THE ECONOMIC GROWTH, ELECTRICITY CONSUMPTION AND EMPLOYMENT CAUSALITY:

Evidence from Zambia

A Research Paper presented by:

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(Zambia)

in partial fulfilment of the requirements for obtaining the degree of

MASTER OF ARTS IN DEVELOPMENT STUDIES

Major:

Economics of Development

(ECD)

Specialization:

Econometric Analysis of Development Policies

Members of the Examining Committee:

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The Hague, The Netherlands
December 2017

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This document represents part of the author's study programme while at the Institute of Social Studies. The views stated therein are those of the author and not necessarily those of the Institute.

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List of Acronyms

ADF	Augmented Dicky-Fuller
CSO	Central Statistics Offices
ECA	Economic Commission for Africa
ECT	Error Correction Term
ERB	Energy Regulation Board
IPP	Independent Power Producers
IRF	Impulse Response Function
LCMS	Living Conditions Monitoring Survey
LFS	Labour Force Survey
LM	Lagrange Multiplier
MMD	Movement for Multi-Party Democracy
NELMP	National Employment and Labour Market Policy
PF	Patriotic Front
PP	Phillips-Perron
SAPP	Southern African Power Pool
SSA	Sub-Saharan Africa
UNDP	United Nations Development Programme
UNIP	United Independent Party
VECM	Vector error correction Models
WBI	World Bank Indicators
WHO	World Health Organisation
ZACCI	Zambia Association of Chambers of Commerce Industry
ZESCO	Zambia Electricity Supply Corporation
ZDA	Zambia Development Agency

Acknowledgements

First and foremost, without God almighty, I would not have been where I am today, and all glory belongs to him alone. Further, I would like to express my deepest gratitude to my Supervisor, Dr Elysaios Papyrakis, who has provided guidance and full support with patience and was readily available to render help and guidance and responded to my emails on time. Gratitude is also extended to my second reader Dr Nicholas Howard for his critical thoughtful comments, advice and his door was always open for discussion.

Secondly, special thanks go to my Parents, Mr. Nathan and Mrs. Olive Banda for teaching me the value of girl child education even when I thought of giving up and that the sky is not the limit. They aspired me to reach to reach heights. Also, the NUFFIC scholarship that was awarded to me when I was at the verge of giving up.

Thirdly, I express heartfelt gratitude to my fiancé Isaac Kangwa for his advice, inspiration and encouragement throughout my study period at ISS. The confidence he has in me is immeasurable and the listening ear are indebted to me.

Fourth, my brothers Edwin and Nathan and my sisters Trudy, Masiku, Bertha, Sonala, Brenda, Peggy, Linda, Marion, Christabel, Carmen, Milazi and Belinda for the financial, spiritual and emotional support rendered and my friends Handsen, Amanda, Cynthia and Diane for making my life memorable worthwhile at ISS and the Netherlands.

Last but not the least, church members of Voorburg International Seventh Day Adventist Church for encouraging me and their prayers that kept me going during my study and stay in the Netherlands.

Abstract

In this study, the causal relationship between electricity consumption, economic growth, and employment for Zambia from 1974 to 2016 is examined using the cointegration techniques, Vector Error Correction Model (VECM) and Impulse Response Function (IRF). From our trivariate model, our results establish with new evidence the existence of cointegration amongst the variables. The results indicate the presence of a long-run cointegration relationship between economic growth, employment rate and electricity consumption in Zambia. Additionally, a neutrality causality exists between economic growth and electricity consumption and between economic growth and employment. Also, there is a long-run unidirectional causality running from employment rate to electricity consumption per capita (KWh) and no feedback.

Keywords

Cointegration, Economic Growth, Electricity consumption per capita, Employment rate, Granger causality, Zambia.

Relevance to Development Studies

Economic growth is essential for the development of any country because it bears a strong link with entrepreneurial activities, education, investment, labour force productivity in the economy. The ability to affirm the precise causal outline of economic growth, employment and electricity consumption is of stupendous significance to policy implications, particularly for countries that are susceptible to shock in the electricity sector and have a sole source of energy. This study then adds to the existing literature and can then be integrated in Zambia's development plans.

Structure of the Paper

This research paper is structured as follows. Chapter 1 looks at the introduction to give insight into the background, economy's features, policies and description of the paper. Chapter 2 provides the literature review and empirical evidence on Economic Growth, Electricity consumption and Employment. Chapter 3 presents the data, its sources and methodology used to carry out the analysis. Chapter 4 provides the regression results and discussion and lastly the conclusion and policy recommendations are provided in Chapter 5.

Chapter 1

1.1 Introduction

1.1.1 Background of the Study

An important notion of development economics like economic growth is a vital stage in the development stairway and the attainment of a high sustainable economic growth rate remains a key theme for many countries in the world today. The world economy has been whirling from various economic shocks such as the financial crisis and oil shocks, with impacts being experienced in the real economy on employment, consumption, production and standard of living. This is because all these variables drive economic growth. A vital factor of rapid economic growth is people's access to employment opportunities whether most of the employed work in the informal or formal sectors because disposable income is derived from working. Thus, the availability of job quality and employment level a country attains will sequentially impact on economic growth, (Seyfried, 2005). It is recognised that employment unswervingly affects the country's GDP as the work force produces agricultural or manufactured goods thus arousing an increase in purchasing power which fosters economic growth. Therefore, employment contributes to an increase in the potential which exists in stimulating an economy's GDP and any decline in GDP will be reflected in decline in employment rate. Moreover, in times of economic disorder, the concentration somewhat falls on the reduced standard of living and employment, (Bello 2003).

Further, an economy's production and consumption of electricity are primary indicators of its size and level of development. These indicators are evident in many developed countries as well as the emerging economies in their industrialisation stages. Everyone including government agencies, economist, engineers as well as businessmen acknowledges the significance of electricity to economic growth. As Yergin and Gross (2012) put it, electricity is the "oxygen" of economic growth and it is impossible in this era to operate industries and factories and provide cities with comfortable homes and amenities. According to Akinlo (2008) energy is as vital as labour, land and capital in production and thus it can be denoted as a basic need. Particularly electricity implies high economic status of an economy because it helps generate employment and alleviate poverty. Likewise, as asserted by Samouilidis and Mitropoulos (1984), most economies that have increased economic growth show increased electricity consumption per capita because economic growth is positively related to electricity.

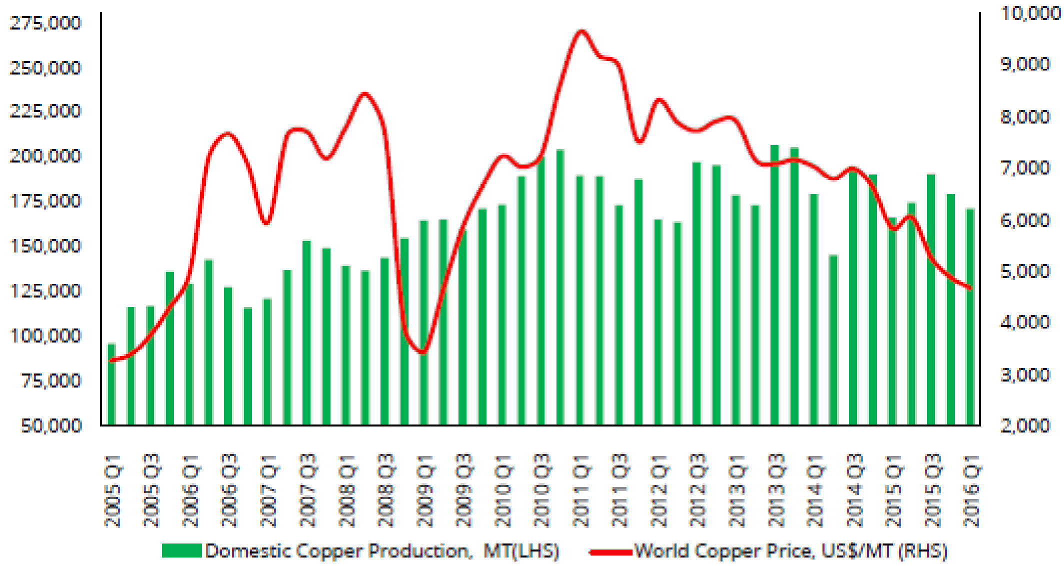
However, the poor electrification rates, low energy supply and high level of unemployment are some of the major problems most Sub Saharan African (SSA) countries Zambia inclusive still face since time in memorial. Shahateet (2014) postulates that that there has been a growing debate on the relationship between economic growth and the various economic variables. Is the concept of electricity as an oxygen of economic growth and the idea of reduction in employment being an indicator of low economic growth the same across countries? In solving questions like this one, the relationship between electricity consumption, employment and economic growth in the case of Zambia between 1974 and 2016 over a period of 42 years is examined in this study. Further, since electricity is a form of energy, the terms electricity and energy have been used synonymously.

1.1.2 Zambia's Economy

Zambia is a low-income landlocked country located in the Southern part of Africa and shares borders to the south with Zimbabwe, Namibia and Botswana; to the north with Tanzania and the Democratic Republic of Congo; to the east, Mozambique and Malawi; and to the west, Angola. The country lies sandwiched between longitudes 22° and 34° east and latitudes 8° and 18° south. Zambia's total land area covers about 39 million hectares and 58% is hypothetically suitable for agricultural production even though most of this productive land is not yet fully developed for the intention of raising the agricultural sector share to the Zambian economy. Notwithstanding potential irrigation programmes from large water bodies, Zambia`s agricultural activities mainly depend on rain fall, (World Bank, 2016a).

As Copper production is Zambia's backbone ever since the 1970s to date, Zambia remains dependent on its primary export commodity and it represents roughly 70% of the country's foreign exchange revenue. For this reason, the country remains vulnerable to fluctuations in external commodity prices. For instance, the falling copper prices reduced global demand between the first quarters of 2011 and 2016 as shown in figure 1.1 and significantly weighed heavily on the economy inhibiting economic growth in Zambia. As a result, copper mining companies in Zambia reduced production by 4.6% in 2015 (CSO *LCMS,* 2015; World Bank, 2016).

Figure 1.1: Declining copper prices in the past 5 years



Source: World Bank (2016a)

Despite, the decline in copper prices, expansion in the mining sector has been on the rise especially in the North-Western province of Zambia. For this reason, demand for electricity has been rising and this trend is anticipated to continue due to a rise in economic activities in all sectors of the economy but particularly in the industrial sector in the hope of achieving the status of middle income industrialised country by 2030. However, there are challenges like low levels of access to clean and safe energy for the majority of the population and inadequate electricity infrastructure to promote economic growth (Tembo and Merven, 2013). CSO LCMS, (2015) postulates that in 2015 Zambia's population was estimated at 15.5 million and 58.2 percent of the population was mainly concentrated in rural areas against 41.8 percent in the urban areas. In comparison with the year 2010, CSO LCMS (2010), the population increased from 13 million to 15.5 million, urban population increased by 7.1% and rural population reduced by the same margin showing a shift from the rural to urban areas.[1] The electrification rate was 22% in 2015 with only 31% of the total population having access to electricity countrywide (ERB, 2015).

In 2015, Zambia's economy was affected by both external and internal macroeconomic pressures predominantly the decline in both commodity prices and global trade as shown in figure 1.1, (Ministry of Finance, 2015 Economic Report). The external macroeconomic pressures which include depreciation and instability of the Kwacha against the US dollar caused a significant increase in the cost of inputs and final goods imported and slower regional and global growth (critically in China which procures about 45% of copper globally). Domestic macroeconomic pressures include a rise

[1] see Appendix 1 for graph Zambia's population

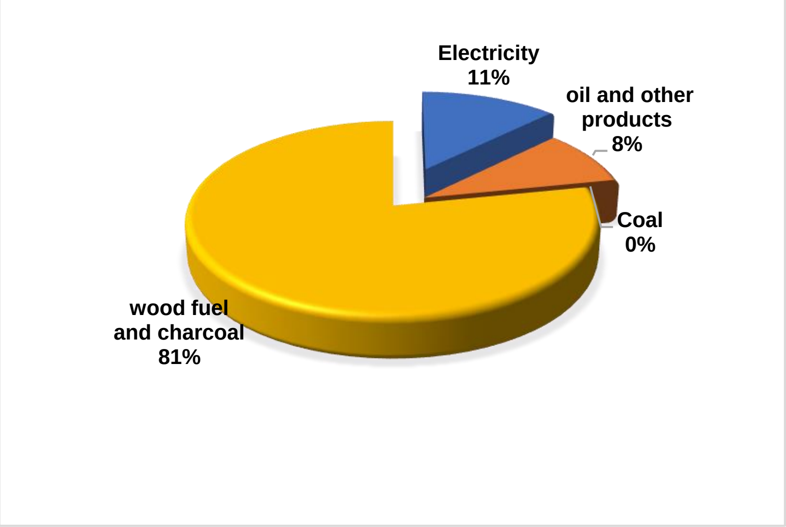
in inflation and poor rainfall that resulted in reduced harvest and energy crisis (electricity) that affected all sectors of Zambia's economy, (World Bank, 2016a). Therefore, there is a need to understand the relationship between electricity consumption and economic growth and how the economic system can be enhanced to minimise the impacts of droughts in Zambia.

1.1.3 Electricity consumption in Zambia

Zambia has a rich variety of local energy sources such as forests and woodlands, coal, hydropower and other renewable energy sources although the major energy source is hydropower. Generally, energy consumption and especially electricity consumption is quite very low regardless of the enormous energy potential Zambia owns and the underdevelopment of the power sector remains the norm of the day, (Karekezi and Kimani, 2002; Economic Commission for Africa (ECA), 2004). Electricity is the second most vital source of energy after charcoal and wood fuel (traditional fuels) in Zambia accounting for 11% of the country's energy supply while the traditional fuels accounts for about 81% (figure 1.2) in 2008.

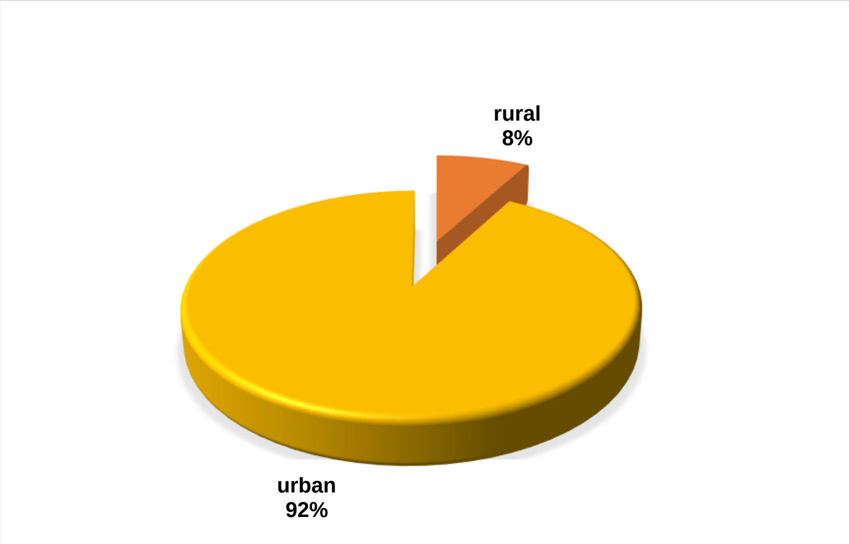
According to Davidson and Sokona (2002) what the average person used in England more than a century ago is more than what the average African is still using today. The discrepancy in the consumption of electricity, on one hand between Africa and the rest of the world and on the other hand amongst African countries themselves, is widely noticeable. For example, as Saghir (2002) assessed that only 4% of the rural population in Ghana has access to electricity compared to 62% of the urban population. In Zambia also, from the total of 947, 708 of the population who have access to electricity, as can be seen in figure 1.3 below, 92% are from the urban residence while only 8% are from the rural areas, (CSO LCMS, 2015).

Figure 1.2 Zambia's Energy Consumption in 2008



Source: EIA (2011)

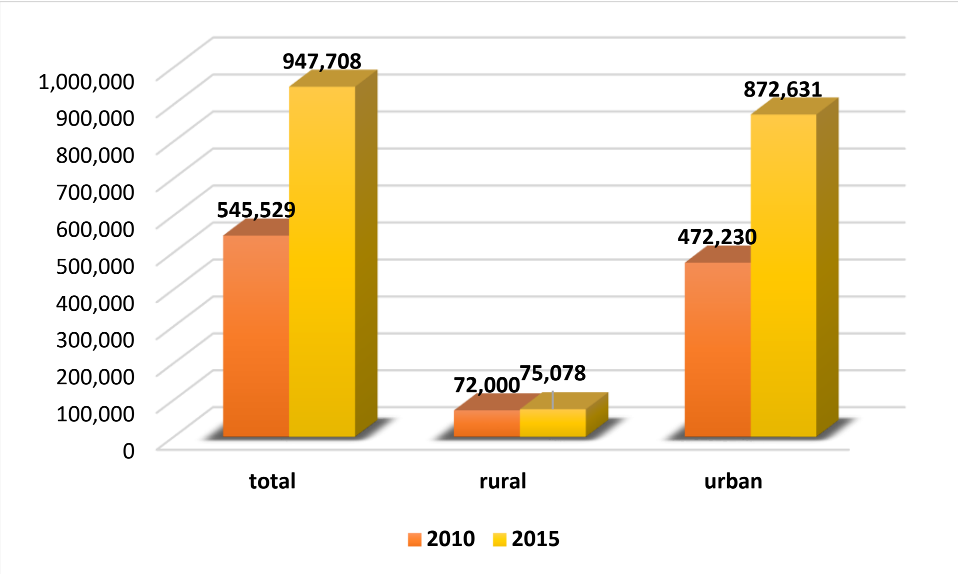
Figure 1.3: Zambia's Household's Connectivity to Electricity by Residence 2015



Source: Author's own using data from CSO, 2015

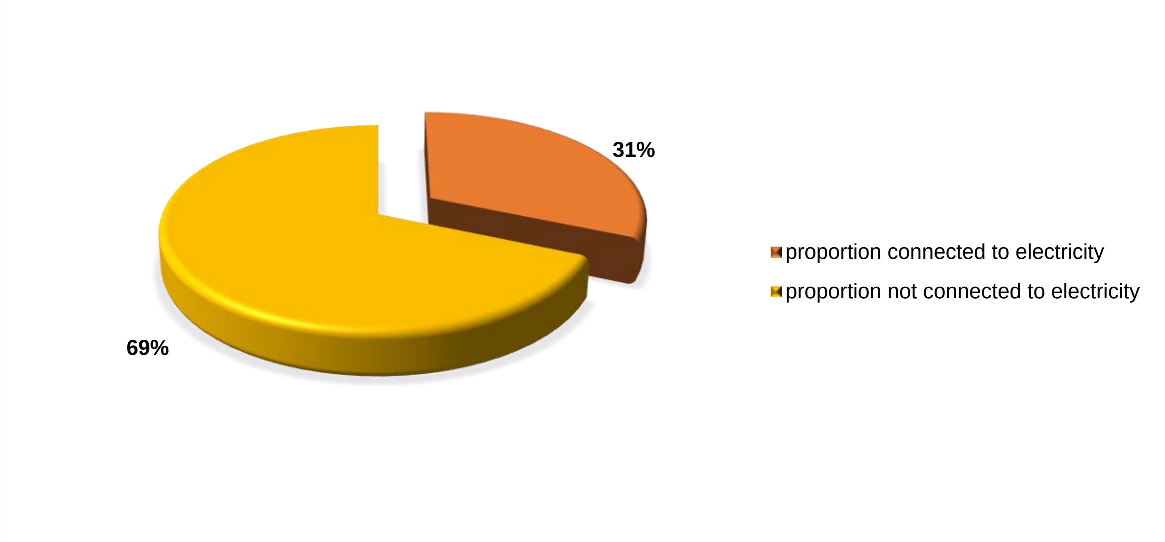
Even if the total number of households reported to have an electricity connection increased to 947,000 in 2015 from 584,000 in 2010, a growth of 364,000 (figure 1.4) only 31 percent of households indicated being connected to electricity countrywide as shown in figure 1.5 and nearly all connections were in urban areas due urbanisation, (CSO, 2015).

Figure 1.4: Zambia's Household's Connectivity to Electricity by Residence in 2010 and 2015



Source: Living Conditions Monitoring Survey, 2015 (CSO, 2015)

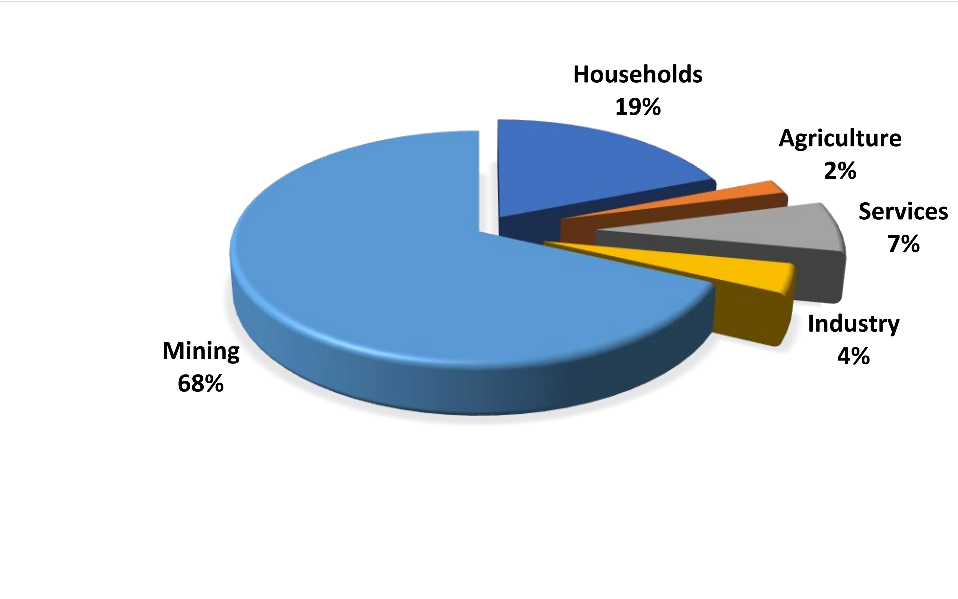
Figure 1.5: Proportion of the Population Connectivity to Electricity, 2015



Source: Authors compilation based on data from CSO (2015)

Of the 31% of Zambia's electricity consumption as shown in figure 1.5, 68% is dominated by the mining sector, 19% households, 7% services, 4% industry and 2% agriculture sector making the majority without access to electricity to be dependent on fire wood and charcoal for household energy needs. Figure 1.6 below shows electricity consumption by sectors in Zambia in 2008.

