ddot{g}r_t$	3.7069	3	0.295
$el\ddot{p}r_t$	All	6.9868	9	0.638

*, **, *** Imply 10%, 5%, and 1% level of significance respectively

The results above indicate that none of the estimates are statistically significant

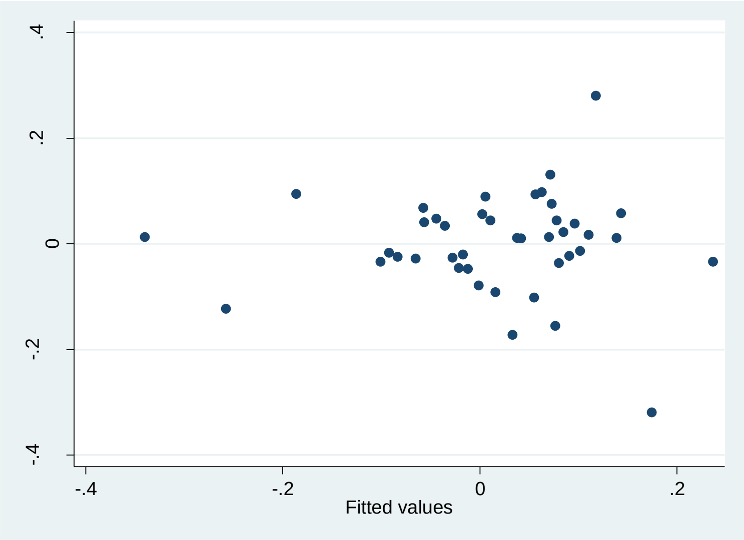
Electricity production has been observed according to the previous ADF and ARDL tests to not provide sufficient evidence for rejecting the hypothesis of non-stationarity and no co-integration respectively. As such this stage used VAR for electricity in place of VECM, because this variable does not satisfy the criterion of being integrated to order 1 in conjunction with being co-integrated (LeSage,1990).

After estimating the model, a Wald test is conducted to indicate Granger causality directions. The null hypothesis is no Granger causality from any of the variables to electricity; in the table above, there is not enough evidence to reject the null hypothesis that manufacturing, capital and agriculture do not Granger cause electricity production at 10% level of significance. Therefore, it can be deduced thus far that there is no proven back flows from any of the sectors unto electricity production. This is in line with the unidirectional growth hypothesis subscribed by (Odhiambo,2009; Zaman et al.,2013).

6.6. Residue Plots

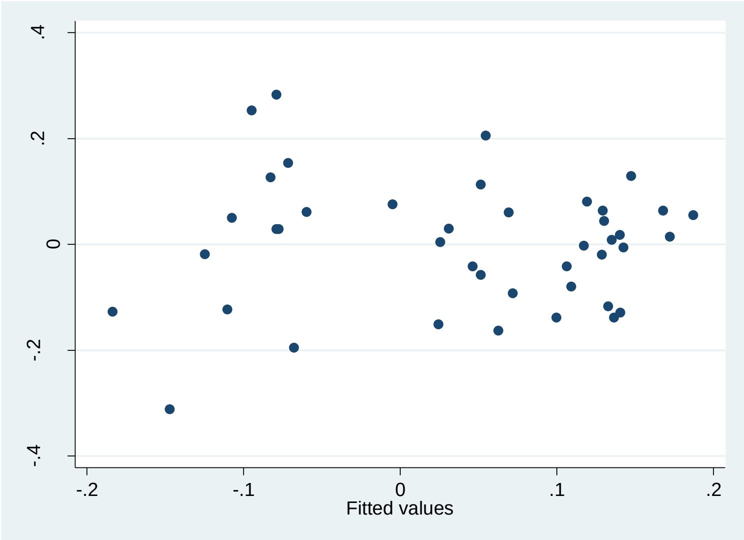
Below are a series of residue plots which are used in this study for obtaining a visual impression about the degree of randomness to which the estimate of the errors is distributed. These are supposed to be stochastic and if not they may indicate a certain degree of non-random distribution which could in turn suggest autocorrelation.

