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ESTIMATING LONG RUN AND SHORT RUN DETERMINANTS OF ENERGY DEMAND IN TANZANIA: A CASE OF ELECTRICITY CONSUMPTION

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Abstract

Research in energy sector is quite important on promoting social and economic development as well as fostering industrialisation in support of the current government policy. Due to the changing structure of Tanzania's economy brought by the upcoming industrial activities and little knowledge on the energy sector, this study attempted to analyze the factors affecting demand for energy in Tanzania. Using demand for electricity as case of investigation, the study employed co-integrated property of time series approach covers the period from 1985 to 2015, estimate the long run and short run models to understand the relationship between quantity of electricity demanded as dependent variable and price of electricity, income, prices of substitute i.e. charcoal, petrol and diesel, income, population and temperature as independent variables. The study found that in the short run model, income, and price of charcoal as a substitute were significant determinants of electricity demand in Tanzania, while price of petrol, diesel, population and temperature found to be insignificant factors for electricity demand in Tanzania. Furthermore in the long run the study found that income, price of electricity and price of petrol to be significant determinants of electricity demand in Tanzania, whereas price of charcoal, temperature, price of diesel found to be insignificant in determining demand for electricity in Tanzania. Moreover only income found to be significant in both models. In view of the above, the following were recommended; first, to support the current industrialisation policy there is a need of advanced technology in electricity generation, this reduces generation costs hence declining electricity prices as electricity is one of the inputs in the production process. Second, expanding generation capacity from which increasing demand will be met to satisfy the community whose income level is significantly rising. Finally, the government should undertake strong regulation of the price of substitutes especially petrol and charcoal since their increase significantly affects electricity demand.

Keywords: Demand for energy, Long run model, Short run model

1. Introduction

In recent years, developing countries have made large investments to extend the electricity grid to the rural poor. The estimates of the International Energy Agency shows that approximately $9 billion was spent on electrification in 2009, and the number is expects to rise to $14 billion per year by 2030 (International Energy Agency (2011)). This is not surprising, given that electrification is widely touted as an essential tool to help alleviate poverty and spur economic progress; universal energy access is one of the UN's Sustainable Development Goals (UNDP (2015), World Bank (2015)). Sub-Saharan Africa and Asia said to account about 85% of the people around the world who lack access to electricity.

Energy has remained as a vital input for socio-economic development of any country (Bruce et al. 2000; Ezzati and Kammen, 2001). The growth hypothesis claims that energy consumption has an important role in economic growth both as a direct input in the production process and indirectly as a complement to labor and capital inputs (Saatci and Dumrul, 2013). Energy demand is a derived demand that arises for satisfying some needs which are met through use of appliances. Hence, demand for energy then depends on the demand for energy services and the choice of energy using processes or devices (Bhattacharyya and Timilsina, 2009). The derived nature of demand influences energy demand in a number of ways, which in turn has influenced the demand analysis by creating two distinct traditions one based on the neoclassical economic tradition while the other focusing on the engineering principles coupled with economic information (Worrel et al. 2004). In this current study the focus is on the neoclassical economic tradition of demand. Demand for energy varies on different economic agents where at the household demand for energy relies on utility maximization principle while at the business firms energy is used in as an input in the production and producers focus on cost minimization. In this study energy demand is measured by the total amount of energy consumed in the economy.

Theoretical underpinnings explain that demand for electricity is just like demand for any commodity, whereby price and income remains the major determinants. Though various empirical and theoretical discussions have been provided further to include influence of price of substitutes, population and weather conditions. Economic theory would suggest that like any other demand, electricity demand will fall as the electricity unit price increases, holding other factors constant (Fan and Hyndman, 2011). Chaudry (2010) estimated energy demand at the economy-wide and the firm level in Pakistan during 1998–2008 and found that an increase in electricity price will lead to a decrease in electricity demand for energy. An early study by Pindyck (1979) analyze the structure of demand for energy on a pooled time-series cross-section data for a group of OECD countries and a few less developed countries and found that in the long run income and the price of energy have significant on energy demand at the residential, industrial and transport sectors.