Figure 1.6: Electricity consumption by sectors in Zambia



Source: Author's own based on data from EIA, (2011)

It is inevitable to understand electricity consumption without talking about how the electricity it is supplied.

1.1.4 Electricity Supply in Zambia

Zambia generated electricity from the hydroelectric energy which expounded for 94.1% (2,269 MW) of national installed capacity in 2015. Alternative sources like Solar Photovoltaic (PV) (0.006 MW) generation plants and Diesel (92 MW), Heavy Fuel Oil (HFO) (50MW) accounted for the shortfall of 5.9% (figure 1.7) (Mwila et al., 2017). Zambia Electricity Supply Corporation (ZESCO) a governmental parastatal established in 1970 is responsible for generating, transmitting and distributing electricity in Zambia. It also participates in the cross-border transaction of electricity using the bilateral markets and Southern African Power Pool (SAPP).[2] ZESCO during the year 2014 observed growth in electricity exports by 16%, rising to 1,256.3 GWh in 2014 from 1,083.4 GWh in 2013. Fortunately, the electricity imports dropped significantly by 82.4%, from 72.9 GWh to 12.8 GWh in 2013 and 2014 respectively because of new generation developments that were established in the year, (ZESCO Annual Report, 2015).

In 2010, the Zambian government commissioned the construction of four hydro plants namely Kabompo, Itezhi Tezhi, Kariba North Bank Extension and Lower Kafue Gorge. Further, in 2015 it commissioned Maamba coal and Ndola Energy, (ERB 2015).[3] However, given the fact that at present, over 99% of electricity comes from hydropower and that almost all the developments being established are hydropower plants, this puts Zambia's electricity system susceptible to droughts. Droughts lead to a decline in run-off water which is required for generation of electricity which affects the hydropower plant availability. The effect is evident during the 1991/2 rainfall season when the drought was devastating causing an estimated US$300 million loss in the hydroelectricity sector (Kandji et al., 2006). Similarly, in 2015, due to 2014/15 poor rainfall as a contributing factor in Zambia, analogous to the happenings in developing countries and most of the emerging countries, Zambia's economic growth slowed down to an estimated 3.2%. Furthermore, the 2015 hot season was recorded to be the hottest season which led to high evaporation from various sources of hydroelectric power sources. In general, the poor rainfall and hot season was as result of climate change which significantly led to severe electricity supply reduction, (Mwila et al 2017).

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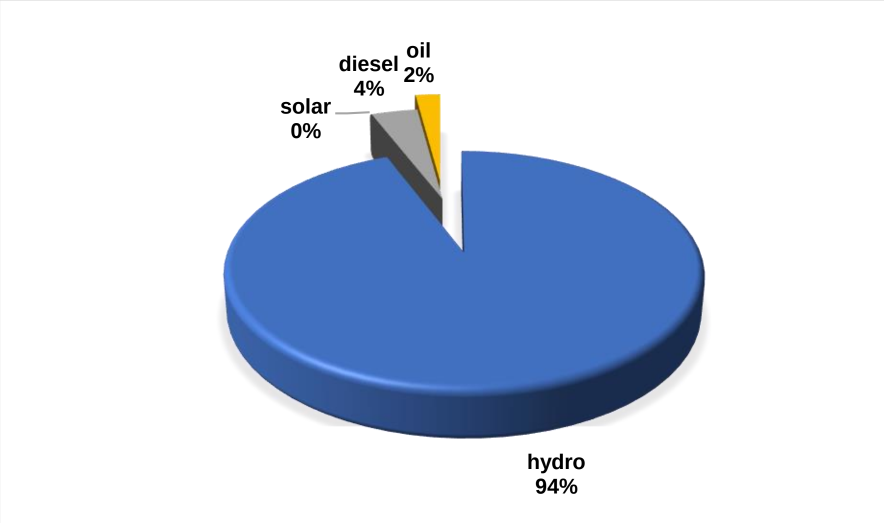
[2] Established in 1990, the Southern African Power Pool's aim is to provide reliable and economical electricity to member countries. Membership is restricted to electricity companies that were members of the Southern African Development Community (SADC) in 1994. Countries connected to the electricity grid include Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. Non-SADC countries participation is subject to approval http://www.sapp.co.zw/. See Map 1 for SAPP grid

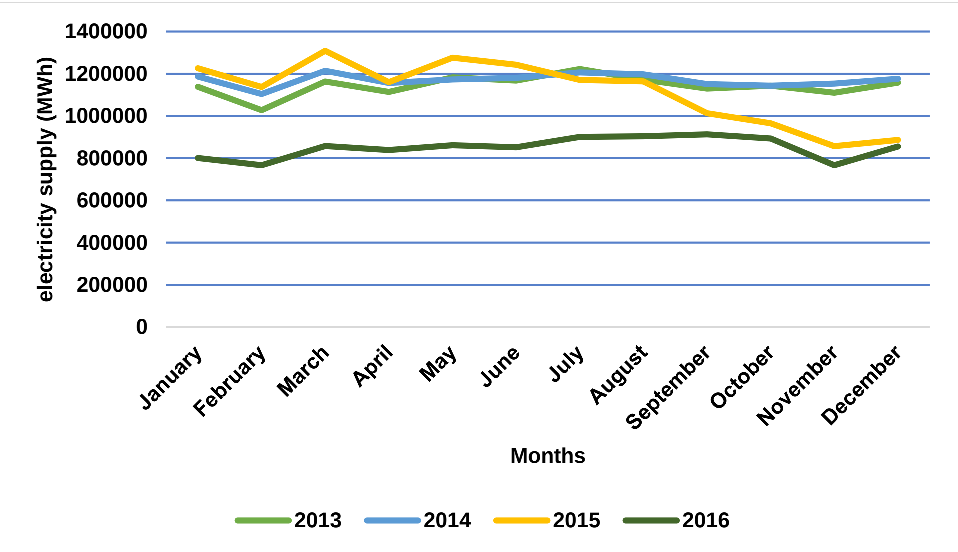
[3] More details in Appendix 2 for table showing electric power stations in Zambia

Figure 1.7: Installed generation capacity in Zambia, 2015



Source: Authors own using data from Mwila et al (2017)

Figure 1.8: 2013-2016 Monthly Transmission



Source: Author's own based on secondary data collected from ZESCO

As shown in figure 1.8 above, the total generation sent out from both ZESCO and Independent Power Producers (IPPs) power plants dropped by 4.5 percent in 2015. Electricity sent out reduced from 14,039,582,000 KWh to 13,436,506,000 KWh in 2014 and 2015 respectively.

At the beginning due to the power deficit ranging from, ZESCO undertook load shedding as a way of load management of at least 3 to 5 hours a day in most densely populated areas like Matero, Kanyama, Kalingalinga, to mention but a few in Lusaka the capital city. However, by July 2015, ZESCO increased the extent of load shedding to at least eight (8) hours a day for most of its households country wide including both industrial and commercial customers.

According to Mwila et al. (2017), given the severity of the power deficit crisis in 2015, the following measures were constituted by Government of Zambia:

i. ZESCO entered into agreements with SAPP utilities and emergency power suppliers to present the importation of electricity from some sources within the SSA region like South Africa and Mozambique;
ii. In January 2016 through Statutory Instrument (SI) No.74 of 2016, an announcement of a prohibition on importation and local manufacturing of luminescent bulbs and ineffective lighting equipment;
iii. Besides the Intromission of more IPPs to aid in the generation of electricity, in the Northern Province of Zambia, ZESCO built and commissioned Lunzua power plant.
iv. In 2015, the Zambian government through the Industrial Development Corporation (IDC), launched purchasing two solar power plants of 50 MW each to be presented to two dissimilar buyers;

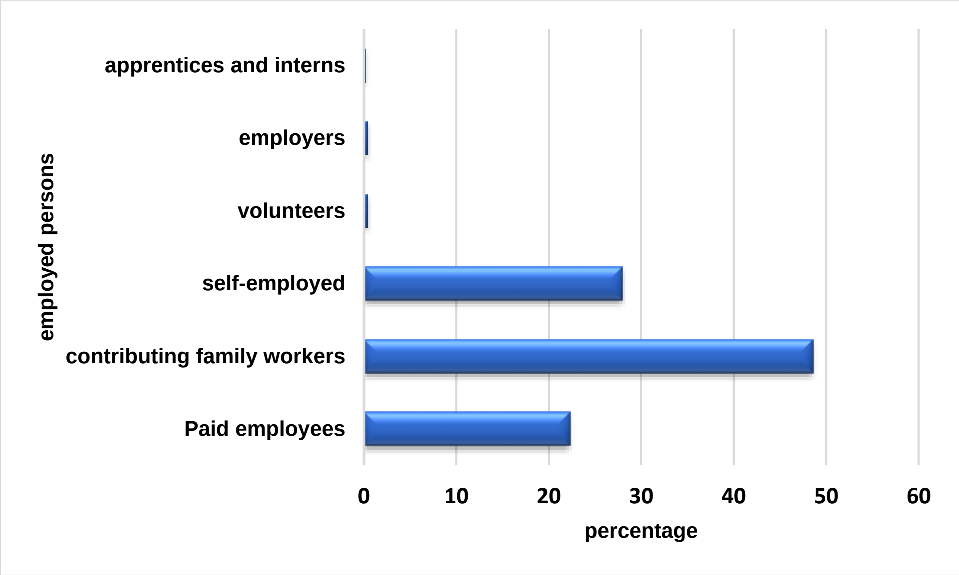
The government promptly implemented these measures because business operations and financial viability were being highly affected by the reduction in productivity leading to shutting down and massive laying off workers in most of these business operations[4] (Mwila et al., 2017). Thus, the next area of interest in this study is the employment sector.

1.1.5 Employment in Zambia

As earlier alluded in the preamble, since the copper industry is Zambia's backbone, its economic growth path has been led by this industry while other sectors like manufacturing and agriculture have received little consideration concerning forming a logistical and infrastructure network that is supportive and permits these industries to grow. However, a large part of its population is involved in marginal employment. There is a total of 5.86 million employed people in Zambia out of which 22.3% are paid employee, 48.6% are contributing family workers, 28% self-employed, 0.4 volunteers, 0.4% employers and 0.2% apprentices and interns. The ratio of contributing family member plus self-employed to paid employed conveys that there is a limitation regarding secure jobs in Zambia. Therefore, a substantial component of the labour force in Zambia is involved in the informal sector doing semi-productive and marginal activities, (CSO LFS, 2014).

[4] See appendix 3 for link diagram from electricity to employment to economic growth

Figure 1.9: Percentage Distribution of the Employed in Zambia, 2014



Source: Authors own based on data from CSO Labour Force Survey (2014)

According to UNDP (2016) considering the employment status, agriculture had the highest percentage of the employed representing 80.2% contributing family workers, 41.3% self-employed, 14.4% paid employees and 47.7% employers. The percentage of contributing family workers and self-employed is quite high signifying that the level of subsistence farming economic activities is extremely low. Comparatively, the employed only represent a share of 3.8% and 1.4% in manufacturing and mining respectively. Even if the mining sector produces the mass of Zambia's revenue, it creates minimal employment opportunities directly and indirectly, implying that the sectors that record high economic growth do not substantially impact on employment in Zambia. This is evident in the period 2001-2011 when economic growth was steady and capital accumulation had risen rapidly but this growth was employment neutral.

Bhorat and Jacobs (2012) ascertain that employment in the services sectors in Zambia has risen on average by more than 4% per year. Occupations in the services sector are more focused in informal retail, trade and wholesale sub-sector. They suggest that the sectors that are less able to absorb more labour, are the ones driving economic growth in Zambia. Table 1.1 below shows the sector employment elasticity. It shows that when GDP increased by 1%, there was a 0.39% increase in employment. Employment in the services and agriculture sectors increases by 0.57 and 0.44 respectively, showing an absorptive labour rate as they exhibit growth rates above the aggregate estimate of 0.39%.

Table 1.1: Sector Employment Growth Elasticities in Zambia, 2001-2011

	Average Annual Growth		
	Employment (%)	**Value Added (%)**	**Elasticity**
Industry	0.04	9.6	0.00
Services	2.2	3.8	0.57
Agriculture	2.0	4.5	0.44
Total GDP	2.2	5.7	0.39

Source: UNDP (2016)

Table 1.2 shows that presently the employed have relocated to the informal sector in the urban sector from the rural agriculture sector. However, relocation from agriculture to high efficiency sectors like manufacturing is considered the core gateway to economic growth and unfortunately, Zambia's growth pattern has not lead to this structural change as many find employment in the informal urban sector. With the given statistics, a large segment of the employed comprises the poor in the agriculture sector representing 81% of the working poor. Therefore, an increase in labour earnings plus a growth of productivity in the agriculture sector can stimulate economic growth.

Table 1.2: Employment by Sector in Zambia, 2005-2014

Industry	Employed population (number, % total employment)				Formal employment (number, % sectoral employment)			
	2005	2008	2012	2014	2005	2008	2012	2014
Total	4,131,531 (100)	4,606,846 (100)	5,499,673 (100)	5,859,225 (100)	495,784 (12)	511,338 (11)	847,420 (15)	944,256
Agriculture, Forestry and Fishing	2,983,968 (72.2)	3,284,208 (71)	2,872,331 (52.2)	2,864,158 (48.8)	29,840 (1)	71,888 (2)	87,420 (3)	106,943 (3.7)
Mining and Quarrying	166,143 (4)	92,810 (2)	88,251 (1.6)	82,725 (1.4)	154,513 (93)	62,082 (67)	67,608 (77)	67,002 (80.9)
Manufacturing	55,499 (1.3)	159,194 (3.5)	216,660 (3.9)	223,681 (3.8)	18,870 (34)	36,923 (23)	73,814 (34)	76,470 (34.1)
Construction	33,399 (0.8)	80,255 (1.7)	187,906 (3.4)	182,806 (3.1)	12,692 (38)	13,889 (17)	36,676 (20)	59,085 (32.3)
Trade, Wholesale and Retail Distribution	88,080 (2.1)	425,209 (9.2)	645,571 (11.7)	692,078 (11.8)	9,689 (11)	28,706 (7)	110,365 (17)	110,875 (16)
Transport, storage, information, andcommunica	22,773 (1)	94,800 (2.1)	137,301 (2.5)	172,374 (2.9)	22,773 (56)	29,484 (31)	61,797 (45)	72,297 (41.9)

Source: CSO Labour Force Survey (2005, 2008,2012,2014) cited in UNDP (2016)

1.1.6 Electricity and employment policies in Zambia

Table 1.3: Zambia electricity reforms

Year	Party Name	President	Electricity policies
1964-1991	UNIP	Dr Kenneth Kaunda	Infrastructure development through: • Central Africa power Corporation (CAPCO)-companies where joined from Zimbabwe and Zambia • Victoria Falls, Kafue Gorge and Kariba Dam power stations. • Nationalisation of ZESCO in 1970
1991-2002	MMD	Dr Fredrick T. J Chiluba	• Rural Electrification Fund (1994) • Electricity Act (1995) • Commercialisation of ZESCO Ltd • Power Rehabilitation Programme
2002-2008	MMD	Mr Levy Patrick Mwanawasa	• Rural Electrification Act (2003) which enabled founding of Rural Electrification Authority in 2003 • Amendment of Electricity Act 1995 in 2003 • Rural Electrification Master Plan (2008)
2008-2011	MMD	Mr. Rupiah B Banda	• Biofuels industry • Enactment of the Power systems Development Plan (2008-2030) • Revised NEP
2011 to date	PF	Mr. Michael. C Sata then Mr. Edgar C Lungu	• No amendments till date

Source: Ministry of Energy and Water Development (2010) and World Bank (2016)

1.1.6.1 Electricity policies in Zambia

As shown in table 1.3, the electricity industry in Zambia has experienced a sequence of structural reforms since independence and each president elected to power amends the energy policies (World Bank, 2016a). There was the primary National Energy Policy (NEP) framed in 1994 which sought to promote optimal transmission and energy utilisation, particularly local energy forms for socio-economic growth in a health and safe atmosphere. Due to the enactment of Poverty Reduction Strategy Paper (PRSP) attributes of 2002, the energy policy was critically reviewed and an amended one was formulated that takes into consideration the present situation in the energy sector like renewable energy, cost effective tariffs and household energy to move away from wood fuel dependence, for the country as a whole, as well as regional and international surroundings (Ministry of Energy and Water Development, 2007).

The 2007 NEP aims at ensuring the energy sector is underlying prospective to drive economic growth as well as alleviate poverty. The policy is thus a reference for policy makers in the private sector, government, civil society and Non-Governmental Organisations on Government's planned activities in the energy sector. In the electricity sub-sector of the NEP framework, the Ministry of Energy and Water Development is accountable for guaranteeing the economy's demand for electricity is fulfilled as well as the timely power availability to meet the country's needs.[5]

According to Haanyika (2008) pertaining to the Rural Electrification and electricity sector especially, the NEP together with government targets the:

i) Facilitation of improved access to electricity by restructuring and liberalising the electricity market
ii) Encouraging the utilisation of spread out renewable energies and affordable technologies.
iii) In 1995, the government accomplished an Institutional and legal framework by legislating new regulations, that is, the Energy Regulation Act and the Electricity Act. The Energy Regulation Act delivered for the instituting of a self-governing supervisory body with the purpose of stimulating private sector involvement and competence. The Electricity Act provided for regulation and liberalisation of the electricity sector, and, a related administration mechanism and Rural Electrification Fund (REF) was ratified in the very year 1995. Nevertheless, rural electrification experienced a lot of sustained

[5] See Zambia's Energy Institutional Framework and Implementation available in Appendix 4

challenges. Therefore in 2003, the Rural Electrification Act was enacted by the Zambian government primarily for the role of rural electrification.

1.1.5.2 Employment Policies in Zambia

In Zambia, there has been a gradual decline of the formal sector as the primary source of employment. Employment in the formal sector as a proportion of the total labour force, has been deteriorating over the years from 75 percent to 10.3 percent in 1975 and 1999 respectively (CSO, Selected Socio-economic Indicators, 1999). Unlike the energy policies, the employment policies have not changed since 2000 when the National Employment and Labour Market Policy (NELMP)was established. The NELMP is the legal policy document on employment in Zambia established by the Ministry of Labour and Social Security and other stakeholders in the year 2000. The policy document categorises policy areas for promoting employment and ameliorating the efficiency of the Labour market such as productivity enhancement, governance, social security, population growth, occupational health and safety, HIV/AIDS, labour migration employment and gender, child labour, a collection of interconnected sector policies for creation of jobs, environmental degradation and information system of the labour market. The principal advantage of this policy is the acknowledgement for the necessity for a harmonised conceptualisation to promote employment. However, because of financial constraints, the policy remains unimplemented (Ministry of Labour and Social Security, 2004).

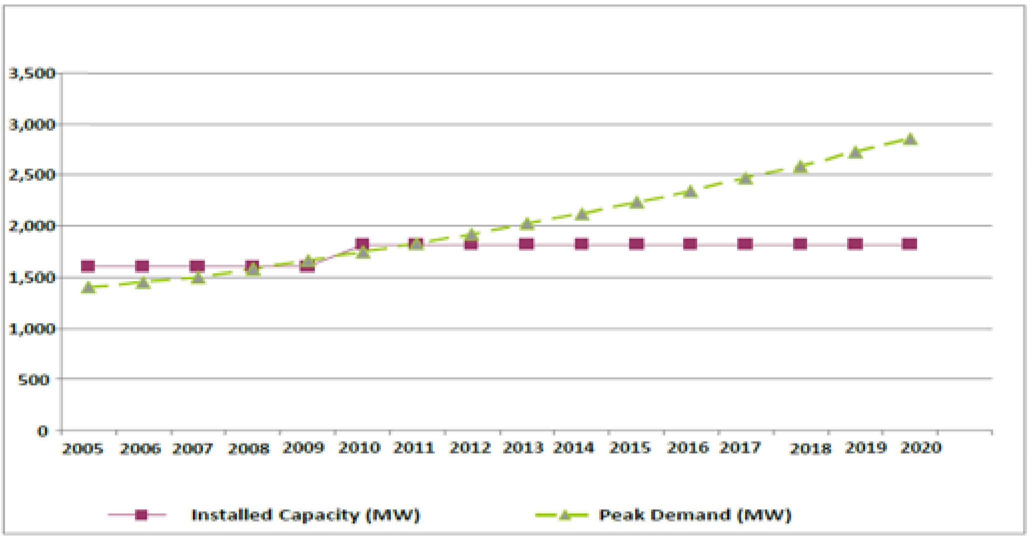
Administration of the Labour Legal Framework in Zambia is overseen by several fragments of labour legislation to regulate and enforce the labour market. These include: -

(i) Zambia Institute of Human Resources Management Act No. 11 of 1997,
(ii) Industrial and Labour Relations Act Cap 269,
(iii) Factories Act Cap 441,
(iv) Workers Compensation Act, Cap 271,
(v) Employment Act Cap 268,
(vi) Minimum Wages and Conditions of Employment Act Cap 276,
(vii) Pension Scheme Regulations Act, No. 28 of 1996,
(viii) Employment (Special Provisions) Act Cap 270,
(ix) National Pension Scheme Act, No. 40 of 1996,
(x) Preferential Claims in Bankruptcy Act of 1995, and
(xi) Employment of Young Persons and Children's Act Cap 274.