Figure 8: RESIDUE PLOT FOR MANUFACTURING VALUE ADDED VECM ESTIMATION



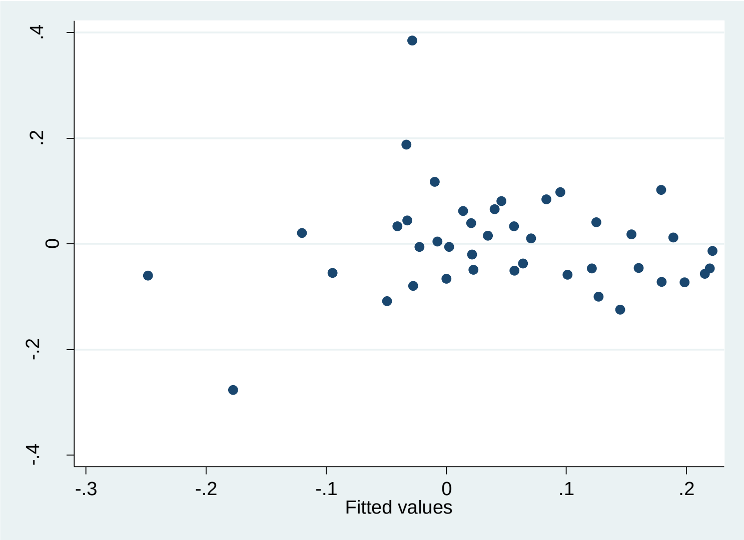
From the above residue plot for manufacturing error correction estimate, the residues are not that well behaved in that they cluster between -1 and 2 of the fitted values. This suggests that they are not stochastic and hence their relationship could be predicted.

Figure 9: RESIDUE PLOT FOR GROSS CAPITAL FORMATION VECM ESTIMATION



From the above plot, the residuals for the gross capital error correction seem to be well behaved. This means that they are rather randomly distributed with no specific recognizable pattern.

Figure 10:RESIDUE PLOT FOR AGRICULTURE V.A. VECM ESTIMATION



The residue plot for agriculture however, does not indicate an element of pure randomness judging visually. These necessitate checking for heteroscedasticity, in this study the test that shall be performed is the autoregressive conditional heteroscedasticity.

6.6.1. ARCH effect testing and models re-estimation

ARCH-LM test results are presented in the Table 6 for the three VECM model estimation i.e. [5], [6] & [7];

Table 6: ARCH effects test results

Model no:/Dep. Var.	Lags(q)	χ^2	Df	Prob $> \chi^2$	Decision rule
[5]/ $\boldsymbol{m\ddot{v}a_t}$	1	8.991	1	0.0027	Reject H0
	2	9.376	2	0.0092	Reject H0
[6]/ $\boldsymbol{c\ddot{a}p_t}$	1	0.019	1	0.8892	Do not reject H0
[7]/ $\boldsymbol{a\ddot{g}r_t}$	1	6.743	1	0.0094	Reject H0

H_0: No ARCH effects VS. H_1: ARCH(q) disturbances: where q = {1, 2, …n}

From Table 6, the results indicate that the model specification where manufacturing value added is the dependent variable has ARCH (2) effects, the one with Agricultural value added has ARCH (1) effects while there was not enough evidence to reject absence of ARCH effects for a similar model for gross capital formation.

After conducting an ARCH test for the VECM estimate the models [5], [6] and [7] have been found to have disturbances that follow an ARCH (1) process, therefore the study calls for re-estimation of the models taking into account the conditional heteroskedastic error variances. Below are the ARCH results for when manufacturing value added is the dependent variable as specified in model [5];

Table 7: ARCH re-estimation model [5] "$\ddot{mva}_t$"

Mean/average effects	**[5]-$\ddot{mva}_t$**	**Coeff.**	**Z**	**Pr>|z|**
	$\ddot{cap}_t$	0.431***	6.68	0.000
	$\ddot{elpr}_t$	-0.539***	-9.17	0.000
	$\ddot{agr}_t$	0.349***	5.75	0.000
	_cons	-0.904	-22.8	0.000
Variance effects	ARCH (1)	1.32**	2.18	0.029
	_cons	0.002	1.47	0.142

*, **, *** Imply 10%, 5%, and 1% level of significance respectively

When the error term variances are estimated under ARCH (1) effects we observe significant average negative impact of electricity, unlike the previous ECM model [5] where in the short-run electricity has a positive insignificant effect on manufacturing value added in this estimation it is negative and significant at 1% level of significance. The rest of the variables are positive as expected. And the ARCH variance coefficient is observed to be significant at 5% level of significance.