According to Momani (2013) factors that directly influence the change of electrical energy demand in any country include; economic, demographic and technological factors, factors related to policy change and environmental factors. The economic factors that drive the electrical demand are income and price. The income is reflected by the Gross Domestic Product (GDP) of a nation where the demand is expected to increase with the growth of economy while the increase in the price of the energy unit (i.e. in kWh) leads to reduced consumption. The demographic factor implies that population is an important factor that might influence electricity demand; with growing population, the total energy requirement in all sectors is expected to rise. Normally electricity power industry advances a nation's productivity, promotes business development and expansion, and provides employment opportunities. Policy changes like the

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currently industrialisation policy in Tanzania may alter energy consumption trend. Cheng and Lai (1997) suggested that for newly industrializing countries in general, energy is an important factor in economic development. Production in industries such as manufacturing, construction and transportation demands a substantial amount of energy. Consequently, an increase in output influences energy consumption. Environmental factors cannot be ignored as research shows high correlation between electricity consumption and environmental pollution. Shahbaz et al (2014) have examined the relationship between industrialization, electricity consumption and CO2 emissions in Bangladesh and found that electricity consumption causes production of greenhouse gases, industrial growth and financial development.

Despite the importance of energy to the Tanzanian economy, still various challenges have been noted to hinder the sector at significant level whereby majority of individuals i.e. about 65% of the population remains unconnected due to among others, raising electricity tariffs, inadequate of the supplier to meet the demand, inadequate power production, poor infrastructure, poverty among the majority of rural households (Brophy, et al., 2009). Supply shortage is quite common in many developing countries, especially for commercial energies in general and electricity in particular, which arise due to mainly inappropriate policies and investment decisions (Bhattacharyya and Timilsina, 2009). Such constraints has increased consumption of biomass and other alternative energies especially in rural areas. Due to this, it is approximated that many people i.e. about 90% in developing countries depend on the biomass energy to meet their cooking needs (Mekonnen and Kohlin, 2008). In Tanzania, the main challenges facing the operation of electricity power sector includes frequent major breakdowns arising from the use of outdated and heavily loaded equipment, lack of coordination between the town planning authorities and electricity company of Tanzania (TANESCO) which results in poor overall power system planning and over loading of equipment, inadequate generation due to operational/technical problems arising from machine breakdown and low water levels, and high indebtedness to TANESCO by both public and private consumers who are slow to pay for electricity consumed as and when it is due (MEM, 2014; 2015). Due to poor performance of electricity sector, including low production capacity, the issue of power rationing in Tanzania has been a common problem almost in every day’s life. This leads to the adoption of alternative power generation from the Independent Power Producers (IPPs), and Emergency Power Producers (EPPs). Since the Tanzania’s electricity sector is heavily dependent on hydropower which means the energy provision cannot be ascertained in times of drought (Yergin, 2011)). The recent efforts of the government to invest in new hydropower generation at stiglaz gorge and the contruction of gas pipeline from Mtwara to Dar es Salaam is clear indication of the need to increase and ensure adequate energy supply.

However, as is widely known the research in energy sector is quite important on promoting social and economic development as well as fostering industrialisation in support of the current government policy. Empirical studies have covered a lot on the determinants of electricity demand. Some have gone further to explain these determinants in classification of the consumers of electricity such as residential, industrial and commercial. However a point to note is that the conducted studies in Tanzania was on specified customers, for instance Kulindwa (1985, 1996) and Lufunga (1997) focused on residential electricity in Dar es Salaam city. Where it was shown

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that electricity demand is mainly determined by income, price of electricity, stock of electrical appliances and time. While price of substitutes such as kerosene, gas and charcoal were insignificant.

The current study is aimed at understanding the determinants of electricity energy in Tanzania. There are scant literature that have covered this issue in Tanzania. Some of the studies which have analysed energy demand in Tanzania include that of Kulindwa (1996), Lufunga (1997), Simbila (2007) and Mkumbo (2011) with mixed results have been provided. For instance Kulindwa (1996) found that demand for electricity is significantly determined by price of electricity and income while price of substitutes are insignificant, while Mkumbo (2011) found that besides income, price of substitutes matter on determining demand for electricity. Therefore the current study aimed at addressing such existing research gap by analyzing factors affecting demand of electricity in Tanzania.