1.2 Problem Statement

Zambia Development Agency (ZDA, 2014) reports that, since the past decade, the economy of Zambia has been growing at 5% annually on average and the demand for electricity has surpassed this development. According to Tembo and Merven (2013), in Zambia, electricity demand between 2000 and 2006 grew at an annual average rate of 6%. This was mainly caused by the rise in demand from the mines and quarry sub-sector. As a result, Zambia reduced its exports and increased its import of electricity, but its electricity imports were not adequate to cater for the deficit, so it resorted to substantial power rationing. However, the 2006 power rationing only affected the residential sector and did not have any impact on the mining sector owing to contractual supply agreements, (World Bank, 2008; IMF, 2008). Again, as shown in figure 1.10 below, it was anticipated in 2010 by then Ministry of Energy and Water Development, (2010) cited in Mwila et al. (2017) that demand would outstrip electricity supply.

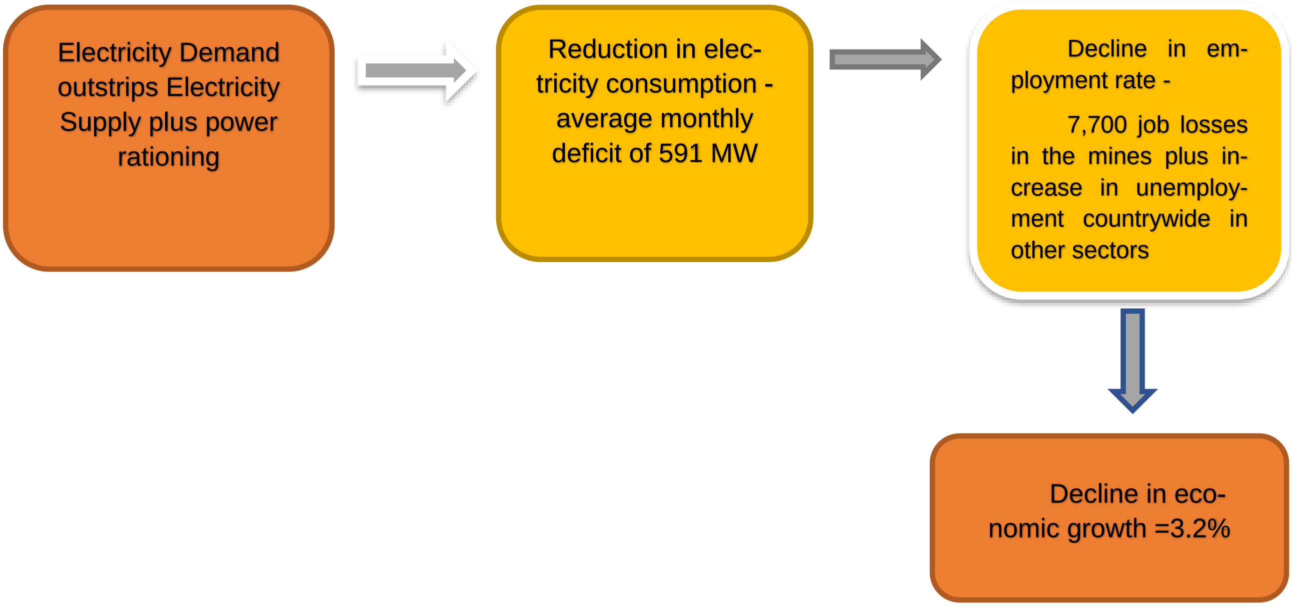
Figure 1.10: Projected demand by 2020



Source: Ministry of Energy and Water Development, (2010) cited in Mwila et al. (2017)

Further, the deliberate shutdown of electricity in 2015 to prevent the collapsing of the power distribution system caused many instabilities in the country. Since 2011, only a few households in Zambia experienced load shedding but in 2015, on average, there was 8-12 hours of no electricity every day for most households, businesses (both formal and informal) and mines. Water supplies were regularly down since pumps were unable to work minus power. Since the early 1990s, Zambia has been facing the challenge of high unemployment. Earning an income for many Zambians rests profoundly on being able to secure employment. Even when there are other options like pursuing entrepreneurial activities, the uncertainty that comes with the business makes the option an unfeasible choice or unpleasant because of lack of business management skills, being unable to have start-up capital and anticipating making losses (World Bank, 2016). Therefore, could unemployment coupled with a reduction in electricity consumption affect economic growth?

Figure 1.11: Relationship between electricity consumption, employment rate and economic growth as at 2015



Source: Author's own based on data from World Bank (2015 and 2016a) and Nyirenda in the Times of Zambia newspaper dated July 15, 2015.

Figure 1.11 above is a flowchart of this research. At the national level, the power crisis in 2015 caused reduced productivity and joblessness encompassing all businesses in the industrial, manufacturing and services sectors. The manufacturing sector reported having increased costs of production and reduced output, as they were required to run generators which were costly. As alluded earlier, in the mining sector which is the backbone of Zambia's economy, mining accounts for 12% of Zambia's GDP, 70% of total export earnings, 62% of Foreign Direct Investment (FDI) and is a source of government revenue and formal employment. In 2015, the sector already being affected by lower copper prices, had proclaimed laid-off roughly 7,700 workers, closures and suspended investment because of declining production and profitability due to power rationing and thus hurting Zambia's economic growth, (World Bank, 2016a). Further, the Zambia Association of Chambers of Commerce Industry (ZACCI) as reported by Nyirenda in the Times of Zambia newspaper dated July 15, 2015, reported that job losses had increased countrywide. Specifically, in 2015, the impacts on copper mines made the headlines (World Bank, 2016b). The Mulyashi Open

Pit Mine and Baluba Underground Mine were mandated to make redundant 1,640 workers in September 2015, as supplies to the private Copperbelt Energy Corporation (CEC) were cut and production reduced. Since September 2015 CEC's electricity volume reduced drastically first by 30 %, then later by 16 % in a short period (Waltina, 2016). Most of these activities have been explained from the supply side point of view. Therefore, as argued by Tembo and Merven (2013), knowledge of the demand side is needed as well. The purpose of this study is to examine if a relationship in the framework (figure 1.11) between electricity consumption, employment rate and economic growth in Zambia exists.

1.3 Justification and Relevance for the Research Topic

Akarca and Long (1979) stress that determining the effect on economic growth to changes in employment and electricity is very vital in understanding the responsiveness of the economic system to higher electricity prices, discoveries of new electricity sources, electricity deficit, changes in energy policies and changes in employment rate. As Ghosh (2009) highlights, the electricity consumption level can be used as an indication of the socioeconomic development of a country, hence a lot of current studies focus on investigating the causality relationship between economic growth and electricity consumption. Recently, there have been numerous studies on the causality between economic growth and electricity although most of them have centred more on developed, Latin American and Asian countries. Moreover, there have been a few studies in Africa and more specifically SSA. Notwithstanding, the few studies in SSA, empirical results have been unconvincing. Further, the few studies have been limited to using two variables (bivariate model) and may suffer from the problem of omitted variables and alter the direction of causality thus yielding bias estimates (Lütkepohl, 1982). For instance, the only study am aware of done on Zambia is by Wolde-Rufael (2006) who used a bivariate framework for the period 1971 to 2001 might have suffered the problem of omitted relevant variables. He used a modified version of the Granger causality test due to Toda and Yamamoto (1995) and a cointegration test proposed by Pesaran et al. (2001) which allowed him to skip the pre-testing of unit roots and cointegration tests. At best, our study using a trivariate cointegration and VECM framework including employment, therefore, is the first to be done on Zambia. Therefore, this study will contribute by extending and complementing the already existing researches on the relationship between economic growth and electricity consumption. Employment rate is incorporated as a potential determinant of both electricity consumption and economic growth in Zambia because as people get jobs, their income increases, more household will change from using traditional fuels to more convenient forms of energy such as electricity and thus demand for electricity increase and leads to economic growth (Mdluli 2007; Howells 2008). [4]

Having knowledge on the relationship and direction of causality between these variables in Zambia may have policy implications from a policy perspective of whether implementing energy conservation policies will either have adverse effects or not on economic growth, (Ghosh, 2002). Thus, the knowledge which will be acquired is imperative in helping Government tailor policies and institutional frameworks necessary to develop a reliable electricity system that will foster electricity infrastructure expansion to help the country's rapid industrialisation strategy and enable Zambia as an energy-dependent country and also facilitate measures to dodge power rationing that it is experiencing at present and thus encourage sustainable development.

1.4 Research Objectives

To examine the relationship between Economic growth, Electricity consumption and employment rate in Zambia.

1.4.1 Main Research Questions

i) Does electricity consumption promote Economic growth in Zambia?
ii) Does employment rate promote Economic growth in Zambia?
iii) Does a change in electricity consumption have an impact on the employment rate?
iv) How does economic growth respond to changes in electricity consumption and employment rate?

1.5 Limitations of the Study

The Real GDP per capita data collected from Penn World Tables database was weighted and thus this might have given spurious findings.

Chapter 2

Literature Review and Empirical Studies

This chapter highlights the theories that illustrate the relationship between economic growth, electricity consumption, employment rate along with studies conducted in different countries on the causal relationship. It has been categorised into four segments namely: electricity, employment and economic Growth nexus; electricity consumption - economic growth nexus; employment – economic growth nexus and; employment – electricity consumption nexus. Of specific significance are the studies conducted in various countries to give an unbiased and informed account of economies belonging to different organisations, located in different regions, using bivariate or multivariate frameworks and whether they are dependent on energy or not. These characteristics have made the empirical studies to yield different causality results.

2.1 Electricity, Employment and Economic Growth Nexus

In trying to examine the overall relationship between electricity, employment and economic growth and make recognition of the significance of energy in economic growth, it is vital to have knowledge of the function energy has in the production process. Stern (1999) argues that there is a bias as to the role of electricity in economic growth in mainstream theories of growth.

2.1.1 Electricity in production

As stressed by Stern (2011), electricity's role in production and economic development is vital, therefore, production ought to be regarded as a function of labour, capital and electricity. In view of production theories, neo-classical economic theory describes the economy as a closed one where inputs of labour and capital produces output. Hence, increase in inputs or their worth results in economic growth. As stressed by Stern (1999), inputs that are in existence at the commencement of the period under discussion and are not directly depleted in production are known as primary factors of production (however they can be used up and replaced). Intermediate inputs are those created during the production process and are consumed completely in the process. Capital and labour in this view are considered direct (primary) factors of production while energy inputs like fuels having an indirect importance are considered intermediate goods, (Vlahinić-Dizdarević and Žiković, 2010). Therefore, less emphasis has been put on energy as an intermediate good by main growth theory because of it its role as an intermediate good in production much. They assume that the available amount of energy in any period in the economy is endogenously known, although it is determined by economic constraints like generating capacity and biophysical constraints like oil reservoirs pressures, (Stern and Cleveland, 2004:5).

Georgescu_Ruegen (1971) as cited in Onyakoya, et al. (2013) was the initial researcher who examined energy's function in the economic growth structure. In 1973-1974 after the first oil crisis other academicians began formulating energy dependent production functions that included energy (Berndt and Wood, 1979; Tintner et al., 1974). Alam (2006) approves that there is a shift from neoclassical economics to one that takes into account energy as a factor of production and that in the production process, energy is used to transform the raw materials into finished goods.

The efficiency law also known as the second law of thermodynamics denotes that a minimum quantity of energy is needed to accomplish the conversion of matter. This means that there should be restrictions to the replacement of other inputs for energy. In short, all economic activities require energy although other activities like services may not involve the direct processing of materials. Nevertheless, it is only at the micro-level that this is possible, indirect use of materials is required at the macro-level in all economic activities in the accumulation of capital, (Stern and Cleveland, 2004). Equally, Sanchis (2007) affirms that because electricity consumption is positively related to output, it affects capital accumulation and therefore, when electricity consumption reduces, productivity declines leading to a decline in socioeconomic growth as well.

Energy demand is also a resultant from the demand of goods and services. Most economic activity would be impossible without electricity, even the small and medium-scale enterprises that are the main source of employment in the informal sector for the poor. The kind of economic growth that creates jobs and raises incomes depends on greater utilisation of electricity. For instance, in an industry where electricity is introduced, this will raise the productivity locally by supplying process heating, lighting and motive power. As a result, this will increase earnings, which will create more household demand for electricity as people would want to engage in activities that generate income by powering machines that raise productivity and by providing lighting that extends the day, (Saghir, 2005). Usually as productivity and incomes rise, most industries expand their business and thus as one of the expansion criteria, they employ more workers as argued by (Boltho and Glyn, 1995). In their study, they observed that employment increases during a boom and reduces during a recession. Wholly, this is mirrored in the strong correlation between economic growth and electricity consumption. Economies that have been seen to develop are those that replaced animal and human labor with more suitable and proficient sources of technology and energy and without a doubt, in our modern era, no country has succeeded to significantly decrease poverty without greatly increasing the use of energy.

Further, for electricity consumption to flow through economic growth, it needs to work with other sectors to ensure greater economic growth, (Saghir, 2005). In our study, as claimed by Seshamani (1997), employment is a bridge that paves way to a better standard of living and thus economic growth. On the other hand, electricity is considered to be a catalyst (Onyakoya et al., 2013; Yuan et al. 2008) and works together with other sub-sectors like education and health to spur economic growth.

2.1.2 Education

Access to electricity provides people with spare time to go to school, boosts productivity instead of collecting traditional energy sources like wood fuel and charcoal. Electric lighting in both schools and homes enables both children and adults to attend evening classes and study after daytime activities. This will thus lead to a reduction in illiteracy and thus lead to economic growth as most people would be learned and get formal employment, (Saghir, 2005). Sodipe and Ogunrinola (2011) argues that formal employment is the most preferred source of income in most developing countries and thus when education is encouraged it helps individuals have a higher likelihood of finding employment. Further, through education, electricity leads to higher levels of literacy in women and thus transforms into improved children's health, (Saghir, 2005).

2.1.3 Health

Electricity improves living conditions significantly through better health by allowing households to switch from traditional energy sources whose emissions cause respiratory diseases. It also helps reduce malnutrition by boosting household incomes and agricultural production and helps in powering equipment used for treating and pumping water to ensure supply of safe clean water thus reducing the prevalence of waterborne disease particularly in shantytowns, (WHO, 2002). Further, it creates a vital feature of sanitary improvement by means of more progressive medical equipment and upgraded food hygiene. As a result, this will lead to improved living conditions through better health, longevity and improvement of the labour force, (Kauffmann 2005:4)

2.1.4 Improving Women's quality of life

Increasing access to energy brings uneven welfare for women in productive activities, education and health, because women in many parts of the world spend more time collecting fire wood and water and cooking than men, (Saghir, 2005). As quoted by Lee (2015) "*if we want to drive progress in the world, we need to make sure girls are in the driver's seat*". When women have access to electricity, it gives them opportunities to engage in income generating activities and employment because they have extra time and they will be healthy as they will not be dependent on wood fuel, (Saghir, 2005).

A survey was done in rural India on the impact of women's access to electricity. The likelihood that a woman will read is strongly correlated to whether the home has electricity or not. Notwithstanding the level of income, nearly households without electricity showed that no reading takes place. Approximately 11% (women) of the sample on average spent about an hour a day reading and of these, most of them came from higher income households. However, amongst the women from lower income households, there is a higher probability of reading for those women from households with electricity. Besides, higher-income women have a higher literacy rate than lower income women and so would have a higher probability of reading (Saghir, 2005).

2.2 Electricity consumption and Economic Growth Nexus

Electricity is a multifaceted energy "currency" that supports a wide range of services and products which encourages entrepreneurial activities, increases worker productivity and improves the quality of life. Further, it is a requirement for the profitable operation of almost all sub-sectors of the economy thus having access to electricity spurs economic development (Yuan et al. 2008). Electricity accessibility is generally considered a catalyst behind industrial production and economic activity (Onyakoya et al., 2013). For that reason, the electricity significance in any economy cannot be overstated. This is because most sectors such as communications, construction, health, entertainment, education and manufacturing expressively repose on electricity generation supply for their everyday routines, (Ackah and Takyi, 2014).

Whether electricity is a catalyst of economic growth or economic growth takes precedence over electricity consumption has facilitated interest among policy analysts and economists to examine the causality direction between electricity consumption and other economic variables for instance income, energy prices, GDP GNP or employment (Masih and Masih, 1997; Yang, 2000; Asafu-Adjaye, 2000).

2.2.1 Electricity Consumption- Economic Growth Hypotheses

As stated in the preamble of this chapter, many variables of the economic system have been used as proxy or incorporated to the bivariate model to find the causality direction between economic growth and electricity consumption and this issue has been extensively researched. This is because the causality direction has important policy implications. As a result, Shahateet (2014) argues that, there are four hypotheses that can be tested. Firstly, when there is a unidirectional causality running from economic growth to electricity consumption, this is the Conservation Hypothesis. It implies that economic growth is positively related to electricity consumption and signifies that an economy relies less on electricity and that energy conservation policies like load shedding may have no impact on economic growth (Wolde-Rufael, 2006; Squailli, 2007). Policymakers may then use these results in increasing government spending or reducing the tax burden and attracting investors, (Vlahinić-Dizdarević and Žiković, 2010). Secondly, is the Growth Hypothesis which affirms that electricity is an input like labour and capital in the production process and an incentive for economic growth. The hypothesis suggests there is a unidirectional causality running from electricity consumption to economic growth. Therefore, any changes to electricity consumption/supply will negatively affect economic growth as the economy is reliant on energy (Ozturk, 2010; Apergis and Payne, 2009, Wolde-Rufael, 2004). Thirdly, when a bidirectional causality between electricity consumption and economic growth exists, this means that electricity and economic growth are associated and are comparable. Changes in the demand for electricity will affect economic growth and vice versa. This is called the Feedback Hypothesis (Yang, 2000; Jumbe, 2004; Squailli, 2007). Fourth is when there is no causality between economic growth and electricity consumption. This implies that a change in electricity consumption has no influence on economic growth and vice-versa. This is known as the Neutrality Hypothesis, (Yu and Choi, 1985; Asafu-Adjaye, 2000). This suggests that neither expansive nor conservative policies vis-à-vis electricity consumption will not affect economic growth.

According to [Akinlo, 2008; Energy Information Administration (EIA, 2013)], the role of energy in economic growth is very vital. Therefore, a lot of empirical studies try to examine the relationship to confirm the correct linkage between electricity consumption and economic growth for different countries using Causality and cointegration tests.[6]

2.2.3 Empirical Studies on the Electricity Consumption-Economic Growth nexus

Empirical literature on Economic Growth and electricity normally yield contradictory results in terms of causality direction similar to the Chicken-egg causality as to which one comes before the other, the chicken or the egg (Thurman and Fisher, 1987). Outcomes vary owing to different time periods used, alternative variables, econometric methodologies and countries studied on the economic growth and electricity consumption relationship. Power deficit crises, climatic changes, disproportionate carbon emission levels, price increases in crude oil and economy's characteristics

[6] A summary on the causality between economic growth and electricity consumption of the main findings of previous time series studies is given in Appendix 12.

such as diverse economic and political histories, cultures, institutional arrangements and electricity policies have further kindled this debate.

For instance, Karanfil and Li (2015) made observations in their panel data study on economic growth and electricity consumption on 160 countries (East Asia and Pacific, North America and Africa) from 1980 to 2010 and the results were varying based on countries' regional locations, levels of income, according to common characteristics like mostly members of the same international organisations like OPEC, OECD, SADC, BRICS or G7 and for some they used multivariate framework to avoid the omitted variable bias. There are also numerous country-specific studies that analyse the Granger causality relationship between real GDP and electricity consumption and similarly they yield contradictory results too. The theoretical inspiration for the Granger causality test is rooted in policies of energy conservation which might have significant consequences to economic growth thus to the economy. Evidence of either direction will have a substantial effect on the formulation of energy conservation policies.