The accompanying independent variables i.e. gross capital formation, electricity production and agriculture value added are observed to be significant at 1% level of significance. Agriculture is observed to have an elasticity value of 0.34 while capital formation has 0.431 and electricity has -0.539. What this means is that for every 1% increase of value addition in the agricultural sector manufacturing grows by 34%; for the 1% increase in gross capital formation in Tanzania the manufacturing sector value addition grows by 43.1% and finally for a 1% increase in electricity input the manufacturing sector suffers by 53.9%.

Table 8: ARCH re-estimation of model [7] "$\ddot{agr}_t$"

Mean/average effects	**[7]-$\ddot{agr}_t$**	**Coeff.**	**Z**	**Pr>|z|**
	$\ddot{cap}_t$	0.03	0.26	0.79
	$\ddot{mva}_t$	0.523***	5.17	0.000
	$\ddot{elpr}_t$	0.908***	8.09	0.000
	_cons	0.904***	7.57	0.000
Variance effects	ARCH (1)	0.678	1.37	0.171
	_cons	0.013	1.59	0.112

*, **, *** Imply 10%, 5%, and 1% level of significance respectively

In this case capital formation is observed to have a positive insignificant coefficient and so are the estimates under variance effects. The ARCH effects in this case would only be significant if we become more generous on the confidence level (at 80%). Again the results for electricity consumption are consistently positive and significant as from the ECM long-run estimation in Table 4, [6].

Generally, it can be argued that the ARCH effects in this model are not as strong because of the observed non-significant ARCH (1) coefficient estimate. However, the accompanying estimates for Agricultural value addition and electricity production are observed to be significant at 1% level of significance.

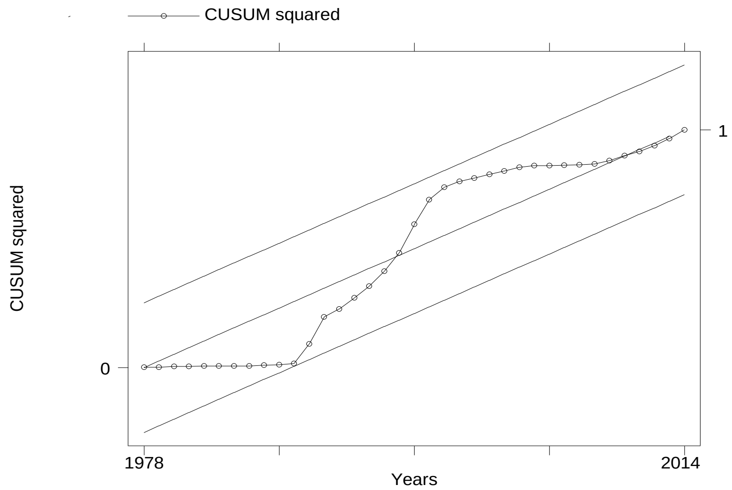
From Table 8 above; manufacturing has an elasticity estimate of 52.3% while the electricity variable has an elasticity estimate of 90.8%. This implies that for every 100% increase in either manufacturing value addition or electricity production (which for the case of Tanzania is assumed to equal consumption) the agricultural value addition improves by 52.3% or 90.8% respectively.

These results indicate that the manufacturing sector's contribution is not as strong as that by electricity which is seen to have an impact close to 100%. This could be attributed to some aspects of agriculture value addition being inseparable from manufacturing, and therefore it is probable that electricity does carry with it some effect from the manufacturing processes. These results support further the ones generated through the Error Correction procedure, where it was indicated in model [7] of Table 4; that manufacturing V.A. and electricity have long run Granger Causal impacts on agricultural V.A. in Tanzania.