2.0 Energy Demand in Tanzania

Tanzania is gifted with diverse energy sources most of which are untapped, these include biomass, hydro, uranium, natural gas, coal, geothermal, solar and wind. The primary energy supply includes biomass (90%); petroleum products (8%); electricity (1.5%), and the remaining (0.5%) is contributed by coal and other renewable energy sources. More than 80% of energy delivered from biomass is consumed in rural areas; heavy dependence on biomass as the main energy source contributes to deforestation, while the importation of oil costs about 25% to 35% of the nation’s foreign currency earnings. To-date only about 18.4% of the country's population has gained access to electricity. Extending the National Grid to many parts of the country including rural areas is not financially and economically feasible

Energy policies of 1992 and 2003 as well as the Electricity Supply Industry (ESI) Reform Strategy and Road Map 2014 to 2025 identify the different sources of energy in the country being natural gas, coal, uranium and renewable energies (hydro, solar, wind, geothermal, bio-energies, tidal waves). The 1992 and 2003 energy policy documents state the main objective for the development of the energy sector being, “to provide an input in the development process by establishing an efficient energy production, procurement, transportation, distribution and end user systems in an environmentally sound manner and with due regard to gender issues”. In order to improve the security of supply, the government is diversifying the sources of electricity generation to include natural gas, coal, hydro, uranium and renewable energies. The ESI reforms will spearhead investment in various generation sources to meet both present and future demand. Envisaged growth in generation looks at the following scenario below.

Table 2. 1: Present and Projected Installed Capacity by year 2025

Source	Current Capacity	Additional Capacity (2015-25)	Capacity by 2025
Hydro (MW)	561	1,529.00	2,090.84
Natural Gas (MW)	527	3,968.00	4,469.00
HFO/GO/Diesel (MW)	495	-	438.40
Coal (MW)	-	2,900.00	2,900.00
Wind (MW)	-	200.00	200.00
Solar (MW)	-	100.00	100.00
Geothermal (MW)	-	200.00	200.00
Interconnector (MW)	-	400.00	400.00
TOTAL (MW)	1,583	9,297.00	10,798.24

Source: URT 2014 Electricity Supply Industry (ESI) Reform Strategy and Road Map 2014 to 2025

According to the Tanzania Investment Brief of 2015, there is a rapid increase in electricity demand in Tanzania due to the accelerated productive investments, increasing population, and increasing access to electricity. There is a rise in demand for electricity at 10% to 15% annually while unconstrained peak demand is at 950-1,000 MW and highest energy demand is recorded at 16.9 Gwh/Day in 2015 (MEM, 2015). As should be expected the electricity demand is high in urban than in rural areas due to presence of electric-intensified industries and services in urban, price affordability in urban, income differences, and availability of alternative energy sources such as firewood for cooking and heating in rural areas. Extending electricity access has remained a critical challenge for Tanzania. The national electrification rate in Tanzania was 42% as of 2013. Further, in urban areas electricity is available to 70.6% of population while in rural areas to 3.8%. According to the last available estimates, 37.4 million people do not have access to electricity (ADB 2015). The Tanzanian government set expanding electricity access to 250,000 people annually as one of its objectives.

Table 2.2; Energy Demand

	2007	2008	2009	2010	2011
Energy generated (GWh)	4232.4	4449.0	4833.7	5371.7	5219.5
Energy sold (GWh)	3178.1	3377.4	3589.3	4047.7	4000.2
Peak Demand (MW)	653.3	693.8	755.4	832.6	823.0
Number of customers in '000	667.5	723.9	783.3	849.2	923.8