2.1.6.1 African Country Studies

Using the Error Correction Model (ECM), Jumbe (2004) observed unidirectional causality running from overall GDP (both agricultural and non-agricultural GDP) to electricity consumption but he found bidirectional causality running from GDP (non-agricultural) to electricity consumption when he used Granger-causality. Wolde-Rufael (2006) examined 17 African countries using revised form of the granger causality test as recommended by Toda and Yamamoto (1995) for the period 1971-2001 and observed Granger causality for 12 countries and a long run relationship for 9 countries. First, there was neutrality causality between electricity consumption and economic growth for Algeria, Congo Brazzaville, Kenya, South Africa and Sudan. Second, for Benin, Congo DR and Tunisia, he found a unidirectional causality running from electricity consumption to economic growth. Third, a unidirectional causality running from economic growth to electricity consumption was observed for Zimbabwe, Senegal, Zambia, Nigeria, Cameroon and Ghana. Fourth, a bidirectional causality was observed for Egypt, Gabon and Morocco. Particularly, for Zambia, because Wolde-Rufael (2006) found that when economic growth increases it instigates more electricity consumption or demand because he observed a positive long-run unidirectional causality running from economic growth to electricity consumption implying energy conservation policies may be implemented without endangering economic growth. However, he suggests that in reality, this is not reasonable because already there is a large portion of the population that does not have access to electricity in Zambia and the present energy infrastructure is insufficient to keep up with the high demand that outstrips its supply from all sectors of the economy therefore to advocate for policies that will result in a reduction of electricity consumption will have more adverse effects on the economy.

Wolde-Rufael (2009) re-analysed the study using the same countries although now he used data from 1971 to 2004 and also considered effect of labour and capital. He observed that though electricity stimulates economic growth within these countries, labour and capital are the most important factors of production and electricity is just a contributing factor. Incorporating employment in his bivariate model for South Africa for the period 1971 to 2006, Odhiambo (2009) empirical results showed that there is a bidirectional causality between and electricity consumption and economic growth. Also, he observed that employment Granger-causes economic growth in South Africa.

2.1.6.2 Asian Country Studies

Narayan and Singh, (2007) found a unidirectional causality running from electricity consumption to GDP for Fiji, an energy dependent country. On one hand, Glasure and Lee (1997) used a standard GC and no causality was found between economic growth and electricity consumption for Singapore. On the other hand, a bi-directional causality between electricity consumption and GDP was stated for South Korea and Singapore when ECM and cointegration was used. Using Hsiao's version of Granger Causality for Taiwan between 1954 and 1997, Yang (2000) observed a bi-directional causality running from economic growth to electricity consumption. However, reducing the time series to 39 years, Cheng and Lai (1997) reported a unidirectional causality using the GC technique using annual data from 1955 to 1993. Adding other economic variables for a research by Asafu-Adjaye (2000) who used the cointegration and ECM tests observed different results on the direction of causality between energy consumption, energy prices and income in India, Indonesia, Thailand and the Philippines. A bi-directional Granger-causality between energy consumption and income for the Philippines and Thailand while for Indonesia and India, a unidirectional Granger causality running from electricity consumption to income was indicated.

2.1.6.3 Other countries

Akarca and Long (1979) reported a unidirectional causality running from energy to employment rate and later economic growth when they used US monthly data for the period 1973-1978. However, previously for the same country, Kraft and Kraft (1978) empirical results showed a unidirectional causality running from economic growth to electricity consumption. Usually, a unidirectional causality running from economic growth to electricity consumption is common for countries with a strong tertiary sector like industrialised countries. As an economy moves through different stages of growth, the complementarity between other inputs, electricity and economic activity changes substantially. Electricity consumption in advanced economies is often used in final process like cooling, heating and transportation rather than in production processes. In such circumstances, the external shocks have a smaller impact on economic growth, while, and at the same time, economic growth has a more significant impact on the imports, production and level of electricity consumption, (Vlahinić-Dizdarević and Žiković, 2010).

In relation to this, other scholars like McAvinchey (2003) studied on the forecasting demand of electricity while others like Martin-Rodriguez and Caceres-Hernandez (2005) focused on the analysis of energy demand. Despite the contradictory empirical results, the studies yield the presence of causality between economic growth and electricity consumption.

2.3 Employment and Economic Growth Nexus

According to the UNDP Human Development Report 1996 as cited by Seshamani (1997), employment bridges the gap between opportunities for human development and economic growth. Employment is considered to make way to a lot of opportunities such as endowing individuals politically, socially and economically thus promoting human development and alleviating poverty. Walterskirchen (1999) argues that employment and economic growth go hand-in-hand because the greater the amount of goods and services produced, the greater the labour essential for production. Similarly, Daveri and Tabellini (2000) argue that when employment increases, this means that incomes in the economy increase as well. It also implies that a given capital stock is incorporated with more labour. This increases the return to capital and thus the savings rate increases also, and thus higher savings rate coupled with higher aggregate income translates to higher capital accumulation and fosters economic growth. However, there is no direct connection between employment and economic growth but there is evidence of countries that fall into four broad categories according to Seshamani (1997).

First, the declining employment opportunities with economic growth category. This describes a situation where there is no significant number of jobs being created despite economic growth or even if employment is being created it is not much to equal the fast growth in the labour force and thus unemployment will rise. This is a case of "*jobless growth*". Examples include Burundi, India, Colombia and Pakistan and most SSA countries have experienced declining employment while levels of economic growth have been high. Botswana's economic growth for instance between 1993 and 1995 grew about 6 per cent while employment was only at 1.5 per cent (UNDP Human Development Report, 1996).

Secondly, expanding employment without economic growth category. This describes a situation where there are significant employment opportunities being created despite little or no economic growth hence household incomes cannot expand much notwithstanding employment opportunities being created. Also known as "*growthless jobs"*. A good example of this is Mexico.

Thirdly, economic growth with employment. This is the most appropriate situation because economic growth increases as employment increases and vice versa. Also known as "*job-creating growth*". Examples include Botswana, Mauritius and Singapore which have observed increases in incomes as well as employment.

Fourthly, declining economic growth with contracting employment. This is the worst situation as it describes a decline in economic growth as well as a decline in employment opportunities. Also known as "*jobless and growthless"*. This scenario has been experienced by many SSA countries and Zambia is no exception particularly if employment is explained in the formal sector.

2.3.1 Empirical Studies on the Employment - Economic Growth Nexus

2.3.1.1 Developed countries Empirical Studies

The concept that economic growth is positively related to employment is true because empirically, periods of booms are virtually habitually linked to rising employment, while recessions are habitually associated with rising unemployment (Boltho and Glyn, 1995). Table 2.1 shows the relationship between economic growth and employment in particular developed countries. For instance, between 1983 and 1986 for both Canada and Norway, GDP growth was 4.8 and 5.1 respectively and employment was at 2.6 for Canada and 2.4 for Norway. However, during a recession in Canada between 1989 and 92 both GDP and employment dropped at -0.4 and -06 respectively.

Table 2.1: Employment and GDP growth in booms and recessions between 1983-1992 in selected developed countries (short run)

Country	Booms			Recessions		
	Years	Output	Employment	Years	Output	Employment
Canada	1983-86	4.8	2.6	1989-92	–0.4	–0.6
Finland	1978-81	4.7	2.3	1990-93	–4.5	–6.1
Germany, Fed. Rep. of	1988-91	4.6	2.0	1979-82	0.1	0.1
Netherlands	1987-90	3.8	2.7	1980-83	–0.2	–1.5
Norway	1983-86	5.1	2.4	1987-90	0.6	–1.5
Spain	1986-89	4.7	3.4	1978-81	0.4	–2.6
United Kingdom	1985-88	4.7	2.0	1979-82	–0.6	–2.1
United States	1982-85	4.4	2.5	1979-82	–0.3	0.2
Average [1]		4.6	2.5		–0.6	–1.8

Source: Boltho and Glyn (1995)

However, Boltho and Glyn (1995) argue that in the long-run, the relationship is not quite robust as shown in table 2.2. Empirical evidence shows that comparing the pre-oil shock and post oil shock era from 1960 to 1973 and 1973 to 1990 respectively in the OECD countries, employment growth rates were significantly stable over time.

Table 2.2: Employment and GDP growth rates from 1960 to 1990 in OECD countries (long run)

Area	1960-73			1973-90		
	GDP	Employment		GDP	Employment	
		Total	Private sector		Total	Private sector
North America	4.0	2.1	2.0	2.5	1.9	2.0
Japan	9.6	1.3	1.2	3.9	1.0	1.0
European Union	4.8	0.4	0.1	2.4	0.5	0.3
EFTA	4.5	0.7	0.1	2.2	0.8	0.3
Total OECD	4.9	1.1	0.8	2.7	1.2	1.2

Source: Boltho and Glyn (1995)

The elasticity variations confirm that the nexus between economic growth and employment is caused by economic situation and macroeconomic policy of an economy. For instance, companies would probably increase employment when there is a boom and reduce during a recession. In another study by Walterskirchen (1999), he generally observed a strong positive correlation between employment and GDP using panel data for all countries and used economic factors, labour market policies and demographic influences that explain changes in employment and unemployment. Saget (2000) examined European countries over the period 1989-1999 and his findings were different for the countries. There was a negative impact on employment for Romania, a positive response of economic growth from employment for, Russia, Slovakia, Poland, Hungary, and Czech Republic and there was no relationship between employment and economic growth for Ukraine and Bulgaria. Seyfried (2005) also examined US's ten largest states between 1990 and 2003 and discovered that response of employment due to economic growth is immediate and lasts for a few months but is transitory.

2.3.1.2 Developing Countries Empirical Studies

Yogo (2008) affirms that it is the worth of employment that is considered more pertinent in most SSA and not the size of employed it comes to the link between economic growth and employment because many persons employed work in the informal sector in these countries. According to him, in the long run, the strength of economic growth explains the decrease of unemployment and not by rigidities in the labour market. Using data for the period 1981 to 2006, Sodipe and Ogunrinola (2011) examined that the employment elasticity of economic growth is substantial and positive implying growthless jobs in Nigeria. Implies that in Nigeria there were jobs regardless of no adjustment in economic growth. According to them, the fast growing labour force in relation to the rate of growth of the formal sector, has shown that developing economies' labour markets have three similar characteristics. First, the informal sector keeps on broadening as many who are unemployed engage in self-employment or take up low-wage occupations as they wait for employment in the formal sector when there is a vacancy or an opportunity. Second, there is also the issue of under employment and disguised employment in the informal sector which makes the reported rates of unemployment in official documents to be low. Third, family enterprise unpaid employment, part-time employment and self-employment have an uneven contribution to total employment.

Aksoy (2013) in his study on the relationship between employment and economic growth, applied the Toda-Yamamoto Granger-causality for Turkey for the period 1988-2010 and observed the link varied across nine different industries. He found no causality between employment and economic growth across five industries and causality was observed for the rest of the four industries which include manufacturing, social service, energy production and distribution, transportation and communication. No causality was found for construction, mining, tourism and commerce, financial intermediation, agriculture industries.

Abdullah et al (2011) in his study included other macroeconomic variables like government expenditure and capital for the period 1970-2005 for Singapore, Philippines and Malaysia and his results showed that there was no causal relationship running from economic growth to employment. It follows from the above literature that the relationship between employment and economic growth varies across countries, periods and regions.[7]

2.3 Employment and Electricity Consumption Nexus

According to Arouri et al. (2014), although there are limited studies that pursue to recognise whether there is a causal relationship between employment and electricity, there are five hypothetical effects that can connect increased employment and electricity consumption. First is the Substitution effect which implies that limitations in electricity availability can result to substitution through increased labour utilisation and vice versa. Second is the Price effect which signifies that there is an impact on employment when an external shock affects energy sources like oil prices and coal which may subsequently have effects on economic growth as well. When old electricity technology is replaced with new technology, this can foster employment through the impact it has on an economy's level of growth as observed in the emerging economies and this effect is the Technological effect. Fourth is the income effect. This is when an increase in economic growth increases income and thus employment increase as well as firms expand. As a result, there is an increase in domestic demand for goods and services and thus electricity. Lastly is the Demographic effect which influences both electricity consumption and employment. Workers may shift from using traditional fuels once they are employed to more efficient energy use like electricity and an increase in population may have a greater demand for electricity.

[7] A summary on the causality between employment and economic growth of the main findings of previous time series studies used in this study is given in Appendix 13.

2.3.1 Empirical Studies on the Electricity Consumption-Employment Nexus

2.3.1.1 Developed Country Studies

Narayan and Smyth (2005) examined the relationship between employment and electricity consumption between 1966 and 1999 for Australia and found that employment Granger-causes electricity consumption. Oxley et al. (2004) in his study in New Zealand using data from 1960 to 1999 with gas, oil, coal and electricity consumption as various energy sources, observed that electricity consumption and oil has an impact on employment. Ewing et al. (2007) found no causality when he used coal as the proxy for electricity consumption monthly data for the USA from 2001 and 2005. Payne (2009) expanded his data and used 1976 to 2006. His empirical resulted revealed that energy influences employment in the long run.

2.3.1.2 Developing Country Studies

Arouri et al. (2014) examined the relationship between employment and energy in 16 African countries from 1991 to 2010. They observed that the results vary across countries; no causality was observed for Ghana, Morocco, South Africa, Senegal and Nigeria; unidirectional causality running from energy consumption to employment for Congo DR and Egypt; unidirectional causality running from employment to energy consumption for Zambia, Cameroon, Ethiopia and Tunisia; and a bidirectional causality for Tanzania, Kenya, Benin, Mozambique and Algeria. Odhiambo (2010) assessed the relationship between economic growth, electricity consumption and labour force participation between 1972 and 2006 for Kenya and found that electricity consumption Granger-causes employment but then again economic growth and electricity consumption foster greater labour participation in the economy. Ghosh (2009) examined this relationship in India but used electricity supply in place of electricity consumption and observed that when electricity supply increases employment increases as well. According to him, this implies that in India, growth in electricity supply and economic growth foster employment. For Turkey, Bayat et al (2011) narrowed down his study and analyzed the relationship between GNP, employment electricity consumption within the manufacturing sector between 1960 and 2005. Although a causal relationship was found running from employment to GNP, there was no causality between employment in the manufacturing sector and electricity consumption in Turkey. However, Polat and Uslu (2011) analyzed the same relationship although using date from 2005 to 2010 and found that electricity consumption does Granger-cause employment.[8]

[8] A summary on the causality between employment and electricity consumption of the main findings of previous time series studies used in this study is given in Appendix 14.

Chapter 3

Data and Research Methodology

3.1 Data

I used secondary data downloaded from World Bank Indicators (WDI) and Penn World Tables database, collected secondary data from ZESCO and CSO which contains annual observations from 1974 to 2016 of Electric power consumption per capita (KWh), GDP per capita (current US$) and employment. All the three variables are converted to natural logarithms to smooth the data in the model and this yield better results compared with the linear functional form. Also, the first difference of the variables is taken to approximate their growth rates. The variables used in this study are presented in table 3.1 and table 3.2 provides summary statistics for the variables in levels and in first differences.

Considering the explanation in section 2.1.1 of Chapter 2 of the role of energy in production, we utilise the conventional neo-classical one sector aggregate production technology (Berndt and Wood, 1979; Yuan et al., 2008) where energy, labour and capital are treated as separate inputs. Therefore, since our study only examines economic growth, energy (electricity) and labour, our economic growth function is of the form:

$\boldsymbol{Y_t = f(E_t, L_t)}$ which can be expressed as:

$$\boldsymbol{Economic\ growth_t = f(Electricity\ Consumption_t, Employment\ Rate_t)}$$

Preceding researches like Narayan and Smyth (2005) and Odhiambo (2009) incorporated employment rate in their analyses involving economic growth and electricity consumption. Thus, this model is not in isolation.

The specific sources and definitions of the variables used are emphasised below:

i) **Real GDP per capita (at constant national prices in millions 2011US$)**

Real GDP per capita is the total economic output measurement of a country divided by the population and adjusted for inflation (Saghir, 2005). This is used as a proxy for economic growth. The variable Real GDP was downloaded from Penn World Tables database and Zambia's population in the same period was used to convert to real GDP per capita. Further, comparing our converted Real GDP per capita to the calculated Real GDP per capita from WBI, the difference is insignificant. According to WBI, using constant national prices in dollars has the same purchasing power over GDP as the dollar has in USA thus making it easy for comparative studies across countries. In the analysis of causal relation as claimed by Yoo and Kwak (2010), using GDP, instead of GNP may be suitable because the total energy consumption of a country is dependent on goods and services produced within the country and not outside

ii) Electricity consumption per capita (KWh)

This is the total amount of electricity consumed per individual annually plus imports and minus exports, of those who have access to electricity expressed in Kilowatts per hour (KWh) (Stern, 1999). Further, according to the WBI, electricity consumption is equal to production minus the power plants' own consumption and transmission, distribution, and transformation losses minus exports plus imports. Thus, electricity consumption is equivalent to electricity supply. The time series data from 1974 - 2014 was downloaded from the World Bank Indicators**Error! Bookmark not defined.** while 2015 and 2016 series were secondary data from ZESCO. The figures from ZESCO are comparable because World Bank gets reports from ZESCO to compile their database.

iii) Employment rate

This is the percentage of the labour force that is employed. Unemployment rate annual data from 1990 – 2016 was downloaded from World Bank indicators while the preceding period from 1974 -1989 from CSO Labour Force Survey (1988), economist intelligent unit (1989) and the Zambia National Commission for Development Planning Economic Report (1980) cited in Kalinda and Floro (1992). The downloaded unemployment rate values were then subtracted from 100 to obtain the employment rates.

Table 3.1: Description of Variables and Time Series Alteration

variable name	Definition of variables
year	year
RGDP	Real GDP at constant 2011 national prices (in millions)
Elec_p	Electricity consumption (kWh per capita)
Population	Population (in millions)
RGDP_p	Real GDP per capita at constant 2011 national prices (in millions)
Employ_r	employment rate (percentage of the labour force employed)
lRGDP_p	Natural logarithm of GDP per capita at constant 2011 national prices (in millions)
lElec_p	Natural logarithm of Electric power consumption (kWh per capita)
lEmploy_r	Natural logarithm of employment rate
ΔlRGDP_p	Change in GDP per capita at constant 2011 national prices (in millions)
ΔlElec_p	Change in Electric power consumption (kWh per capita)
ΔlEmploy_r	Change in employment rate

Source: Author's own compilation

Table 3.2: Descriptive Statistics of Variables

Variables	No.obs	Mean	Std. Dev.	Minimum	Maximum
Variables in levels					
Year	43	1995	12.55654	1974	2016
Population	42	9.558568	3.246804	4.81081	15.72134
RGDP	41	23969.07	11168.73	15434.49	55283.68
RGDP_p	43	2578.325	530.4059	1901.854	3636.06
Elec_p	43	788.4811	192.1865	556.1211	1178.804
Employ_r	43	84.73786	5.556483	70.9	92.47
Variables in Natural log					
lRGDP	43	7.834989	.2001751	7.550584	8.198656
lElec_p	43	6.642786	.2330731	6.320986	7.072255
lEmploy_r	43	4.437409	.0668462	4.261271	4.526884
Variables in first Differences					
ΔlRGDP	42	.0015465	.0405223	-.1153755	.0681458
ΔlElec_p	42	-.0154782	.0551616	-.1800766	.1495647
ΔlEmploy_r	42	.0063241	.0256709	-.0748768	.0801373

Source: Author's own compilation using STATA based on statistics from WBI

3.2 Model Specification

A four-stage approach is used to examine the direction of causality. First and foremost, the Augmented Dicky-Fuller (ADF) (Dickey and Fuller, 1981) Phillips-Perron (PP) (Phillips and Perron, 1988) tests of unit root or stationarity are employed to examine if a unit root exists in the time series data. Second, to check whether the three variables, real GDP per capita, electricity consumption and employment rate are cointegrated, the Johansen test is used (Johansen, 1988 and Johansen-Juselius, 1990). If co-integration exists among the variables we proceed to the VECM or otherwise use the VAR if co-integration does not exist. Third, the modelling method incorporated in this study to determine the long-run causality between GDP and electricity is supported by the ordinarily used Engle-Granger approach (Engle and Granger, 1987) by means of the Vector Error Correction Model (VECM). Fourth, we employ the Granger causality test to examine which variable causes or precedes the other in the case of Zambia i.e. either economic growth or electricity consumption or employment.

3.2.1 Unit Root Tests

For the unit root tests, we test whether we should accept or reject our null hypothesis using Augmented Dicky-Fuller (ADF) (Dickey and Fuller, 1981) and Phillips-Perron (PP) (Phillips and Perron, 1988) tests of unit root or stationarity. Our null hypothesis (**H_o**) and alternative hypothesis (**H_1**) are as follows:

H_0: $\boldsymbol{\delta = 0}$ (Unit root or non-stationary)
H_1: $\boldsymbol{\delta \neq 0}$ (No Unit root or stationary)

According to Gujarati (2003) our equation is written as below where we replace Y_t with economic growth, then electricity consumption and thereafter employment to test all the three time series for unit root. We estimate both (i) random walk with drift (constant term included) and (i) random walk with drift and trend and our ADF test is as follows:

1. **Random walk with drift:**

$$\boldsymbol{Y_t = \rho_1 + \delta Y_{t-1} + \sum_{i=1}^{z} \infty_i \Delta Y_{t-i} + \mu_t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{(1)}$$

2. **Random walk trend and drift:**

$$\boldsymbol{Y_t = \rho_1 + \rho_2 t + \delta Y_{t-1} + \sum_{i=1}^{z} \infty_i \Delta Y_{t-i} + \mu_t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{(2)}$$

Where $\boldsymbol{\mu_t}$ is the error term, $\boldsymbol{\rho_1}$ is the drift and $\boldsymbol{\rho_2}$ is the parameter of the time trend. We test for unit root in both level and difference forms. We consider the T-statistics and compare with the critical values. If the T-statistic of the respective variables is greater than its critical value at either 1% or 5% or 10% level of significance, we do not reject the $\mathbf{H_0}$ that there is a unit root and if the T-statistic is less than its critical value, we reject the $\mathbf{H_0}$ and accept the $\mathbf{H_1}$ that there is no unit root specifically, variables are integrated of order (0) or I(0). In an event where we do not accept the $\mathbf{H_0}$, we convert the variables to first difference specifically the variable is integrated of order (1) or I(1) and test for unit root again. When all series are integrated of order one I(1), we can progress to cointegration test using the Johansen methodologies in testing for cointegration because our unit root test results approve the non-stationarity of the variables, (Johansen, 1988, 1991).