6.6.2. CUSUM plots

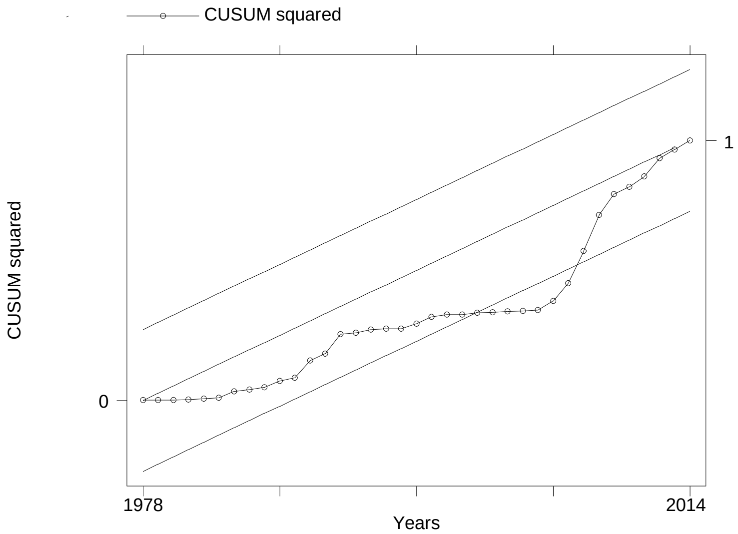
The following graphs show the squares of repetitive error terms for each of the models estimated under Table 4. These cumulative squared residuals are plotted within confidence bands in this case 95%, the plots give a summary about the stability of our estimates within a certain time window. The CUSUMSQ plot is an important chart for identifying changes in the process average.

Figure 11: CUSUM chart for manufacturing estimates in model [5]



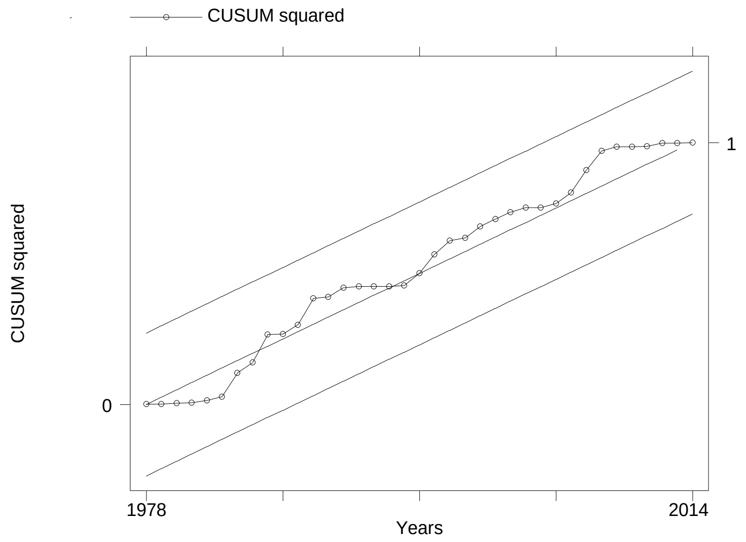
From above 37 points are displayed from the squared residuals of an estimated error correction model. In this model manufacturing value added is the dependent variable and what can be seen here is how the changes in these squared residuals vary but within the average run length (ARL). This implies that the generated estimates follow a relatively stable process that is reliable with 95% confidence.

Figure 12: CUSUM for capital formation as specified in model [6]



The process used to estimate this model is observed to exceed the 5% ARL from year 2001 but returned to the controlled distribution mid-2007. It is historically known that Tanzania had political agitations after the 2000 election, the uncertain political environment persisted even in 2005. Such events are hypothesized to have either altered investor’s confidence or led to temporary misallocated public resources towards stabilizing the political environment. What can be understood here is that the ECM estimation for capital for these 6 years should not be interpreted without caution.

Figure 13: CUSUM for agricultural value added as shown in Model [7]



The above graph shows how the cumulative squared residuals for agriculture as estimated in Model [7] are moving very close to their mean values.