Source; Tanzania Investment Brief report 2015

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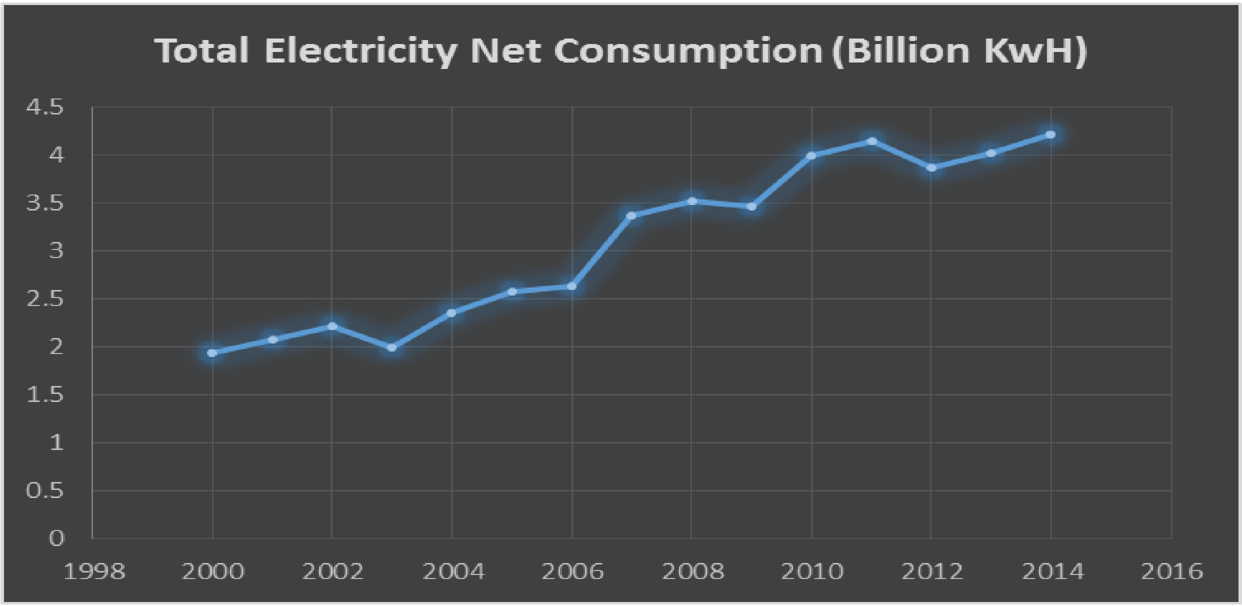
Figure 2.3: Total Electricity Net Consumption Billion Kwh in Tanzania (2000-2014)



Source: *International Energy Statistics, 2015*

Figure 2.3 shows there is an increasing trend of electricity consumption for the past 15 years.

3.0 Energy Supply in Tanzania

Currently, Tanzania has an installed generation capacity of only about 1,500 MW, or 0.033 kW per capita in comparison to South Africa and the United States have generation per capita of 0.85kW and 3.54 kW, respectively (Tanzania Investment Brief - Power Africa report, 2015). The electrical supply varies, particularly when droughts disrupt hydropower electric generation; rolling blackouts are implemented as necessary. Nearly a quarter of electricity generated is lost because of poor transmission infrastructure. The unreliability of the electrical supply has hindered the development of Tanzanian industry (URT, 2014).

Electricity power generation has been one of the important section in the energy sector; though choice of electricity generation method and their economic feasibility varies in accordance with demand; this variation of technique and the demand is fundamental aspect in determination of the selling price. In particularly the sources of energy are potential in determination of type of supply and demand shifts. The table 3.1 and 3.2 shows power generation in Tanzania from hydro and thermal power plants respectively:

Table 3.1; Installed Capacity and Generated Units of the Hydro-plants as per 2016

Hydro Plant	Installed Capacity (MW)	Generated MW per 2016
Kidatu	204	713.28
Kihansi	180	680.93
Mtera	80	281.45
Pangani	68	138.15
Hale	21	43.28
Uwemba	0.845	3.76
Nyumba ya Mungu	8	38.14
Total	**561.84**	**1898.99**

Source: *TANESCO, 2016*

Table 3.2; Thermal Power Plant and their capacities as per 2015

Name of thermal Plant	Installed Capacity (MW)	Fuel type
Kinyerezi I	150	Natural Gas
Ubungo I	100	Diesel
Ubungo II	120	Diesel
Tegeta	45	Natural Gas
Dodoma	55	Diesel
Nyakato	60	Heavy Fuel
Somanga	7.5	Natural Gas
Mtwara	18	Natural Gas
Arusha	50	Diesel
Songas	180	Natural Gas
PAP Diesel Power station	100	Diesel
Off-Grid Diesel Station	76	Diesel
Total	**961.5**	

Source; TANESCO, 2016

The thermal electric supply is considered to be stable, since it does not depend on seasonality fluctuations of the supportive rivers (Shahbaz et al., 2013). The thermal generation in the country has been highly preferable especially on natural gas, recent discoveries of adequate natural gas volume has stimulated preference and globally accepted as being environmental friendly. Generally their capacity exceeds that of hydropower generation, although further investment are highly recommended in order to meet growing energy demand in Tanzania.

5.0: Methodology and Data

This study employed the annual time series data. By using the secondary data on electricity consumption as dependent variable, while GDP per capita, average price of petroleum, average price of diesel, average price of charcoal, population, temperature, and per unit average price of electricity used as independent variables. The data collected covered from 1985 to 2015. These data were obtained from National Bureau of Statistics (NBS), Bank of Tanzania (BOT), Tanzania Electricity Supply Company (TANESCO), Energy and Water Utilities Regulatory Authority (EWURA), and Ministry of Energy and Minerals (MEM).