3.2.2 Co-integration test

The co-integration concept can be outlined as an organised co-movement between two or more variables over the long run. Engle and Granger (1987) argue that if both A and B have unit roots or non-stationary, we would anticipate that a linear combination of A and B would be a random walk. But, the two variables may have the concept that a certain arrangement of them
$Y = A - xB$ is stationary. We say that A and B are co-integrated. If such a concept holds, thus we use the VECM, (Granger, 1981; Engle and Granger, 1987 cited in Lütkepohl and Krätzig (2004). If A and B are both non-stationary and if the linear combination of the time-series of the two variables is also non-stationary, then the standard Granger causality test is appropriate. However, if each of A and B is co-integrated and non-stationary, then any standard Granger causal conclusions will be inappropriate and a broader test of causality, based on an error-correction model (ECM), should be adopted (Engle and Granger, 1987). Prior to estimating the co-integration just after unit root tests, we determine the lags to be used for the Johansen test of co-integration using Schwartz criterion and we select either the Akaike's Information Criterion (AIC) or Final Prediction Error (FPE) or Hannan and Quinn Information Criterion (HQIC) or Schwarz's Bayesian Information Criterion (SBIC). Afterwards, we then proceed to the Johansen test of co-integration. The purpose of Johansen test of co-integration is to estimate the cointegrating rank of the VECM which illustrates if there is co-integration or not among our variables. Supposing that co-integration does not exist, this means there is no long run relationship among our variables and we therefore proceed to the VAR model using variables in difference form. However, if we find that our trace statistic is less than our critical value at 5% level of significance, we accept our null hypothesis

that there is a co-integration or there is an error term(s) or the variables have long run relationship at that chosen rank.

3.2.3 Vector Error Correction Model (VECM)

A Vector Error Correction Model (VECM) is a restricted Vector Autoregression (VAR) that has cointegration restrictions built into the model specification, so that it is intended for procedure with cointegrated series that is non-stationary. The VECM confines the long-run conduct of the endogenous variables to come together to their cointegrating associations while permitting a variety of short-run relationships. The cointegration term is identified as the error correction term because a sequence of partial short-run adjustments corrects the deviation from long-run equilibrium and amended progressively, (Davidson and MacKinnon, (1993) and Hamilton, 1994).
Resulting from the cointegration and unit root tests, the correction model equations below (A-C) were estimated, were the present value is dependent on its own past values plus past values of the other two variables and the error term. In addition, the series is a random walk with drift:

$$\Delta lRGDP\_p_t = \sigma + \sum_{i=1}^{p-1} \vartheta_i \Delta lRGDP\_p_{t-i} + \sum_{i=1}^{p} \theta_i \Delta lElec\_p_{t-i} + \sum_{i=1}^{p} \omega_i \Delta lEmploy\_r_{t-\mathrm{i}} + \varphi_1 ECT_{t-1} + \mu_{1t} \dots\dots \textbf{(A)}$$

$$\Delta lElec\_p_t = \sigma + \sum_{i=1}^{p-1} \theta_i \Delta lElec\_p_{t-i} + \sum_{i=1}^{p} \vartheta_i \Delta lRGDP\_p_{t-i} + \sum_{i=1}^{p} \omega_i \Delta lEmploy\_r_{t-\mathrm{i}} + \varphi_2 ECT_{t-1} + \mu_{2t} \dots\dots \textbf{(B)}$$

$$\Delta lEmploy\_r_t = \sigma + \sum_{i=1}^{p-1} \omega \Delta lEmploy\_r_r + \sum_{i=1}^{p} \theta_i \Delta lElec\_p_{t-i} + \sum_{i=1}^{p} \vartheta_i \Delta lRGDP\_p_{t-i} + \varphi_3 ECT_{t-1} + \mu_{3t} \dots\dots \textbf{(C)}$$

Where Δ is the difference operator, t is the time trend, $lRGDP\_p$, $lElec\_p$, and $lEmploy\_r$ are logarithms of real GDP per capita, electricity consumption per capita and employment rate respectively with their respective coefficient estimates $\vartheta, \theta, \omega$ and φ as the coefficient estimate for ECT. Resulting from the cointegrating relationship in the long run is ECT_{t-1} the lagged error-correction term, p is the lag length based on the selected lag criterion and σ is the constant. μ_{1t}, μ_{2t} and μ_{3t} are error terms that are mutually uncorrelated white noise residuals with mean zero and restricted covariance matrix. In each equation above, the change in the dependent variable is caused by both its lagged values, other variables and the past period's disequilibrium in level $\boldsymbol{ECT_{t-1}}$. Table 3.2 gives in detail the summary statistics for the variables in both their levels and first differences.

3.2.4 Granger Causality Test

To determine causality a Wald test on the joint significance of the lagged explanatory variables is conducted. Generally, Granger causality is done to see the short run causality running from independent variable to dependent variable.

3.2.5 Diagnostic tests

After our causality tests we run the diagnostic tests to find out if our model is appropriate using (i) Lagrange Multiplier (LM) test for residual autocorrelation; (ii) checking for stability of the estimates and; (iii) the Skewness-kurtosis test for normally distributed disturbances.

3.2.5.1: Lagrange Multiplier (LM) Test for Residual Autocorrelation

We employ the LM test for residual autocorrelation to check if autocorrelation exists at lag order in our model. A good model is one that has no autocorrelation and we can check this if after testing we find that our P-value at lag order is greater than 0.05.

3.2.5.2 Test for Stability of the VEC Estimates

The model is said to be stable or well specified if all the plotted eigenvalues lie inside the circle i.e. they are less than one when the test of stability is performed.

3.2.5.3 Test for Normally Distributed Disturbances

According to Frain (2006), the Jarque-Bera test is found to be lacking in power when the sample size is equal to or less than 50. As our sample size is 42, we opted to use the Skewness-Kurtosis test for normally distributed disturbances or residues. We have our hypothesis as:

H_0: the residues are not normally distributed

H_1: the residues are normally distributed.

A good model is one that has normally distributed residues and we can estimate this if our P-value after testing is greater than our critical value at 5% level of significance.

3.2.6 Impulse Response Function (IRF)

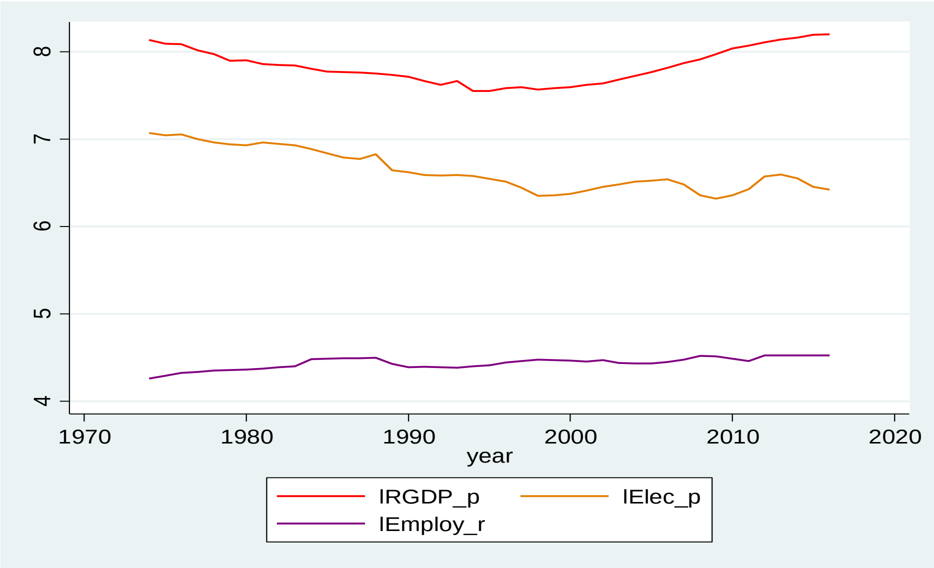
According to Lütkepohl (2005), when the model is well specified, we can approximate and explain the IRFs as an alternative way to analyse the causal relationship between our variables. IRFs from a cointegrating VECM do not mostly disappear compared to IRFs from a stationary VAR disappear with the passage of time. This is because of the time-invariant variance and mean in the stationary VAR that can return to its mean once a shock affects any variable in the stationary VAR. However, the first difference variables in the cointegrating VECM do not return to their mean. A shock that does not disappear with the passage of time is known as a permanent shock and one that does not is a transitory shock. Nevertheless, Hamdi et. al (2014) argues that the VECM Granger causality test also has some limitations because the test cannot capture the relative strength of the relationship beyond the selected time period and thus to solve this problem, the IRF is used.

Therefore, to better understand the responsiveness of the dependent variables in the VECM when a shock is applied to the error term i.e. how shocks in electricity consumption and employment rate are transmitted to real GDP per capita and vice versa, the Orthogonalized Impulse Response Function (OIRF) is examined. We observe the effect on the VECM system when we introduce one period standard deviation shock to one of the endogenous variable. The OIRF therefore traces the effect of one standard deviation shock to one of the innovations (impulse, shocks, error terms and residuals) on current and future values of the endogenous variables, (Lütkepohl, 2005; Enders, 1995). Using equation (A), (B) and (C) form section 3.2.3, when a shock is applied to $\boldsymbol{\mu_{1t}}$, it will bring a change in $\boldsymbol{lRGDP\_p}$ in equation (A). This will then change $\boldsymbol{lRGDP\_p_{t-i}}$, $\boldsymbol{lElec\_p_{t-i}}$ and $\boldsymbol{\omega_i \Delta lEmploy\_r_{t-i}}$ during the next period. Therefore, a shock in either $\boldsymbol{\mu_{1t}}$ or $\boldsymbol{\mu_{2t}}$ or $\boldsymbol{\mu_{3t}}$ will affect the whole VECM system.

Chapter 4

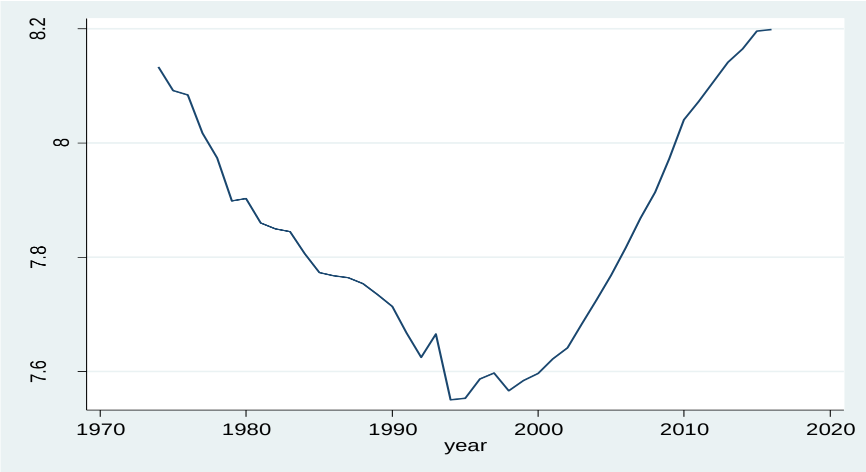
4.1: Results and Discussion

Figure 4.1: Non-Stationarity Trend Between 1974 – 2016 of Real GDP per capita, Electricity consumption and Employment rate in Zambia



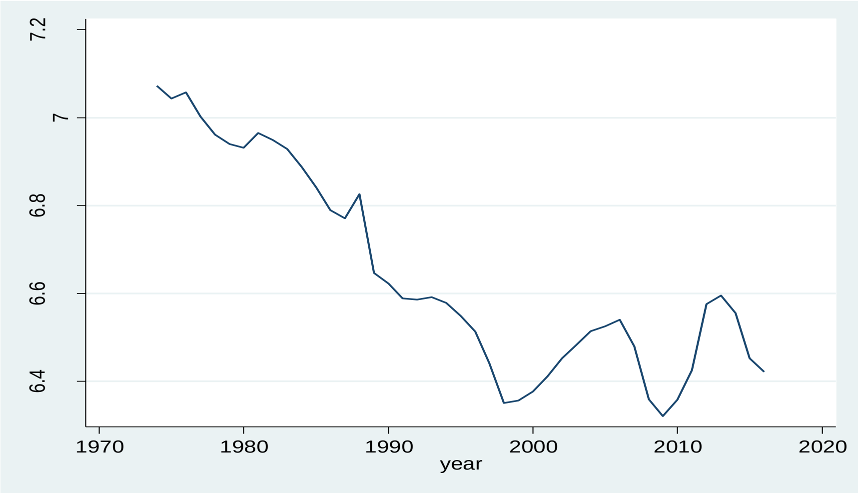
Source: Author's calculation based on WBI and Penn World Table data base

Figure 4.2: : Non-Stationarity Trend Between 1974 – 2016 of Real GDP per capita in Zambia



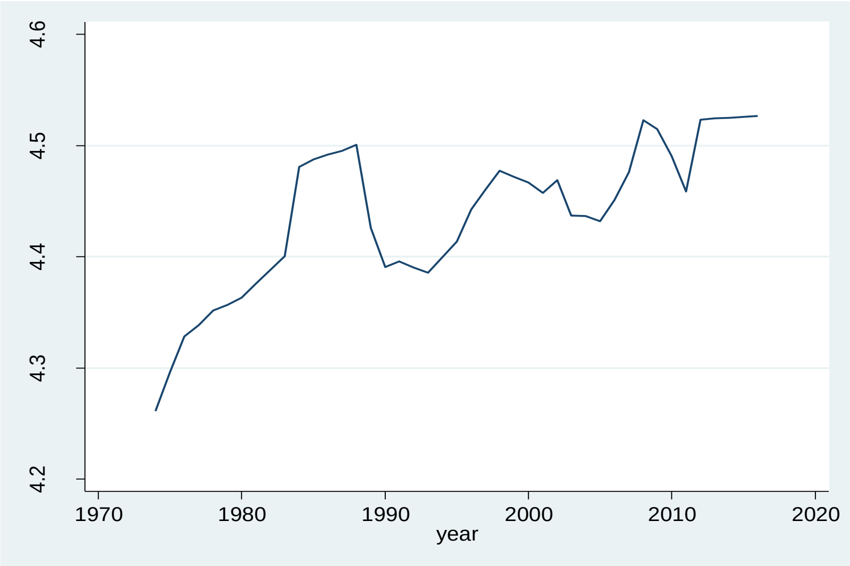
Source: Author's calculation based on data from Penn World table database. Accessed 20 0ctober 2017

Figure 4.3: Non-Stationarity Trend Between 1974 – 2016 of Electricity Consumption per capita in Zambia



Source: Author's calculation based WBI. Accessed 3 October 2017

Figure 4.4: Non-Stationarity Trend Between 1974 – 2016 of Employment rate in Zambia



Source: Author's calculation based on WBI data. Accessed 4 October 2017

Figure 4.1 illustrates the combined trend series of the three variables while figures 4.2, 4.3 and 4.4 are the separate variables in their level form denoting that they have unit root or non-stationary. Using the PP and ADF unit root tests to test for non-stationarity, the results are reported in Table 4.3 below.

4.1.1 Unit Root Tests Results

Table 4.1: Unit Root Results of the PP and ADF unit roots tests

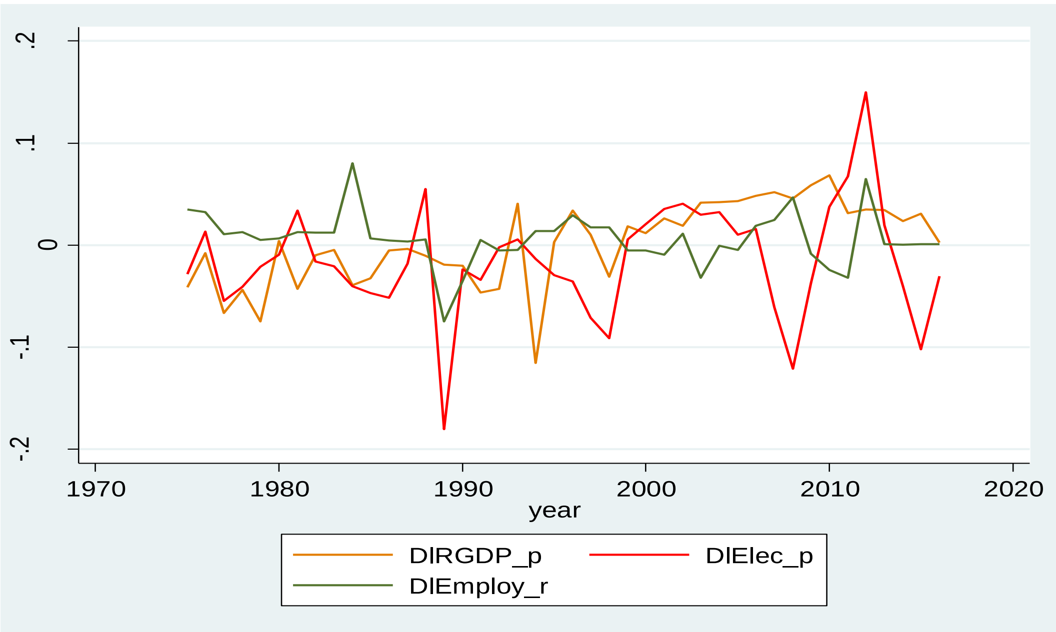
Variable	Phillips-Perron test (PP)				Augmented Dickey-Fuller test (ADF)			
	Level form		First differences		Level form		First differences	
	trend	No trend	trend	No trend	trend	No trend	trend	No trend
Log Real GDP per capita, PPP (constant 2011 international $)	-0.675	-0.782	-6.584	-3.974	-0.210	-0.509	-3.314	-1.503
Log Electric power consumption (kWh per capita)	-1.713	-1.627	-4.465	-4.473	-1.979	-0.431	-3.524	-3.362
Log Employment rate	-2.888	-2.470	-5.129	-5.165	-2.133	-0.380	-3.760	-3.116
Level of Significance	**Critical Values**				**Critical Values**			
1%	-4.224	-3.634	-4.233	-3.641	-3.770	-2.631	-3.770	-2.633
5%	-3.532	-2.952	-3.536	-2.955	-3.293	-2.364	-3.303	-2.374
10%	-3.199	-2.610	-3.202	-2.611	-2.976	-2.058	-2.984	-2.067

Source: Author's compilation based on the research findings

With our null hypothesis that a unit root exists (non-stationary) and the alternative being that there is no unit root (stationary), from Table 4.3,[9] we discover that the results from both the PP and ADF unit root tests (trend or no trend) cannot reject the null hypothesis for all our variables: lRGDP_p, lEmploy_r and lElec_p because their t-statistics are all greater than the critical values at all levels of significance from both the unit tests. Following both unit root tests, this indicates that all variables have a unit root and are non-stationary in their level form.

Using the same null hypothesis and alternative for the variables in their first differenced form, the findings from the PP unit root tests signify that PP t-statistics for lEmploy_r and lElec_p are less than the critical values at all levels of significance signifying stationarity. However, lRGDP_p first difference with trend t-statistics is significant at 1% and 5% level of significance and its first difference without trend t-statistics is not significant from the ADF unit root tests but greater than its critical values at all levels from the PP unit root tests. Therefore, following the PP test statistics at all levels of significance, all three variables become stationary after first differencing signifying that all three variables are integrated of order I(1). The time series trend of stationarity is shown in figure 4.5 below.

Figure 4.5: Stationarity Trend of Real GDP Per Capita, Electricity Consumption and Employment in Zambia during the period 1974 – 2016 (after first difference)



Source: Author's calculation based on WBI and Penn World Table database

[9] The detailed regression output of the two test is in Appendix 4

Lag Selection Criteria

A random selection of lags can interfere with estimates and give rise to inappropriate conclusions vis-à-vis causality. In this study we employed the HQIC and SBIC because they deliver consistent estimates of the true lag length ***p*** unlike the AIC and FPE statistics that overestimate the lag length, (Lutkepohl, 2005).

Using the Lag selection criteria as shown in figure 4.6 below based on Schwert's formula, both the HQIC and SBIC numerical quantities imply that the preferred lag is lag 1 therefore we use 1 lag to run our Vector Error Correction Model.