Figure 4, a plot for model [6] where capital formation is the dependent variable estimates are not significantly stable, teetering between the out of control and in control process at certain times which is limited at 5%; this is not the case for Figure 3, and Figure 5, which indicate stability of the estimates with time for manufacturing value added and agricultural value added respectively at 95% level of significance.

6.6.3. Specification Test (Ramsey reset)

The Ramsey test is conducted for the three specified models as estimated by means of the Vector Error Correction in Section 6.4. The results of the test are reported in Table 9 as follows;

Table 9:Results for the Ramsey Reset test results

Ramsey RESET test using powers of the fitted values of…				
[5] D. lnmva	F (3, 28) =	0.47	Prob > F =	0.7049
[6] D. lngcf	F (3, 28) =	2.83	Prob > F =	0.0566
[7] D. lnagr	F (3, 28) =	4.39	Prob > F =	0.0119
Null Hypothesis: Model has no omitted variables				

A p-value estimate that is less than the chosen level of significance leads to rejection of the null hypothesis. The test results seem to suggest that the fitted model for agricultural value added as specified in [7] might have incorrect specification at 5% level of significance.

From Table 9; given that 5% is the most used level of significance in literature it can be argued that at this level there is not enough evidence to not reject the null hypothesis of model [7] not having omitted variables or incorrect specification. This could be possibly attributed to the lag specification as reported in Table 2. In that table the variable for agriculture seems to have different lag specifications with Akaike (AIC) being 4 while according to Schwarz (SBIC) it was found to be 1. Thus, there is a probability that model [7] might be correctly specified at 5% level of significance if the lag selected for the variable lnagr(agriculture) was 4 i.e. according to Akaike information criterion. However, in this study as indicated in Section 5.2.1. the Schwarz information criteria was most preferred and chosen over Akaike's.

However, the same estimates in Table 9, [7] (for agriculture) may not reject the null hypothesis at 1% level of significance which is much stricter. This gives confidence in the results obtained, that though the Ramsey reset test might have indicated a possibly incorrect specification at 5% level of significance, such a deduction could not be extended to 1% which is the strictest among recognized significance levels.

6.6.4. Normality Test

This investigation conducted a test to check whether or not the used variables in the study are normally distributed and presents the results in Table10. The test used was the D.H test which is based on the skewness and kurtosis of multivariate data (Doornik&Hansen,2008).

Table 10:Results for the D.H. test;

Doornik-Hansen test for multivariate normality		
D-H statistic (for Logged variables)	chi2(8) = 8.479	Prob>chi2 = 0.3881
D-H statistic (for non-log values)	chi2(8) = 14.782	Prob>chi2 = 0.0635
Null Hypothesis: The specified variables are normally distributed		

A p-value estimate that is less than the chosen level of significance leads to rejection of the null hypothesis

From the above Table 10, the Doornik and Hansen test results are reported; provided that the reported p- values are 0.3881 for the used log values, one may not confidently reject the null hypothesis that the specified variables are normally distributed at 10%, 5% and 1%.

However, when the same test is conducted for the per worker's population data (before they were transformed to natural logarithms) one can still not reject the null at 5% level of significance but can reject at 10%.

What this means is that the procedure of transforming the data has helped in making the data more normally distributed, and hence it is a justification for using log values instead of original ones.

7: DISCUSSIONS

This section presents some discussions about the results taking into account similar works within and outside of Tanzania. The results show that electricity Granger-causality effect on manufacturing sector is not significant. Results register only after Autoregressive Conditional Heteroscedasticity (ARCH) diagnostics and re-estimation procedures have been performed. These results show that electricity has a negative but significant causal impact on manufacturing, while positive and significant for agricultural sector and capital formation as shown in ECM results. What these results present, are a symptom of a deeper issue that may not have been considered by this investigation, issues such as electricity reliability are known to be a challenge in most developing countries including Tanzania. Therefore, for those manufacturing processes that depend upon electricity if the supply is not reliable the overall outcome is likely to be negative due to the costs of self-generation and loss of productivity.