5.1: Empirical Model and Estimation Procedures

At the most basic level, the demand for a good is dependent on the price of that commodity and available income. Such variables define the functional form of the model of electricity consumption as dependent variable, while price of electricity, GDP per capita, population, price of diesel, petrol, and temperature were treated as independent variables. In order to test for the relationship of the function form model described above, the estimation model was given as follows:

$$lnE_d = \beta_0 + \beta_1 lnGDPpc_t + \beta_2 lnAvprcD_t + \beta_3 lnAvprcP_t + \beta_4 lnPuntPE_t + \beta_5 lnAvpPC_t + \beta_6 lnAvTE_t + \beta_7 lnPop_t + \varepsilon_t$$

Where;

$E_d =$ *Amount of Electricity Consumed*

$GDPPc_t =$ *GDP per capita*

$AvprcD_t =$ *Average price of Diesel per annum*

$AvprcP_t =$ *Average price of petrol per annum*

$PuntPE_t =$ *Per Unit price of Electricity per annum*

$AvpPC_t =$ *Average price of Charcoal per annum*

$AcTE_t =$ *Average Annual Temperature*

$PoP_t =$ *Population measured annually*

$\beta_s =$ *Are parameters to estimated*

The estimation technique applied during the analysis was Ordinary Least Square (OLS), however given the nature of the data and variable as well as the equation various procedures were done to ensure reasonable and consistent results. These include; linearization of the model by applying natural logs, Cointegration analysis, and Error Correction Model (ECM) for capturing long and short run effects.

5.4: Empirical Results

5.4.1: Descriptive analysis

Table 5.1: Summary of Descriptive Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
LnE_l	31	0.74917	0.47561	0.07696	1.48388
$LnGDPpc_t$	31	12.037	1.50424	8.57414	13.8187
$lnPuntPE_t$	31	5.18715	0.33582	4.62497	5.6124
$lnAvprcP_t$	31	6.64249	0.59081	5.9852	7.63685
$lnAvpPC_t$	31	7.98291	0.86893	6.46303	9.42136
$lnAvTE_t$	31	3.1532	0.02707	3.11352	3.2308
$lnPop_t$	31	17.2861	0.27747	16.8677	17.8225
$lnAvprcD_t$	31	6.62653	0.5979	5.93357	7.61481

Table 5.1 shows the summary of the descriptive statistics for variables of interest all variables' standard deviation were smaller than their mean. This implies that data used in the analysis were well-behaving. A point to note is on the type of the data used being time series, hence before the analysis logarithm transformation for normality and stationarity was conducted.

5.4.2: Unit Root Testing

By using standard Dickey-Fuller test procedure the stationarity was tested. Through the test, serial correlation was analysed on error terms without adding lagged differences as in Augmented Dickey Fuller (ADF) test. The test identifies number of optimal lags from which unit root is obtained.

Table 1.2: Lags Estimation Results

Variable	lag	LL	LR	Df	P	AIC	HQIC	SBIC
LnE_l	2	26.6657	7.1731*	1	0.007	-1.75302*	-1.7102*	-1.60903*
$LnGDPpc_t$	3	52.9114	5.873*	1	0.015	-3.62306*	-3.56598*	-3.43109
$lnPuntPE_t$	1	26.5899	61.217*	1	0.000	-1.82147*	-1.79293*	-1.72549*
$lnAvprcP_t$	1	22.8519	91.424*	1	0.000	-1.54459*	-1.51604*	-1.4486*
$lnAvpPC_t$	1	17.2211	93.19*	1	0.000	-1.12749*	-1.09895*	-1.0315*
$lnAvTE_t$	1	17.2347	80.588*	1	0.000	-1.1285*	-1.09995*	-1.03251*
$lnPop_t$	1	74.4824	32.003*	1	0.000	-5.36907	-5.34052*	-5.27308*
$lnAvprcD_t$	1	80.2521	161.33*	1	0.000	-5.79645*	-5.76791*	-5.70046*

Source: *Author's Computation (2017)*

Therefore number of lags was tested to obtain stationarity by testing against the t-statistics and critical values. Based on the provided number of lags none of the variables were stationary hence differencing was applied to obtain stationarity and obtained results was given as follows