Figure 4.6: Lag Selection Criteria

```
. varsoc lRGDP_p lElec_p lEmploy_r

   Selection-order criteria
   Sample:  1978 - 2016                         Number of obs      =        39
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	88.3565				2.5e-06	-4.37725	-4.33134	-4.24929
1	233.155	289.6*	9	0.000	2.4e-09*	-11.3413*	-11.1576*	-10.8294*
2	241.082	15.855	9	0.070	2.5e-09	-11.2863	-10.9649	-10.3905
3	244.395	6.626	9	0.676	3.5e-09	-10.9946	-10.5355	-9.71498
4	252.279	15.767	9	0.072	3.9e-09	-10.9374	-10.3405	-9.27382

```
   Endogenous:  lRGDP_p lElec_p lEmploy_r
    Exogenous:  _cons
```

Source: Author's own calculation of regression output from STATA

4.1.2 Johansen Test for Co-integration

After the lag selection criteria, we used the Johansen tests for cointegration. The rule of thumb for the Johansen tests for cointegration is that the variables at level form have a unit root but should not have a unit root after first differencing (Johansen 1988, 1991). Our null hypothesis being that there is 1 cointegrating relationship between our three variables and no cointegrating relationship for our alternative hypothesis, it was ascertained that the three variables, lRGDP_p, lEmploy_r and lElec_p have one cointegrating relationship as shown in figure 4.7. This is because the trace statistics at rank = 1 is less than the critical value at 5% level of significance (9.61<15.41).

Figure 4.7: Johansen Test of Cointegration

```
. vecrank lRGDP_p lElec_p lEmploy_r, trend(constant) lags(1)

                       Johansen tests for cointegration
Trend: constant                                         Number of obs =      42
Sample:  1975 - 2016                                             Lags =       1
-------------------------------------------------------------------------------
                                                          5%
maximum                                        trace    critical
  rank    parms       LL         eigenvalue   statistic    value
    0       3     234.76801          .         37.5854     29.68
    1       8      248.7565     0.48630         9.6084*    15.41
    2      11     253.36377     0.19699         0.3939      3.76
    3      12      253.5607     0.00933
-------------------------------------------------------------------------------
```

Source: Author's own calculation of regression output from STATA

Engle & Granger (1987) and Granger (1981) cited in Lütkepohl and Krätzig (2004) clarifies that variables are cointegrated supposing they bear a familiar stochastic trend, therefore, using the unrestricted VAR model will not be appropriate and the convenient model to use would be the Vector Equilibrium Correction Model or Vector Error Correction Model (VECM). Further, knowing the cointegrating rank of the model you are considering, makes the VECM suitable for limiting an accompanying constraint to improve the estimation precision. This satisfies Engle and Granger (1987) claim that provided two variables A and B are cointegrated and trend is integrated of order one [I(1)] then a unidirectional causal relationship exists. The VECM is then used to determine this long run relationship among variables and to examine the individual series change in relation to this long run equilibrium in the short run dynamics (Lütkepohl and Krätzig, 2004).

4.1.3 VECM

We thus estimate the VECM equations (A) – (C) of Chapter 3 section 3.2.3 with one lagged difference of the three variables using our data from 1974-2016 and cointergrating rank = 1. Similarly, this method has been used widely in many studies, (Lee and Chang, 2007). The coefficients of the lagged ECT results are shown in Table 4.2.

Table 4.2: Vector Error Correction Model Based on our 1 lag

VARIABLES	(EQUATION A) D_lRGDP	(EQUATION B) D_lElec_p	(EQUATION C) D_lEmploy_r
L._ce1	-0.00215	-0.353***	-0.0905*
	(0.0382)	(0.116)	(0.0462)
LD.lRGDP_p	-0.102	-0.119	0.104
	(0.176)	(0.265)	(0.144)
LD.lElec_p	0.0281	0.547***	-0.0709
	(0.101)	(0.152)	(0.0824)
LD.lEmploy_r	0.0952	-0.675**	0.159
	(0.194)	(0.292)	(0.158)
trend	0.00259***	-4.71e-05	-0.000227
	(0.000600)	(0.000902)	(0.000489)
Constant	-0.0517***	-0.00487	0.00935
	(0.0136)	(0.0205)	(0.0111)
DIAGNOSTIC TESTS			
Stability check	stable	stable	stable
Autocorrelation	No autocorrelation	No autocorrelation	No autocorrelation
Normally distributed disturbances	NO	YES	NO
Observations	41	41	41

Standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1*

From Table 4.4 above, our best model is equation (B) with Electricity consumption per capita as the dependent variable and economic growth and employment the independent variables because it fulfils all the three diagnostic tests for a good VECM, that is; Lagrange Multiplier (LM) test for residual autocorrelation, checking for stability of the estimates and the Skewness-kurtosis test for normally distributed disturbances. Checking for stability of the estimates (Appendix 11) we ascertained that our VECM model (1) is stable. Using the Lagrange Multiplier (LM) test for residual autocorrelation in our trivariate VECM (Appendix 11), we do not reject the null hypothesis that there is no autocorrelation at lag order because we discover that the P-value is greater than the 5% significance level. The best test to use if the observations are few (i.e. less than 50) for normality is the Skewness-kurtosis test (Frain, 2006). Therefore, testing all out three models for normally distributed disturbances (Appendix 11) we ascertain that the residuals are normally distributed in Model (2) and our model is well specified or desirable.

The long-run causal effect is measured through the t-test significance of the lagged error correction term (L._cel). Established from the Equations (A) – (C), the resulting causal relationships can be derived between economic growth, electricity consumption and employment. Besides specifying the causality direction amongst variables, the error correction term also assists us to differentiate between the short-run and the long-run causality. To determine the short-run relationship, the significance of the changes in the lagged independent variables and through the F-statistics is measured.

The coefficient of the lagged error correction term (L._cel) in our chosen Equation (B) is negative (-0.353) and is statistically significant at 1% level of significance for lElec_p as the dependent variable, therefore a long run causality running from independent variables, employment rate and economic growth to Electricity consumption exists and no feedback mechanism. Because the L._cel measures the speed of adjustment towards long run equilibrium, the speed at which electricity consumption changes to any adjustments in employment rate and economic growth prior to approaching its equilibrium level means that once there is an adjustment in the employment rate or economic growth to electricity consumption, it approximately takes 35.3% speed per year to change to its previous disequilibrium.

This relationship implies that Electricity consumption changes are sensitive to changes in employment rate in Zambia and it show an immediate response of its own plus that of employment. When employment rate increase by I per cent, electricity consumption follows by 0.55 and 0.67 per cent in a year lag.

Figure 4.8: Cointegrating Relationship Equation

Cointegrating equations

Equation	Parms	chi2	P>chi2
_ce1	2	53.71803	0.0000

Identification: beta is exactly identified

Johansen normalization restriction imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
lElec_p	1	.	.	.	.	.
lRGDP_p	-.4953642	.0690662	-7.17	0.000	-.6307314	-.359997
lEmploy_r	-.7354091	.335062	-2.19	0.028	-1.392118	-.0786997
_trend	.0189158	.	.	.	.	.
_cons	.1121222	.	.	.	.	.

Source: Authors own based on Stata output using WBI data

From figure 4.8 our long run cointegrating relationship can be written as:

$$lElec\_p_t = -0.5lRGDP_{p_t} - 0.74lEmploy_r + 0.11 + 0.02t\text{……………………. (D)}$$

The equation denotes the existence of an equilibrium relationship between electricity consumption, economic growth and employment rate. This implies that in the long-run, electricity consumption has a negative and significant relationship with economic growth and employment rate. When economic growth increases by 1%, electricity consumption will reduce by 0.5% and when employment increases by 1%, electricity consumption will reduce by 0.74%.

4.1.4 Granger Causality

The results for the Granger causality test are shown in table 4.5 below. From our findings we observed that employment rate Granger-causes electricity consumption, but it does not Granger cause-economic growth. We also observe that electricity consumption neither Granger-cause employment nor economic growth and economic growth neither Granger-cause employment nor electricity consumption in Zambia.

Table 4.3: Granger Causality

Null Hypothesis	P-value	Accept or Reject null hypothesis	Outcome
Electricity consumption does not granger cause economic growth	0.7807	Accept	Electricity consumption does not granger cause economic growth
Electricity consumption does not granger cause employment rate	0.3894	Accept	Electricity consumption does not granger cause employment rate
Employment rate does not granger cause economic growth	0.6239	Accept	Employment rate does not granger cause economic growth
Employment rate does not granger cause Electricity consumption	0.0207	Reject	Employment rate granger causes Electricity consumption
Economic growth does not granger cause Electricity consumption	0.6524	Accept	Economic growth does not granger cause Electricity consumption
Economic growth does not granger cause Employment rate	0.4694	Accept	Economic growth does not granger cause Employment rate

Source: Author's own based on findings

4.1.5 IRF

The results of IRF are shown in figure 4.9 below forecasting the response of each variable to the shock of other variables as well as its own shock over the period 2017 to 2036 (horizontal axis) and the vertical axis represents percentage of the response. The following responses were observed:

- Response of electricity consumption to economic growth and employment

In the first 4 years an unexpected one unit shock of economic growth and employment negatively impacts electricity by by -0.005% and -0.01% respectively and there after have a positive permanent effect. However, a one unit shock of its own impacts positively by 0.07% in the first 4 years and then a negative transitory effect follows thereafter.

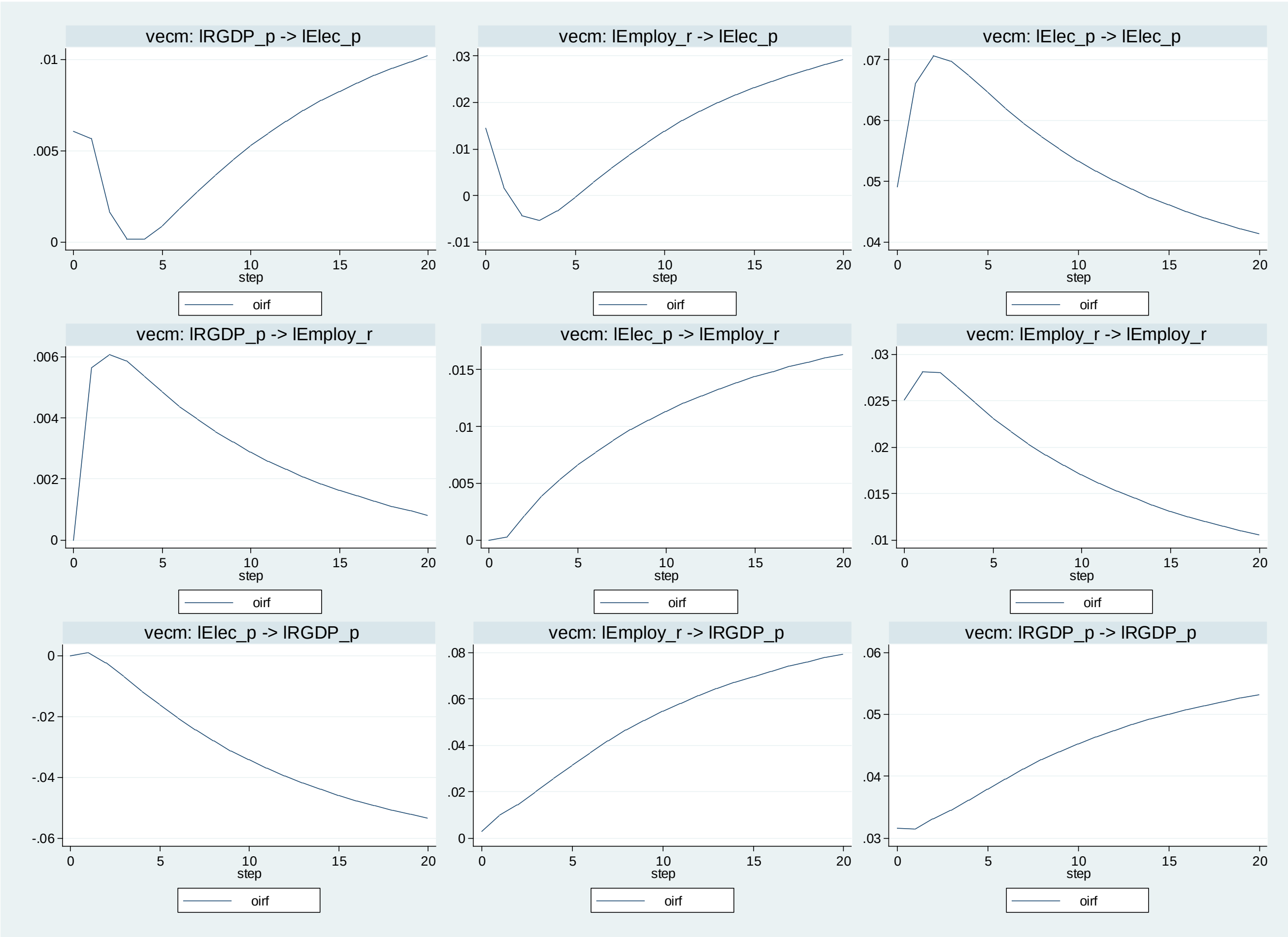
- Response of employment to economic growth and electricity consumption

  A one unit shock in economic growth induces a 0.008% positive effect on the employment rate in the first 2 years and then induces a negative transitory effect thereafter. But, a one unit shock in electricity consumption induces a positive permanent effect on employment immediately in Zambia. The response of employment on its own shock is positive in the first years by 0.3% but induces a negative transitory effect thereafter. Similarly, Seyfried (2005) also examined the US between 1990 and 2003 and discovered that response of employment due to economic growth are transitory.

- Response of economic growth to electricity consumption and employment

A one unit shock of electricity consumption has an immediate negative transitory effect on economic growth while a shock in employment has an immediate positive permanent effect on economic growth in Zambia. Then the shock of its own has a positive permanent effect. From our fingings, we can sum up that Economic growth is more responsive than electricity and employment in Zambia.

Figure 4.9: Impulse responses of the electricity consumption per capita/employment rate/economic growth system (Impulse→Response)



Source: author's own from Stata output

4.2: Discussion

The findings assessed emphasize that for Zambia, electricity consumption, employment rate and economic growth are cointegrated and a long run relationship exists. In our findings, we observe a unidirectional Granger causality running from employment rate to electricity consumption and no feedback. This implies as argued by Narayan and Smyth (2005) that electricity consumption is dependent on the employment rate and any changes in the employment rate will influence the consumption of electricity both in the short and long run. Our findings are similar with Arouri et al. (2014) who observed unidirectional causality running from employment to energy consumption using data from 1991 to 2010 for Cameroon, Ethiopia and Tunisia. Further that this is because of demographic, price, income or the substitution effect.

We also discover that electricity consumption neither Granger-cause employment nor economic growth in Zambia and that economic growth neither Granger-cause electricity consumption nor employment. Our finding on the electricity consumption-economic growth nexus is different to what Wolde-Rufael (2006) observed in his bivariate model during the period 1971-2001. He observed a unidirectional causality running from economic growth to electricity consumption implying that economic growth takes antecedence over electricity consumption and that economic growth instigated more demand for electricity consumption. Further, our results are also different to what Yoo and Kwak (2010) found in developing countries like Argentina, Brazil, and Columbia and what Narayan and Singh (2007) found in Fiji. Using a bivariate model in Yoo and Kwak (2010), they observed a unidirectional causality running from electricity consumption to economic growth. Further, they found out that in countries where there is a high percentage of heavy industry, electricity is most likely to Granger-cause economic growth. Also, a multivariate model in Narayan and Singh (2007) case, they discovered a unidirectional causality running from electricity consumption to GDP and affirmed that this was because of Fiji's dependence on energy. Therefore, our findings might not be consistent and trustworthy with the expectation that countries that are energy dependant are more vulnerable to energy shocks. Theory advocates that the neutrality hypothesis is appropriate for such an outcome like ours, implying that electricity consumption has no impact on economic growth and vice-versa (Yu and Choi, 1985). This suggests that either expansive or conservative policies vis-à-vis electricity consumption will not affect economic growth. However, this kind of outcome is popular for Arab countries from Shahateet (2014) study. Therefore, Wolde-Rufael (2006), Apergis and Payne (2009) and Ozturk (2010) proposed that the growth hypothesis instead will be appropriate for a country like Zambia because in reality, conservation policies like shocks to electricity supply will have detrimental effects on the economic growth of

Zambia. This is because a large portion of the population that does not have access to electricity[10] and the present energy infrastructure is insufficient to keep up with the high demand that outstrips its supply from all sectors of the economy. Therefore, to advocate for policies that will result in a reduction of electricity consumption will have more adverse effects on the economy. For instance, this is what Zambia experienced in mid-2015 when the country experienced an electricity deficit crisis due to poor 2014-2015 rainfall and all sectors were affected. Evidence is given through measures that were instigated to increase the supply of electricity in 2016 that stabilised the economy during load shedding period indicating that electricity expansionary policies are harmonious with improvement of economic performance of the country.

Our findings on the Employment-economic growth of no causality are similar to Boltho and Glyn, (1995) study who observed that in the long run, the relationship is not quite robust. Empirical evidence shows that comparing the pre-oil shock and post oil shock era from 1960 to 1973 and 1973 to 1990 respectively in the OECD countries, employment growth rates were significantly stable over time. Also, the UNDP Human Development Report 1996 as cited by Seshamani (1997), argue that there is no direct connection between employment and economic growth although he categories most SSA countries like Zambia in the category of declining economic growth with contracting employment also known as "*jobless and growthless*". However, Walterskirchen (1999) argues that employment and economic growth go hand-in-hand because the greater the amount of goods and services produced, the greater the labour essential for production. Our results can also be related to Aksoy (2013) who found no causality between aggregate employment and economic growth for Turkey. However, causality was found in some industries when aggregate employment was disaggregated in industries like construction, mining, tourism and commerce, financial intermediation, agriculture industries. As Zambia depends on mining and agriculture, this might be one of the reasons as to why there is no causality between employment and economic in Zambia. More research is therefore needed to observe the causality in various industries in Zambia to find out which industries impacts on economic growth through employment.

Additionally, in examining the response of economic growth to different shocks (from employment, electricity and its own shocks) to that of employment and electricity consumption, we reason out that economic growth is considerable more responsive to shocks in the economy than electricity consumption and employment.

[10] According to LCSM (2015) 69% of the Zambia population does not have access to electricity and only 31 have access to electricity. Of these 69% ,92% households are in the urban areas while 8% are in the rural areas.

Chapter 5

Conclusion

This study attempted to examine the dynamic relationship between economic growth, electricity consumption per capita, and employment rate in Zambia during between 1974 and 2016 and our trivariate model empirical findings illustrate that a long-run cointegration relationship exists. Besides searching existence of causality, the study establishes the direction of those dynamic relationships between economic growth, electricity consumption and employment.

A significant long run unidirectional causality running from employment to electricity consumption in Zambia exists. This is evident by the demographic effect where people shift from using traditional sources of energy like wood fuel and charcoal to more efficient and clean sources of energy like electricity as a result of increase in real income when they get employed, (CSO LCMS, 2015). Arouri et al. (2014), Wolde-Rufael (2009) and Apergis and Payne (2009) discussed that an increase in energy demand in African countries is closely associated with income. Growth in Population creates pressure on rural resources, forces people to move to urban areas, and thus raises demand for energy. They further argued that the increased energy demand over a long period must be met by developing cost-effective alternative energy or from new sources for sustainable economic development.

Further, our findings reveal that there is no causality between electricity consumption and economic growth which thus supports the neutrality hypothesis. This implies that electricity consumption has no impact on economic growth and vice-versa. This suggests that neither expansive nor conservative policies vis-à-vis electricity consumption will not affect economic growth, (Shahateet, 2014). In Zambia, this may be as a result of electricity being the second most vital source of energy after charcoal and wood fuel (traditional fuels) which accounts for 11% of the country's energy supply while the traditional fuels accounts for about 81%. Almost everyone uses traditional fuels whether they have access to electricity or not because it is the cheapest form of energy, (EIA, 2011). Further research is needed on the relationship between form of energy sources and economic growth in Zambia to examine which form impacts on economic growth.

Also, we observe no causality between employment and economic growth. Although Seshamani (1997) terms this condition as declining economic growth with contracting employment (*jobless growthless*), he argues that there is no direct connection between employment and economic growth. Even if the mining sector produces the mass of Zambia's revenue, it creates minimal employment opportunities directly and indirectly, implying that the sectors that record high economic growth do not substantially impact on employment in Zambia. Many people in Zambia are employed in the informal sector. This is evident in the period 2001-2011 when economic growth was steady and capital accumulation had risen rapidly but this growth was employment neutral.

Recommendations

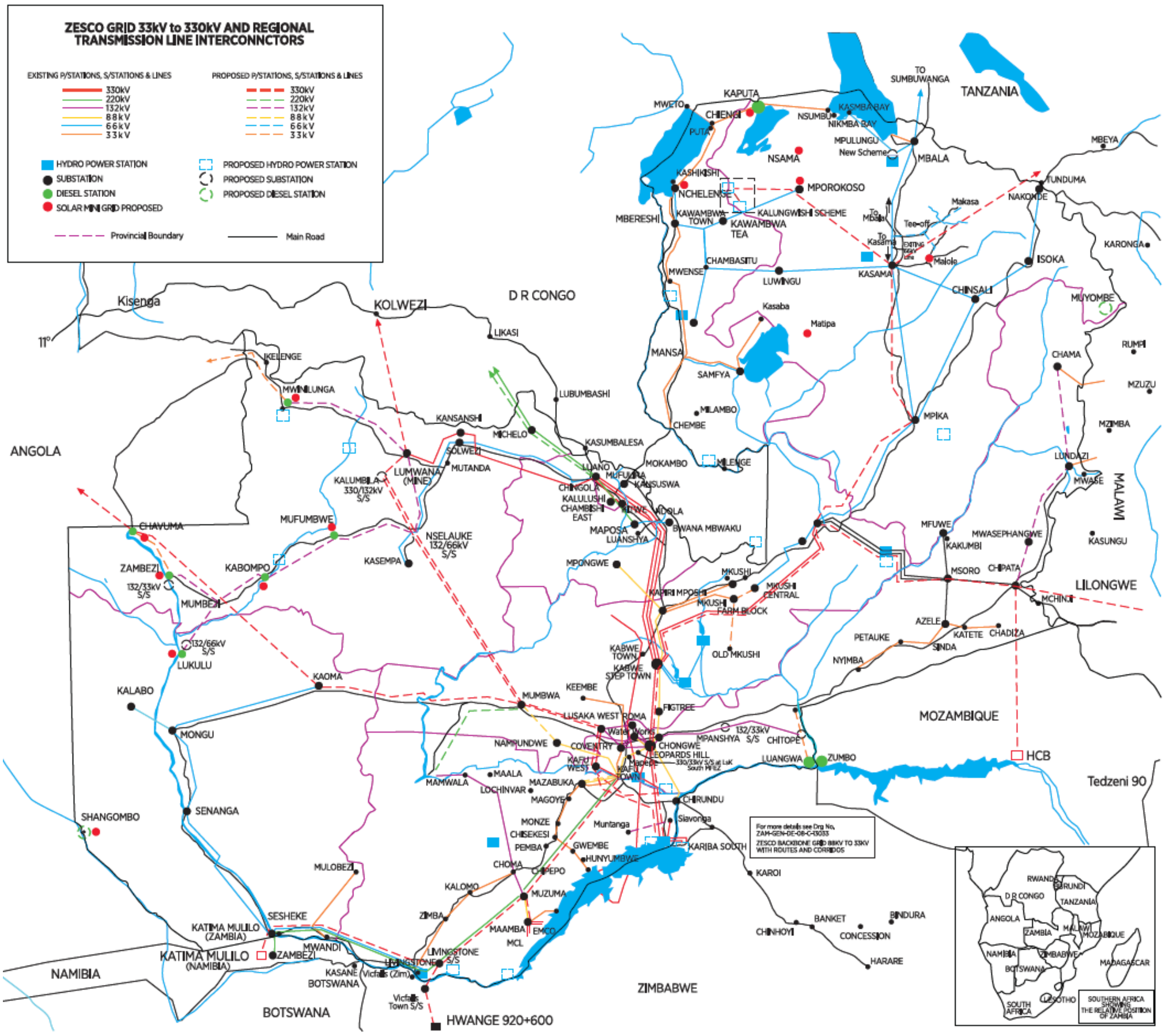
In the light of the findings obtained from this study about Zambia, it is vital that the following recommendations be made. These include:

- There should be an increase in research and development in the energy sector in Zambia.
- Diversification of energy sources: Hydroelectric power has single handedly accounted for the majority share in energy production and consumption in Zambia representing 94%. Due to this, it can cause microeconomic volatility by halting major economic activities like what the country experienced in 2015 due to poor rainfall. Solar energy and coal could be used to complement and backup in times of electricity deficit crisis.
- Support energy conservation and efficiency: This would include sensitising the public on energy efficiency and conservation. It also involves a review and upgrade of energy efficient standards. Meaning that appliances and buildings used in the country should be of high standards such that it consumes the lowest quantity of energy possible.
- Since we have observed that employment granger-causes electricity, Zambia, therefore, is to come up with an employment strategy framework that takes electricity consumption as a fundamental subject of economic policy, not as a residual. Further studies are needed to when employment is disaggregated to examine the source of employment (mining, manufacturing, industry and agriculture) that affects economic growth and electricity consumption.
- When legislators evaluate the prospects for policies focused on improving energy supplies, they need to also evaluate sources of energy demand such as macroeconomic policies, education, health, infrastructure like water supplies, sanitation and roads.

Map 1: SAPP SADC Grid Map

Source: http://www.sapp.co.zw/

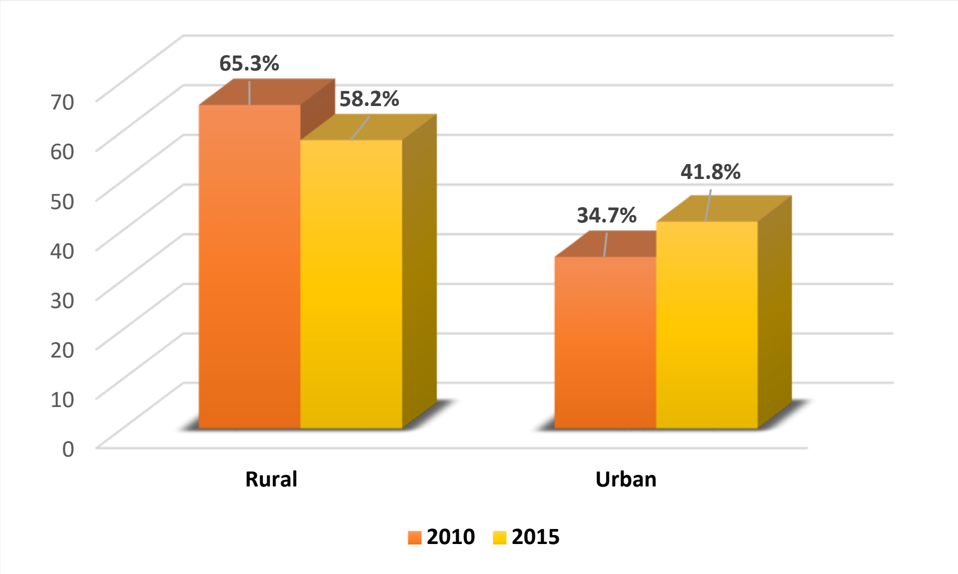
Map 2: Map of Zambia showing Diesel, Solar and Hydro Power Stations



Source: ZESCO Annual Report, 2015

Appendices

Appendix 1: Population Distribution by Residence in Zambia, 2010 and 2015



Source: Author's own compilation based on data from CSO *2010 and 2015*

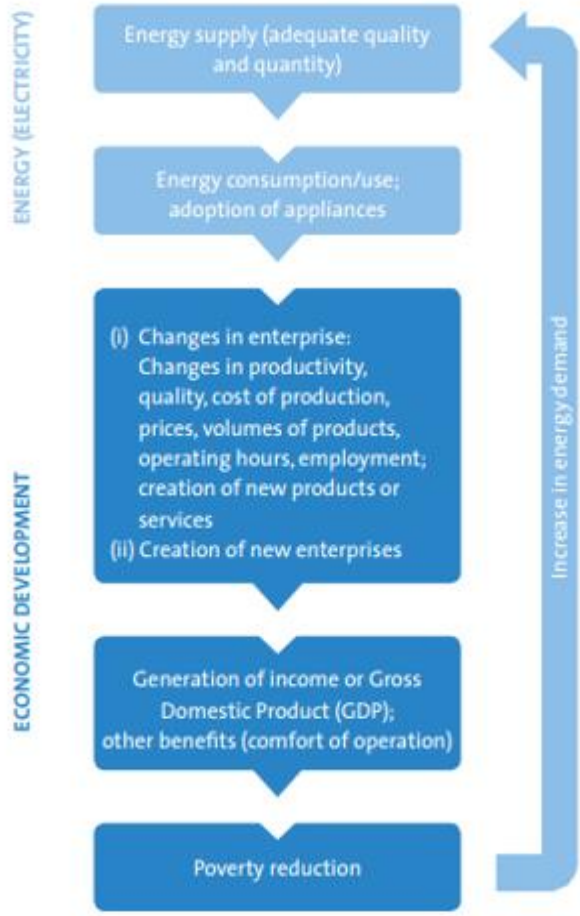
Appendix 2: Electric Power Stations in Zambia in 2015

STATION	GENERATION	TRANSMISSION
Kariba Gorge	6461070	6417518
Kariba North Bank	4322468	4316354
Kariba North Bank E	1180930	1178511
Victoria Falls	786988	784520
LUSEMFWA		214636
NDOLA ENERGY		379945
SUB TOTAL	12751456	13291484
MINI-HYDRO		
LUSIWASI	64038	63916
CHISHIMBA	24399	24200
MUSONDA	6439	6412
LUNZUA	26963	25966
SHIWAN'GANDU	1185	1038
SUB-TOTAL	123025	121532
ZAMBEZI	3032	3016
KABOMPO	3546	3537
MWINILUNGA	4306	4300
LUKULU	2452	2452
SHANG'OMBO	806	806
LUANGWA	2926	2910
MUFUMBWE	2454	2443
CHAVUMA	3607	3553
Itezhi Tezhi	474	473

SUB-TOTAL	23602	23490
GRAND-TOTAL	**12898083**	**13436506**

Source: Author's own based on secondary collected from ZESCO

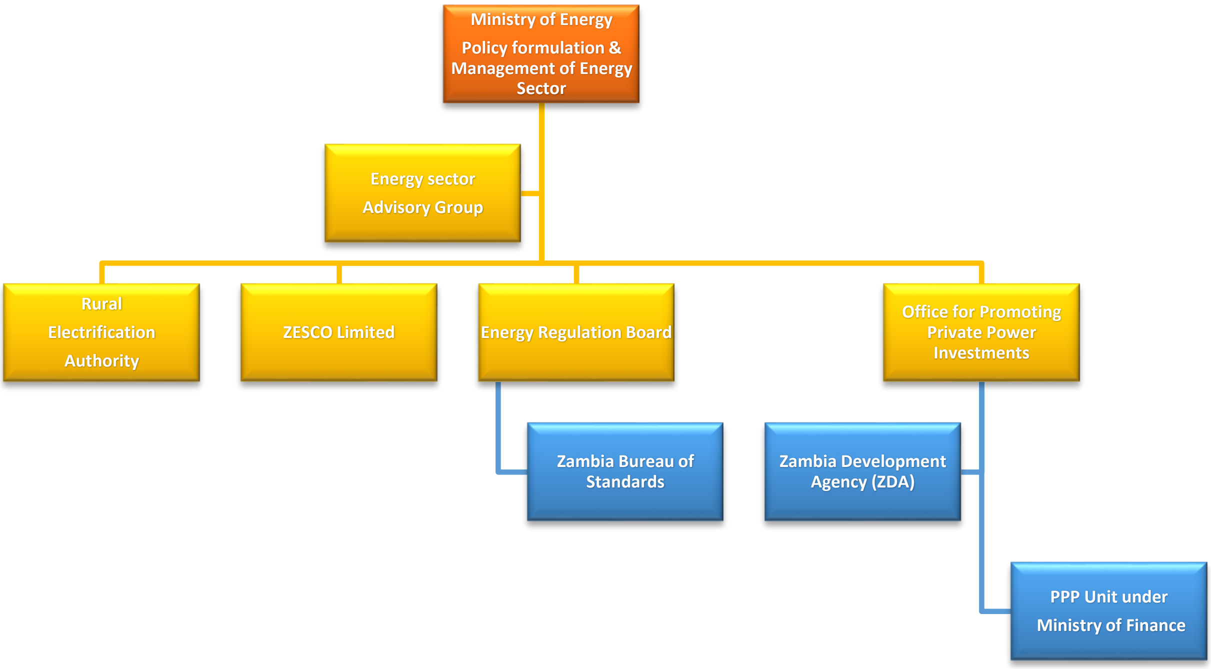
Appendix 3: Link from Electricity through employment to economic growth



Source: Kooijman-van Dijk 2008

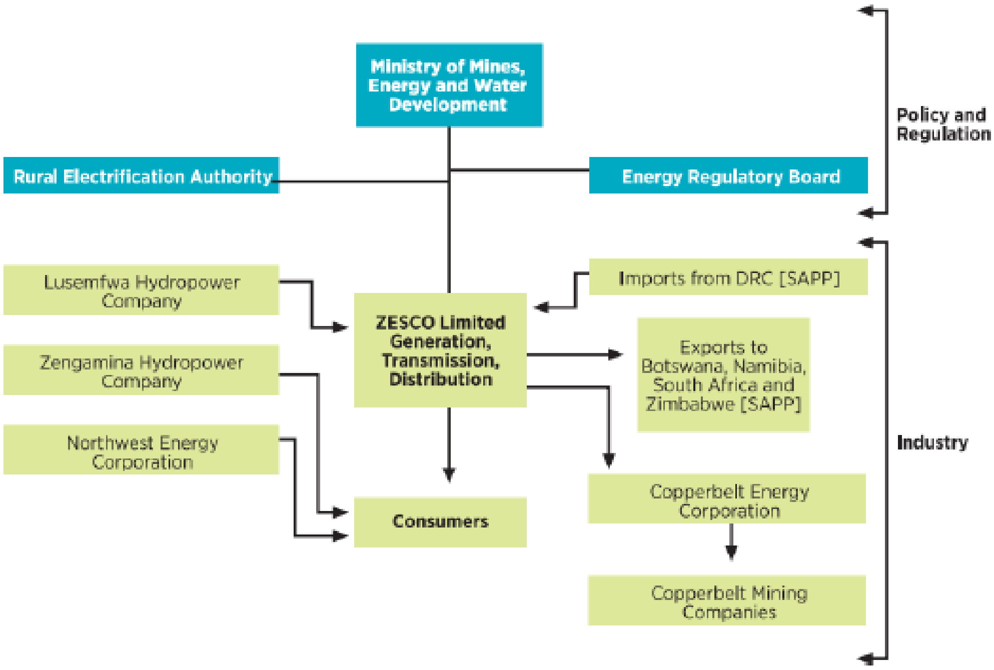
Appendix 4: Zambia's Energy Institutional Framework and Implementation

a) Institutional Framework



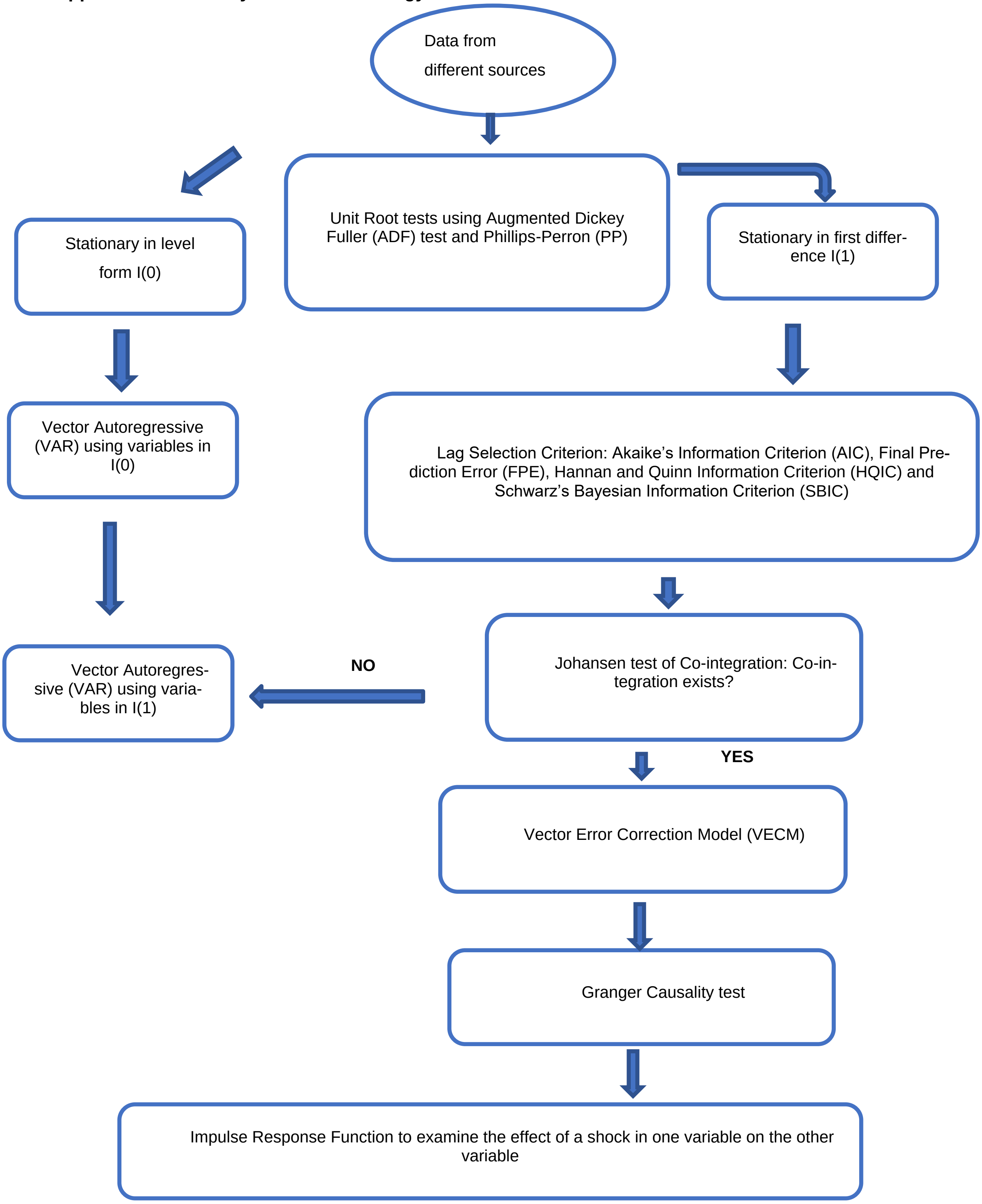
Source: ZESCO (2009)

b) Implementation



Source: Kapika and Eberhard (2013

Appendix 5: Summary of the Methodology



Source: Author's own based on Dickey and Fuller, (1981); Phillips and Perron, (1988); (Granger, 1981; Engle and Granger, 1987 cited in Lütkepohl and Krätzig (2004)

Appendix 6: ADF Tests of Unit Root with Trend (Level Form)

A. Real GDP per capita