This is justified to an extent as it could explain in-part what had been observed by Chontanawat, J. et al. (2008). Who after categorising cross-sectional data for 30 developed (OECDs) and 78 developing countries observed the energy to economic growth Granger causality to be particularly stronger among the OECD’s than developing countries or non- OECD’s. The argument for this could be that, the manufacturing sector is more dominant in OECDs than in non-OECD because of the technological edge possessed by OECDs. Thus, non-OECDs’ demand for energy could be comparatively low and even their rate of replacement of electrical infrastructure could be constrained by their technology (Scott,2013).

It is however too early to make case that the results of this investigation are contrary to those by Solarin (2011) and Odhiambo (2009) who argued for the growth hypothesis. This is because from the results of the study, electricity production has positive significant Granger causality effect on the agricultural sector which is in line with an investigation by Jumbe (2004) for Malawi.

Jumbe (2004) used the primary sector and employed Agricultural GDP as the proxy. Such results may suggest that agricultural productivity is at a stage of development where there are increasing marginal returns to electricity input. This could also be an option for further development of the manufacturing sector whose source of raw materials is the primary sector. This is also apparent from the results which have shown this sector to have a significant impact on manufacturing as discussed in (Jorgenson,1961; Sachs,2008).

Thus, when examining the whole of GDP for Granger causality with commercial energy one embraces the risk of such interactions between sectors that interlink through input-output strings. The take home message here is that indeed there is no clear cut direction of causality between economic growth and electricity production across countries, unless a researcher considers sectoral competitiveness and contributions to this economic growth.

8: CONCLUSION

The investigation in the background managed to show how energy in Tanzania is supplied by one dominant public utility (TANESCO) and implicitly indicated the land mass size which presents a daunting challenge in improving reliable electricity in all regions. This section also gave a snap-shot of the economic situation in terms of growth and how the two dominant sectors manufacturing and agriculture growth shares are negatively correlated.

In the literature review section, the discussions revolved around the four classes of hypotheses derived from extensive literature on energy and GDP growth Granger-causality. The majority of the studies conducted were bivariate and did not consider the different sectors. This study differentiated itself by breaking down the GDP into different sectors and included also other factors such as raw materials and capital to augment electricity supply for Tanzania.

The theoretical section discussed aspects of the a priori model paying also particular emphasis on the economic theory and the data used. The economic model upon which the analysis is based upon was Solow-Swan, and it was used because of its long-run assumption of growth resulting from technological progress far and beyond what factor inputs can possibly contribute.

The methods for actually conducting the investigation were put forward and some of their assumptions briefly discussed. The first step was checking for unit root using ADF, the second step involved co-integration test (ARDL), the results from which a Granger test were based. This thesis also managed to conduct diagnostics so as to have more confidence for policy discussion.

From the ADF test it was found that agriculture, manufacturing and capital were integrated of order 1, while for the case of electricity there was no sufficient evidence to conclude so. Using optimal lags determined through Akaike and Schwarz the ARDL test reports existence of co-joined movement for manufacturing, agriculture and capital but none for electricity. From that stage VECM is used for the first three and indicates long-run Granger causality from electricity to capital and agriculture, but none for manufacturing. Also in the short- and long-run there is dual causal relation between manufacturing and agriculture. By means of a VAR model the results indicate no Granger causality from either sectors or input to electricity.

The Discussion of the results has shown how other studies conducted have matching results with regard to direction of causality and the degree to which certain type of countries may be expected to have more electricity consumption than others.

This thesis has managed to investigate and show how the two linked sectors interact with labour, capital as well as electricity production. And at last the research question highlighted in the introduction section is answered; there is no reverse Granger causality from either sector unto electricity production. However, there is significant Granger causality from electricity unto agricultural sector and gross capital formation. The manufacturing sector seems not significantly affected except when correcting for conditional heteroscedasticity.

Lastly, this study had limited time series observations which only ranged four decades. It would surely be interesting to see what result one gets when time is at least 100 years and the analysis includes also the tertiary sector. This is a potentially viable aspect for further investigation, particularly extending this analysis to include ICT, healthcare, hospitality etc. The sector is quite prominent to the extent of siphoning the labour force from subsistence agriculture and manufacturing, this is at least true in developing countries such as Tanzania.

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