Table 5.3: Stationarity Testing

			ADF Test			
				Critical Value		
Variable	**Lag**	**Level of Differencing**	**T-Statistics**	**1%**	**5%**	**10%**
LnE_l	1	1	-5.233	-3.730	-2.992	-2.626
$LnGDPpc_t$	1	1	-6.455	-3.730	-2.992	-2.626
$lnPuntPE_t$	0	1	-6.007	-3.723	-2.989	-2.625
$lnAvprcP_t$	0	1	-6.352	-3.723	-2.989	-2.625
$lnAvpPC_t$	0	1	-4.695	-3.723	-2.989	-2.625
$lnAvTE_t$	0	1	-6.312	-3.723	-2.989	-2.625
$lnPop_t$	1	1	-4.500	-3.730	-2.992	-2.626
$lnAvprcD_t$	1	3	-4.605	-3.750	-3.000	2.630

Source: *Author's Computation (2017)*

With exception of population, all variables become stationary at first difference such that their Test-Statistics being greater than Critical Values in absolute terms at all levels i.e. 1%, 5% and 10%. This suggests that with exception of population, other variables were integrated at order one. These results are consistent with the notion that most of the macroeconomic variables are non-stationary at non-differencing level, but they become stationary after their first or second difference (Mkumbo, 2011).

5.4.3: Cointegration Test

After establishing the order of integration of variables, then cointegration test followed. Since all non-stationary variables are integrated by the same order of integration (1), then it was possible to establish the long-run relationship between dependent and independent variables. The Engle-Granger two step procedure was used to capture cointegration by analyzing stationarity of the residuals estimated by Ordinary Least Square (OLS) technique. The techniques tests if the residuals are stationary, means there is a long-run relationship among the variables, then it is possible to analyze changes in electricity demand. Equation (3) shows the regression for both dependent variable and explanatory variables differentiated with the same level as I (1). This excludes population variable since its order of integration is I (3).

$$lnE_d = \beta_0 + \beta_1 lnGDPpc_t + \beta_2 lnAvprcD_t + \beta_3 lnAvprcP_t + \beta_4 lnPuntPE_t + \beta_5 lnAvpPC_t + \beta_6 lnAvTE_t + \varepsilon_t \quad (3)$$

As proposed by The Engle-Granger two step procedure after estimating the above equation by using OLS technique the estimated residual was given by equation (4) as follows, and then tested against Augmented Dickey Fuller (ADF) Test to analyze stationarity of the error term.

$lnE_d =$
$\beta_0 + \beta_1 lnGDPpc_t + \beta_2 lnAvprcD_t + \beta_3 lnAvprcP_t + \beta_4 lnPuntPE_t + \quad \beta_5 lnAvpPC_t + \beta_6 lnAvTE_t + \varepsilon_t$

(4)

Table 5.4: Unit Root Test for the Cointegrating Residual

Variable	Test-Statistic	ADF Test Statistic	Order of Integration
ECT	-6.007	-2.989	I (0)

Source: *Author's Computation (2017)*

Provided with results above on Table 5.4, the null hypothesis of unit root by using ADF test was rejected at all levels. Thus the estimated residual is stationary at all levels and it is integrated at order zero, I (0). This implies that all variables contained in equation (4) are cointegrated, hence depicting for a long run relationship between variables. Thus it is possible to use all these variables on analysing the changes in electricity demand.

To examine the existing long-run relationship among the variables, equation (3) was estimated to provide the results by computing the coefficients to explain elasticity of electricity demand as shown on Table 5.5.

Table 5.5: Long run Equation Estimation

Source	SS	Df	MS
Model	6.64312	6	1.10718673
Residual	0.142915	24	0.005954777
Total	6.786035	30	0.226201168

F (6, 24) = 185.93
Prob > F = 0
R-squared = 0.9789
Adj R-squared = 0.9737

LnE_t	Coefficient.	Std. Err.	T	P> [t]		
$LnGDPpc_t$	0.102718**	0.0463695	2.21	0.029		
$LnPuntPE_t$	0.74394**	0.322903	2.3	0.005		
$lnAvpricP_t$	0.659959**	0.278367	2.37	0.026		
$lnAvprcD_t$	-0.2341	0.2568486	-0.91	0.371		
$lnAvpPC_t$	0.116968	0.0996161	1.17	0.252		
$lnAvTE_t$	0.143581	0.8132349	0.18	0.861		
Cons	-4.98005**	2.416258	-2.06	0.037		

Source: *Author's Computation (2017)*

, **, * significant at 10%, 5% and 1% levels respectively*

The estimated equation, shows high goodness of fit of the model as the R-squared is 0.978 and the adjusted R-squared is 0.9737. Obtained coefficients depict the long-run elasticities on electricity demand for the given explanatory variables. However in order to capture both effects in short and long run, the Error Correction Model (ECM) was applied in the estimation processes.