```
DF-GLS for lRGDP_p                                       Number of obs =    33
Maxlag = 9 chosen by Schwert criterion

               DF-GLS tau      1% Critical       5% Critical      10% Critical
  [lags]     Test Statistic        Value             Value             Value
------------------------------------------------------------------------------

    9            -2.157           -3.770            -2.710            -2.392
    8            -2.417           -3.770            -2.764            -2.457
    7            -2.598           -3.770            -2.832            -2.531
    6            -2.718           -3.770            -2.909            -2.610
    5            -2.615           -3.770            -2.992            -2.692
    4            -2.533           -3.770            -3.075            -2.773
    3            -1.589           -3.770            -3.156            -2.850
    2            -0.746           -3.770            -3.230            -2.918
    1            -0.210           -3.770            -3.293            -2.976

Opt Lag (Ng-Perron seq t) =  4 with RMSE  .0253798
Min SC   = -6.817828 at lag  4 with RMSE  .0253798
Min MAIC = -6.728385 at lag  3 with RMSE  .0284121
```

B. Electricity Consumption per capita

```
. dfgls lElec_p

DF-GLS for lElec_p                                       Number of obs =    33
Maxlag = 9 chosen by Schwert criterion

               DF-GLS tau      1% Critical       5% Critical      10% Critical
  [lags]     Test Statistic        Value             Value             Value
------------------------------------------------------------------------------

    9            -1.174           -3.770            -2.710            -2.392
    8            -0.925           -3.770            -2.764            -2.457
    7            -1.004           -3.770            -2.832            -2.531
    6            -0.939           -3.770            -2.909            -2.610
    5            -0.863           -3.770            -2.992            -2.692
    4            -0.895           -3.770            -3.075            -2.773
    3            -1.267           -3.770            -3.156            -2.850
    2            -1.929           -3.770            -3.230            -2.918
    1            -1.979           -3.770            -3.293            -2.976

Opt Lag (Ng-Perron seq t) =  1 with RMSE  .0534511
Min SC   = -5.646066 at lag  1 with RMSE  .0534511
Min MAIC = -5.576174 at lag  4 with RMSE  .0516977
```

C. Employment rate

```
. dfgls lEmploy_r

DF-GLS for lEmploy_r                                    Number of obs =    33
Maxlag = 9 chosen by Schwert criterion

               DF-GLS tau      1% Critical       5% Critical      10% Critical
  [lags]     Test Statistic       Value             Value             Value
------------------------------------------------------------------------------

    9           -1.227           -3.770            -2.710            -2.392
    8           -1.308           -3.770            -2.764            -2.457
    7           -1.385           -3.770            -2.832            -2.531
    6           -1.660           -3.770            -2.909            -2.610
    5           -1.515           -3.770            -2.992            -2.692
    4           -2.366           -3.770            -3.075            -2.773
    3           -2.054           -3.770            -3.156            -2.850
    2           -2.154           -3.770            -3.230            -2.918
    1           -2.133           -3.770            -3.293            -2.976

Opt Lag (Ng-Perron seq t) = 0 [use maxlag(0)]
Min SC   = -7.128729 at lag  1 with RMSE  .0254683
Min MAIC = -6.959487 at lag  1 with RMSE  .0254683
```

Appendix 7: ADF Tests of Unit Root with Trend (First Difference)

A. Real GDP per capita

```
. dfgls D1RGDP_p

DF-GLS for D1RGDP_p                                     Number of obs =    32
Maxlag = 9 chosen by Schwert criterion

               DF-GLS tau      1% Critical       5% Critical      10% Critical
  [lags]     Test Statistic       Value             Value             Value
------------------------------------------------------------------------------

    9           -2.121           -3.770            -2.710            -2.386
    8           -2.151           -3.770            -2.761            -2.450
    7           -1.857           -3.770            -2.828            -2.524
    6           -1.721           -3.770            -2.906            -2.605
    5           -1.523           -3.770            -2.991            -2.690
    4           -1.449           -3.770            -3.077            -2.773
    3           -1.325           -3.770            -3.161            -2.853
    2           -1.984           -3.770            -3.238            -2.924
    1           -3.314           -3.770            -3.303            -2.984