5.4.4: Error Correction Model (ECM)

Table 5.6: Short run Equation Estimation

Source	SS	Df	MS
Model	0.03645796	7	0.00520828
Residual	0.265569771	22	0.012071353
Total	0.302027731	30	0.010414749

F (7, 22) = 0.43
Prob > F = 0.8719
R-squared = 0.424125
Adj R-squared = 0.313331

$dlnE_t$	**Coefficient**	**Std. Err.**	**T**	**P> [t]**	**95% Conf. interval**	
$dlnGDPpc_t$	0.235356**	0.10473985	2.24	0.028	-0.31676	0.552112
$dlnPuntPE_t$	-0.048294	0.2344762	-0.21	0.839	-0.53457	0.437979
$dlnAvprcP_t$	0.149688	0.3290546	0.45	0.654	-0.53273	0.832105
$dlnAvprcD_t$	0.058427	0.262856	0.22	0.826	-0.4867	0.603557
dlnAvpPCt	0.409056**	0.1668921	2.5	0.004	-0.14158	0.550641
$dlnAvTE_t$	-0.826208	1.463489	-0.56	0.578	-3.8613	2.208883
$lnPop_t$	0.057567	0.1112205	0.52	0.61	-0.17309	0.288225
ECT1	-0.634133**	0.165501	-3.83	0.014	-5.04209	3.047115

Source: *Author's Computation (2017)*

The coefficient of Error Correction Term (ECT) is about -0.634133 and statistically significant with t-test of -3.83 at 5% level of significance. This implies that there exists a long run relationship between variables whereby 63% of the previous year's variation can be restored within just a year as a short run period. Furthermore the first model had R-squared of 0.97 showing high goodness of fit while on testing for ECM the R-squared decline to 0.42. This is due to inclusion of population which observed to be non-stationary at first level of differencing whereas in the first model it was excluded.

5.4.5: Interpretation of the Results

Income elasticity seems to be significant at 5% level both in the short run and long run with coefficients of 0.235356 and 0.102718 respectively. These results imply that electricity is a normal good as its demand increases as income increases. On the long run where the coefficient is less than a unit, entailing that electricity demand in Tanzania is not much responsive to the change in income. This suggests that electricity demand in Tanzania is not market determined instead depends on the generation capacity. And since amount generated has to be consumed then currently generated amount is not adequate to meet demand. Also the reason for the increase in amount of electricity as a result of increase in income may be due to the fact that an increase in income leads to an increase in economic activities making more goods to be produced and more services to be provided which in turn require more consumption of electricity power. These results are consistent with other studies' findings Khalid (2010), Simbila (2007), Njega (2014), Chen (2006), Kamaludin (2013), Aziz et al (2013), Chang and Chombo (2003) and Kulindwa (1996) whereby income found to be statistically significant in determination of electricity demand.

Own price elasticity observed to be significant only in the long-run with elasticity coefficient of 0.74394 and -0.048294 in the short-run. This entails that price of electricity matter on the long-run as individuals may have an option for other sources of energy hence reducing consumption of electricity. Despite the necessity of the commodity in developing economies like Tanzania, individuals may shift towards consumption of charcoal, kerosene and diesel as substitutes. Despite the inconsistency in the long-run and short-run periods, obtained results are similar to the study findings by Aziz et al., (2013), Naeem et al. (2010), and Chan and Lee (1997) examining factors determining the electricity consumption. In all these studies price of electricity observed to be significant in the long run while in the short run observed otherwise.

On Cross Price Elasticity three substitutes were considered namely; petrol, diesel, and charcoal. Coefficient for a long run cross price elasticity of petrol is about 0.659959 with a positive sign and significant at 5% level of significance. The positive sign implies that petrol is a substitute energy for electricity in Tanzania in the long run. Despite having a positive sign for being a true substitute in the short run, still price for petrol is observed to be not significant at 5% level of significant with a coefficient of 0.149688. Thus both in the short run and long run price for petrol observed to be substitutes for electricity. Though the magnitude in the long run observed to be at large extent, implying that many industries may change towards the use of petrol and get almost the same utility as that obtained on electricity.

The long run coefficient for cross price elasticity for diesel is -0.2341 and not significant at 5% level of significance. The negative sign implies that diesel in the long run is a complementary good with electricity rather than being a substitute good. However being not significant may justify the importance of electricity to the economy. Furthermore in the short run price for diesel remained to be insignificant, with coefficient of about 0.058427.

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On charcoal, the long run coefficient for cross price elasticity is 0.116968, and insignificant at 5% level of significance. The positive sign implies that charcoal is a substitute for electricity in Tanzania. Thus an increase in price of charcoal, leads to an increase in electricity consumption. However on the short run the cross price elasticity for charcoal is significant at 5% level of significance with coefficient of 0.409056. This implies that charcoal is a substitute for electricity in Tanzania especially for cooking purposes. Though in the short run the extent is large such that an increase in price of charcoal by 1 unit increases electricity demand by 0.4 unit. This entails further on demand for charcoal as vital especially during power rationing and for cooking, while electricity is mostly for lighting during the night.

These results are mixed to other countries' studies examining the cross price effects on electricity demand. For instance Kulindwa (1985) found that price of the substitutes i.e. kerosene, gas and charcoal are insignificant, Lufunga (1997) found that no substitution effect between electricity and kerosene while Erdogdu (2007), Abosedra et al. (2011) found that cross price effects of substitutes are significant on electricity demand. Though a point of discussion is observed not only on prices but also shortage of electricity generation which induces a need for shifting towards other sources of energy regardless of the price differences.

The effect of temperature on demand for electricity remains insignificant for both short run and long run at 5% level of significance at coefficients of -0.826208 and 0.143581 respectively. This is contrary to other studies where it was observed to be significant. For instance Khattak et al. (2010) and Kamerschen and Porter (2004) found temperature to be significant on determining the level of electricity demand.

As it was included in Error Correction Model in its logarithmic form, the population variable observed to be insignificant with coefficient of 0.057567. This implies that population doesn't have any impact on the electricity consumption in the short run. However many studies such as Tariq et al. (2008), and Babatunde and Shuaibu (2009) have confirmed that population is significant in electricity demand determination. For the case of Tanzania, Joseph (1979) found that population were insignificant. Though a point to discuss is that the effect of population on electricity demand can only be noted in the long run, currently it is only about 34% of the total population have access to electricity while majority remains unconnected

6.0 Conclusion

This study examines the determinants of electricity demand in Tanzania where, two models i.e. long run and short run models were used. In the adopted empirical model of investigation, annual electricity consumption was used as dependent variable while GDP per capita used to measure the average income, average price of electricity, average price diesel, average price of petrol, average price of charcoal, annual population, and temperature were used as independent variable. Income found to be significant at 5% level of significance both in the short run and long run. Moreover average price of electricity found to be significant only in the short run while for price of substitutes; price of petrol found to be significant only in the long run. Price of diesel found to be insignificant both in the short and long run periods, while price of charcoal found to be significant only in short run. Among the substitutes, only price of charcoal found to matter in the short run, such that it is possible to switch once there exists electricity power shortage while only petrol found to be significant on long run. This implies that, after a long time it is possible to use petrol and get same utility as consuming electricity. Generally the study found that income, price of electricity, and price of substitutes i.e. charcoal and petrol found to be significant determinants for electricity demand in Tanzania.

7.0 Recommendations

This study recommends the following; First, to support the current industrialisation policy advanced technology in the electricity generation is vital in reduction of generation costs and electricity prices in Tanzania. This will reduce production costs and ensure usage of machines in production hence improve competitiveness of manufacturing sector both locally and internationally. Since electricity prices are positive related with electricity demand hence declining electricity price will increase electricity demand in Tanzania as well as a decline in price of substitutes. Thus the study recommends further for use of natural gas, solar coal, geothermal and wind as other energy sources in order to generate more electric power in the country. Second, Government and its responsible institutions should undertake strong regulation of the prices of substitutes especially petrol and charcoal since their increase significantly affects electricity demand. Thus there is a need for regulating petrol and charcoal prices in order to avoid chaos in electricity demand which might affect other economic activities such as transport, mining and manufacturing. Finally, since there is a positive relationship between electricity demand and income, then the study recommends for expanding generation capacity from which increasing demand will be met to satisfy the community whose income level is significantly raising. Expanding generation capacity will increase supply of electricity hence to ensure adequate and secured power for industrial and residential uses.

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