Opt Lag (Ng-Perron seq t) = 0 [use maxlag(0)]
Min SC   = -6.797646 at lag  1 with RMSE  .0299829
Min MAIC = -6.581289 at lag  3 with RMSE  .0275586
```

B. Electricity Consumption per capita

```
.
. dfgls D1Elec_p

DF-GLS for D1Elec_p                                     Number of obs =    32
Maxlag = 9 chosen by Schwert criterion
```

[lags]	DF-GLS tau Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
9	-1.565	-3.770	-2.710	-2.386
8	-1.847	-3.770	-2.761	-2.450
7	-2.348	-3.770	-2.828	-2.524
6	-2.308	-3.770	-2.906	-2.605
5	-2.786	-3.770	-2.991	-2.690
4	-3.558	-3.770	-3.077	-2.773
3	-4.312	-3.770	-3.161	-2.853
2	-4.156	-3.770	-3.238	-2.924
1	-3.524	-3.770	-3.303	-2.984

```
Opt Lag (Ng-Perron seq t) =  2 with RMSE  .0532887
Min SC   = -5.539149 at lag  2 with RMSE  .0532887
Min MAIC = -4.345077 at lag  1 with RMSE  .0567375
```

C. Employment rate

```
. dfgls D1Employ_r

DF-GLS for D1Employ_r                                   Number of obs =    32
Maxlag = 9 chosen by Schwert criterion
```

[lags]	DF-GLS tau Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
9	-1.469	-3.770	-2.710	-2.386
8	-2.130	-3.770	-2.761	-2.450
7	-2.246	-3.770	-2.828	-2.524
6	-2.388	-3.770	-2.906	-2.605
5	-2.407	-3.770	-2.991	-2.690
4	-3.312	-3.770	-3.077	-2.773
3	-2.428	-3.770	-3.161	-2.853
2	-3.288	-3.770	-3.238	-2.924
1	-3.760	-3.770	-3.303	-2.984

```
Opt Lag (Ng-Perron seq t) =  4 with RMSE  .0232529
Min SC   = -7.110968 at lag  1 with RMSE  .0256352
Min MAIC = -5.854699 at lag  3 with RMSE  .0252877
```

Appendix 8: Phillips-Perron Tests of Unit Root with Trend (Level Form)

A. Real GDP per capita

```
. pperron lRGDP_p, trend regress

Phillips-Perron test for unit root                  Number of obs   =        42
                                                    Newey-West lags =         3

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(rho)           -0.692           -24.676           -19.192           -16.416
 Z(t)             -0.675            -4.224            -3.532            -3.199
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9748

------------------------------------------------------------------------------
lRGDP_p      |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     lRGDP_p |
         L1. |   .9841467   .0237973    41.36   0.000     .9360122    1.032281
      _trend |   .0023222   .0003769     6.16   0.000     .0015599    .0030845
       _cons |   .0756922   .1860167     0.41   0.686    -.3005621    .4519464
------------------------------------------------------------------------------
```

B. Electricity Consumption per capita

```
. pperron lElec_p, trend regress

Phillips-Perron test for unit root                  Number of obs   =        42
                                                    Newey-West lags =         3

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(rho)           -6.198           -24.676           -19.192           -16.416
 Z(t)             -1.713            -4.224            -3.532            -3.199
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.7450

------------------------------------------------------------------------------
lElec_p      |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     lElec_p |
         L1. |   .8939198   .0738175    12.11   0.000     .7446098     1.04323
      _trend |  -.0010272   .0014039    -0.73   0.469    -.0038668    .0018123
       _cons |   .7118324   .5172803     1.38   0.177    -.3344658    1.758131
------------------------------------------------------------------------------
```

C. Employment rate

```
. pperron lEmploy_r, trend regress

Phillips-Perron test for unit root                 Number of obs   =        42
                                                   Newey-West lags =         3

                             ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(rho)         -12.422           -24.676           -19.192           -16.416
 Z(t)            -2.888            -4.224            -3.532            -3.199
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.1666

------------------------------------------------------------------------------
lEmploy_r    |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   lEmploy_r |
         L1. |    .758988   .0884805     8.58   0.000     .5800192    .9379567
      _trend |   .0007001   .0004772     1.47   0.150    -.0002651    .0016654
       _cons |   1.060227   .3845992     2.76   0.009     .2823013    1.838152
------------------------------------------------------------------------------
```

Appendix 9: Phillips-Perron Tests of Unit Root with Trend (First Difference)

A. Real GDP per capita

```
. pperron D1RGDP_p, trend regress

Phillips-Perron test for unit root                 Number of obs   =        41
                                                   Newey-West lags =         3

                             ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(rho)         -49.016           -24.548           -19.116           -16.368
 Z(t)            -6.584            -4.233            -3.536            -3.202
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

------------------------------------------------------------------------------
D1RGDP_p     |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    D1RGDP_p |
         L1. |   -.097086    .167325    -0.58   0.565    -.4358178    .2416457
      _trend |   .0025641    .000573     4.47   0.000      .001404    .0037242
       _cons |   -.051102   .0127416    -4.01   0.000    -.0768959    -.025308
------------------------------------------------------------------------------
```

B. Electricity Consumption per capita

```
. pperron D1Elec_p, trend regress

Phillips-Perron test for unit root                 Number of obs    =        41
                                                   Newey-West lags =         3

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(rho)         -27.354           -24.548           -19.116           -16.368
 Z(t)            -4.465            -4.233            -3.536            -3.202
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0017

------------------------------------------------------------------------------
D1Elec_p     |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    D1Elec_p |
         L1. |   .2942693   .1557394     1.89   0.066    -.0210086    .6095473
      _trend |   .0004887   .0007254     0.67   0.505    -.0009797    .0019571
       _cons |  -.0209826   .0179372    -1.17   0.249    -.0572945    .0153294
------------------------------------------------------------------------------
```

C. Employment rate

```
. pperron D1Employ_r, trend regress

Phillips-Perron test for unit root                  Number of obs    =        41
                                                    Newey-West lags  =         3
```

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		Interpolated Dickey-Fuller		
Z(rho)	-31.669	-24.548	-19.116	-16.368
Z(t)	-5.129	-4.233	-3.536	-3.202

MacKinnon approximate p-value for Z(t) = 0.0001

D1Employ_r	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
D1Employ_r						
L1.	.1835856	.1577748	1.16	0.252	-.1358127	.5029839
_trend	-.0001649	.0003421	-0.48	0.633	-.0008575	.0005277
_cons	.0079118	.0084129	0.94	0.353	-.0091193	.0249428

Appendix 10: Granger Causality Tests

a) No causality running from GDP to electricity consumption

```
. test ([D_lElec_p ]: LD.lRGDP_p)

 ( 1)  [D_lElec_p]LD.lRGDP_p = 0

           chi2(  1) =    0.20
         Prob > chi2 =    0.6524
```

b) No causality running from GDP to employment

```
. test ([D_lEmploy_r]: LD.lRGDP_p)

 ( 1)  [D_lEmploy_r]LD.lRGDP_p = 0

           chi2(  1) =    0.52
         Prob > chi2 =    0.4694
```

c) causality running from employment rate to electricity consumption

```
. test ([D_lElec_p ]: LD.lEmploy_r)

 ( 1)  [D_lElec_p]LD.lEmploy_r = 0

           chi2(  1) =    5.35
         Prob > chi2 =    0.0207
```

d) No causality running from employment rate to GDP

```
. test ([D_lRGDP_p]: L1D.lEmploy_r)

 ( 1)  [D_lRGDP_p]LD.lEmploy_r = 0

           chi2(  1) =    0.24
         Prob > chi2 =    0.6239

.
```

e) No causality running from electricity consumption to GDP

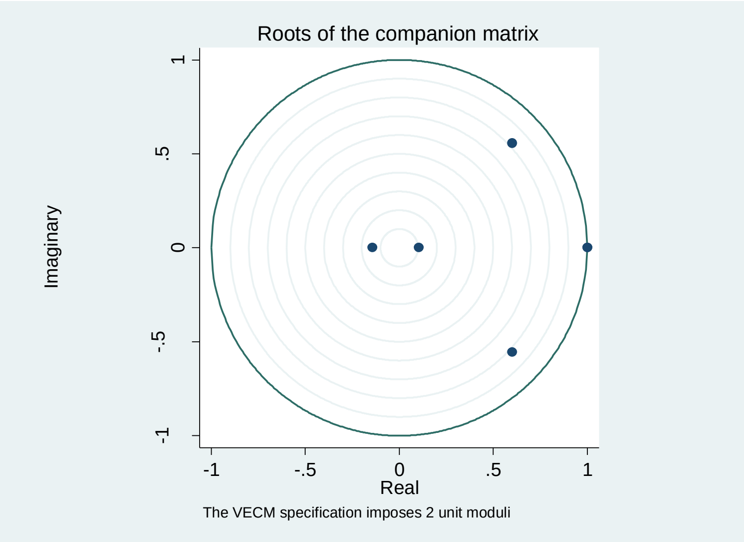
```
. test ([D_lRGDP_p]: LD.lElec_p)

 ( 1)  [D_lRGDP_p]LD.lElec_p = 0

           chi2(  1) =    0.08
         Prob > chi2 =    0.7807
```

f) No causality running from electricity to employment

```
. test ([D_lEmploy_r]: LD.lElec_p)

 ( 1)  [D_lEmploy_r]LD.lElec_p = 0

           chi2(  1) =    0.74
         Prob > chi2 =    0.3894
```

Appendix 11: Diagnostic Tests

a) Stability Test



b) Lagrange Multiplier test on the Null Hypothesis of no Residual Autocorrelation

```
. veclmar

   Lagrange-multiplier test
```

lag	chi2	df	Prob > chi2
1	5.4555	9	0.79293
2	2.8575	9	0.96968

```
   H0: no autocorrelation at lag order
```

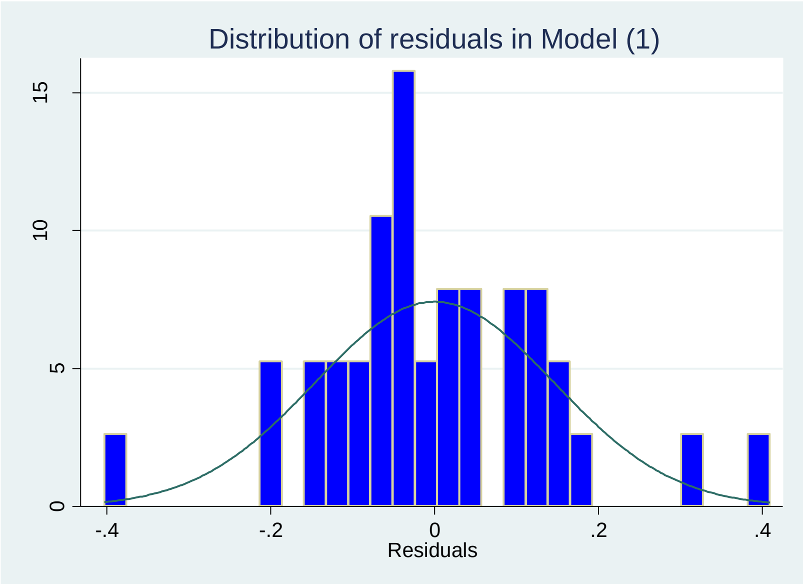
c) Test for Normally Distributed Disturbances using the Skewness-Kurtosis

i. lRGDP-NOT normally distributed (Equation A)

Skewness-Kurtosis test

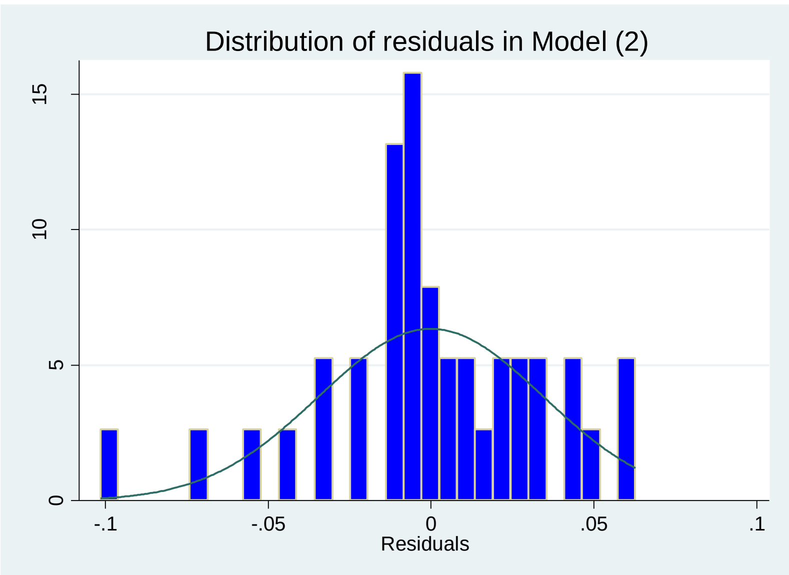
```
. sktest myresiduals

                    Skewness/Kurtosis tests for Normality
```

Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	joint adj chi2(2)	joint Prob>chi2
myresiduals	41	0.0106	0.0152	10.24	0.0060



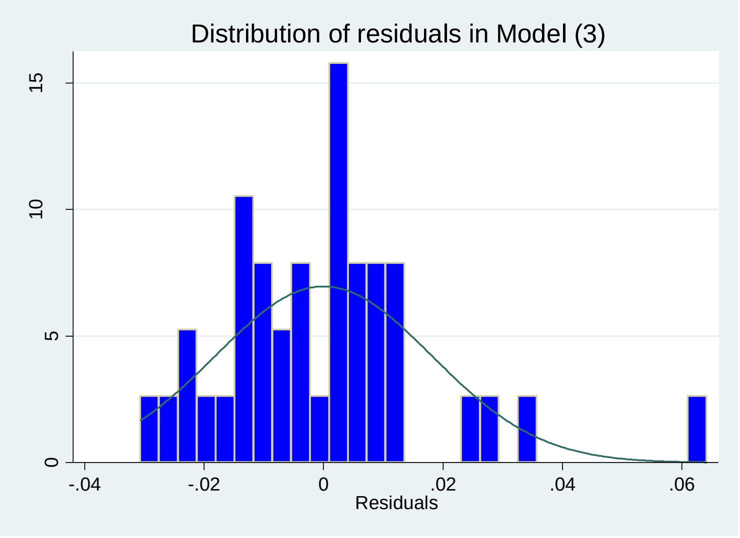
ii. **Elec_p – normally distributed (Equation B)**

```
. sktest myresiduals5

                    Skewness/Kurtosis tests for Normality
                                                          ------ joint ------
    Variable |        Obs  Pr(Skewness)  Pr(Kurtosis) adj chi2(2)   Prob>chi2
-------------+---------------------------------------------------------------
myresiduals5 |         41     0.4059        0.2656        2.05         0.3582
```



iii. **Employ_r – NOT normally distributed (Equation C)**

```
. sktest myresiduals3

                    Skewness/Kurtosis tests for Normality
                                                          ------- joint -------
    Variable |        Obs   Pr(Skewness)   Pr(Kurtosis) adj chi2(2)    Prob>chi2
-------------+-----------------------------------------------------------------
myresiduals3 |         41      0.4717         0.0016        8.88         0.0118
```



Appendix 12: Summary of Empirical Studies on Economic Growth-Electricity Consumption Nexus

Authors	Period	Country	Other variables included	Methodology	Direction of Causality
Kraft and Kraft (1978)	1947–1974	USA		Granger causality	GDP→EC
Akarca and Long (1980)	1950–1970	USA		Sim's technique	GDP x EC
Yu and Choi (1985)	1950-1976	UK		Granger causality	GDP x EC
		USA			GDP x EC
		Poland			GDP x EC
		Philippines			EC→GDP
		Korea			GDP→EC
Masih and Masih (1997)	1952-1992	Taiwan		Co-integration, VECM, variance decomposition	EC↔GDP
	1955-1991	Korea			EC→GDP
Glasure and Lee (1997)	1961-1990	South Korea		Co-integration and Granger causality	GDP x EC
		Singapore			EC→GDP
Cheng and Lai (1997)	1955–1993	Taiwan		Co-integration and Hsiao's Granger causality	GDP→EC
Asafu-Adjaye (2000)	1971-1995	Philippines		Co-integration and granger causality	EC↔GDP
	1971-1995	Thailand			EC↔GDP
	1973-1995	India			EC→GDP
	1973-1995	Indonesia			EC→GDP
Yang (2000)	1954-1997	Taiwan		Granger causality, Hsiao's Granger	GDP→EC
Ghosh (2002)	1950-1997	India		Granger causality	GDP→EC
Morimoto and Hope (2004)	1960-1998	Sri-Lanka		OLS regression and Granger causality	Electricity supply→GDP
Paul and Bhattacharya (2004)	1950-1996	India		Co-integration and Granger causality	EC↔GDP
Jumbe (2004)	1970-1999	Malawi	Agricultural GDP	Granger causality, ECM	EC↔GDP
Narayan and Smyth (2005)	1966-1999	Australia	Manufacturing employment index	Multivariate Granger causality	GDP→EC
Wolde-Rufael (2006)	1971-2001	17 African		Co-integration, Toda-Yamamoto Granger causality	EC↔GDP (Morocco, Gabon, Egypt)

		countries			GDP→EC (Zimbabwe, Zambia, Senegal, Nigeria, Ghana, Cameroon) EC→GDP (Tunisia, DR Congo, Benin) GDP x EC (Sudan, South Africa,, Kenya, Congo BR, Algeria)
Lee and Chang (2007)	1955–2003	Taiwan		Co-integration, VECM, Granger causality	EC→GDP
Narayan and Singh (2007)	1971-2002	Fiji Islands	Labour force	Co-integration, Granger causality	EC→GDP
Squailli (2007)	1980-2003	11 OPEC countries		ARDL, Toda-Yamamoto test	GDP↔EC (Venezuela, Iran, Qatar, Indonesia, Nigeria, Saudi Arabia, Kuwait, UAE) GDP→EC (Libya, Iraq, Algeria)
Akinlo (2008)	1980-2006	Nigeria		Johansen-Juselius, VECM	EC→GDP
	1971-2002				EC→GDP (Australia, Italy, Slovak Republic, Czech R, Portugal)
Odhiambo (2009)	1971-2006	South Africa	Employment	Granger causality	GDP↔EC
Apergis and Payne (2009)	1980-2004	Panama, Nicaragua, Honduras, El Salvador, Costa Rica, Guatemala		Panel cointegration, ECM	EC→GDP
Karanfil and Li (2015)	1980-2010	160 countries		Cointegration and Granger-causality	Mixed results

Source: authors own compilation from different studies on the relationship between electricity consumption and economic growth

Appendix 13: Summary of Empirical Studies on Economic Growth-Employment Nexus

Authors	Period	Country	Other variables included	Methodology	Direction of Causality
Boltho and Glyn (1995)	1960-1993	OECD countries		Employment Elasticity	GDP↔Emp
Walterskirchen (1999)		EU countries		Employment Elasticity	
Sodipe and Ogunrinola (2011)	1981-2006	Nigeria		Employment Elasticity	Emp→EC
Abdullah et al (2011)	1970-2005	Malaysia	Domestic capital		
		Singapore	Government expenditure	Cointegration, VECM	
		Philippines			
Aksoy (2013)	1988-2010	Turkey	Various industries	Toda-Yamamoto Granger Causality	GDP x Emp

Source: authors own compilation from different studies on the relationship between economic growth and employment

EC→GDP *there is a unidirectional causality running from electricity consumption to economic growth.*

GDP→EC *there is a unidirectional causality running from economic growth to electricity consumption.*

EC↔GDP *there is a bi-directional causality between electricity consumption and economic growth.*

EC x GDP *no causality exists between electricity consumption and economic growth.*

ARDL *Auto Regressive Distributed lag.*

VAR *Vector Autoregressive model.*

VECM *Vector Error Correction Model.*

EC *electricity consumption.*

GDP *Real Gross Domestic Product.*

Emp *Employment*

Appendix 14: Summary of Empirical Studies on Employment-Electricity Consumption Nexus

Authors	Period	Country	Other variables included	Methodology	Direction of Causality
Oxley et al. (2004)	1960-1990	New Zealand	GDP	Granger causality	EC→Emp
					GDP↔Emp
Narayan and Smyth (2005)	1966-1999	Australia	GDP	Multivariate Granger causality	Empl→EC
					GDP↔Emp
Ewing et al. (2007)	2001-2005	USA	Coal energy		EC x Emp
					EC→GDP
Payne (2009)	1976-2006	USA (Illinois)		Toda-Yamamoto test	EC→Emp
Ghosh (2009)	1971-2006	India	GDP	Granger causality	EC→Emp
					GDP→Emp
Odhiambo (2010)	1972-2006	Kenya	GDP	Granger causality	GDP→Emp
					EC→GDP
Bayat et al. (2011)	1960-2005	Turkey	Manufacturing	Toda-Yamamoto and Dalado-Luktepohl causality tests	EC x Emp
			sector GDP		EC→GDP
Polat and Uslu (2011)	2005-2010	Turkey		Cointegration and Granger causality	EC→Emp
Arouri et al. (2014)	1991-2010	16 african countries		VAR and Granger-causality	EC x Emp for Ghana, Morocco, South Africa, Senegal and Nigeria
					EC→Emp for Congo DR and Egypt
					Empl→EC for Zambia, Cameroon, Ethiopia and Tunisia
					GDP↔Emp for Tanzania, Kenya, Benin, Mozambique and Algeria

Source: authors own compilation from different studies on the relationship between electricity consumption and employment

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