

Electricity consumption and Economic growth in Botswana: A Vector Error Correction approach

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Abstract

Emerging economies are still faced with need to improve economic growth. One of the main drivers of growth in literature has been found to be electricity consumption. However literature fails to explain the relationship between economic growth and electricity consumption. It is against this background that the study examines the presence of the long run relationship between economic growth and electricity consumption in Botswana. The study use annual time series data for the period 1980 – 2014. Using the Vector Error Correction Model, the study shows that there is a positive long run relationship between the two variables. Electricity consumption drives long term growth and it is an important input in the country's production function. Human capital and inflation are important control variables in explaining this long run relationship. Inflationary pressures on the economy should be kept low and human capital development should be industry relevant for the country to advance its growth efforts. Policymakers should continue with and rather develop instruments that encourage more electricity consumption. In this case electricity subsidies should be given to firms in areas that are critical for country's growth prospects, like mining and agriculture. Policy makers need to make a cost benefit analysis as they design the subsidies to benefit all the targeted economic agents.

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1 Introduction

Economic growth is experienced when the real output of a country increases over time. It comes about as result of changes and working of factors like supply of resources, the rate at which capital formation is taking place, changes in technology, levels of skills and expertise as well as institutional set ups. It remains high on the priority list for countries because of the existence of its correlation with social problems [1]. Economic growth is one of the macroeconomic goals for any nation and its significance has been top on the agenda in recent years and developing nations like Botswana are not an exception. This area has received widespread coverage by researchers and policy makers in recent years. Literature has focused on the effect of macroeconomic variables like trade openness, inflation, gross fixed capital formation and foreign direct investment on economic growth and work has focused on both the short and long term relationships [2,3, 4].

Literature provides results on economic growth based on developed nations which would also help in understanding factors that could be useful in driving growth in developing nations [5]. One of the key inputs to the production process is the consumption of electrical power which is a secondary energy resource which is obtained from the conversion of primary resources like coal and natural gas and former being heavily used as source of electrical energy than the later. The level of consumption of electricity and its relationship with economic growth has also received attention in literature. This has come about because of the changes in the climate conditions which have given rise to the need to understand issues surrounding sustainable energy. Energy has risen on the list of priorities due to the crisis in supply and increased costs of energy that have been noticed in the recent past. Countries rely heavily on energy as such there is a renewed interest on the possible contribution of energy consumption on growth. The debate on this relationship dates back to work by [6] which has formed the foundation upon which studies have been benchmarked. The importance of energy consumption is acknowledged by both developing and developed nations. The sector for electricity had been found to play a key role in the development and growth efforts of the economy as it contributed to the improvement in the quality of life of citizens. Studies have found correlation between electricity consumption and wealth creation [7]

1.1 Problem statement and Research question

There is a huge amount of evidence that electricity infrastructure, generation and consumption contribute to economic growth. According to [8] electricity infrastructure contributes to economic growth and the creation of jobs within the economy. Considering the Botswana economy there is a challenge of power outages due to supply failing to meet demand. This is the case despite the increase in locally generated electricity in the country. This creates problems in the economy as economic activities are adversely affected. There is potential future

problem due the continuous existence of these power failures. The government appears not to pay particular attention to the current situation considering the urgency that it deserves. This may due to lack proper policy advice on the effect of electricity consumption to national output. There appears to be no appreciation of the relationship between consumption of electricity and growth potential of the economy. On the other hand literature fails to explain the relationship between economic growth and electricity consumption. There is generally no consensus on whether growth grangers cause electricity consumption or the other way round (unidirectional causality) and this has not been dealt in previous studies. According to our knowledge studies done are country specific and there is no study done on Botswana to test this relationship. There is still a need to verify if, in the case of Botswana, electricity drives growth over the long term. In other words the key question is whether or not electricity consumption leads growth. Findings in this study support the growth hypothesis which shows that electricity consumption has a positive impact of growth in the long term.

The rest of the study is organized as follows: The next section puts the study into context by explaining electricity consumption and economic growth patterns in Botswana, this is followed by a detailed review of literature, outline of methodology employed in this study, presentation of results and lastly we conclude the study together with some policy implications.

2 Electricity consumption and economic growth in Botswana

Botswana gained independence on the 30th of September 1966. Since that time the country has enjoyed the existence of civilian rule which case power has smoothly change hands among four presidents within the same political party. The policies on social issues had been very much progressive and there have been some huge pockets of investment in capital which have helped generate economic growth. The country is land locked in Southern Africa neighboring Zimbabwe and South Africa. Most of its land is covered by the Kalahari Desert sands. The country has gradually moved from low to middle income status with recent discovery of diamonds which have become the cash cow for financing growth efforts. This overreliance on diamonds as a source of growth is susceptible to external shocks which make it to become unsustainable. Greater strides have been made in recent years on the growth front which has seen the level of gross domestic per capita rising from 70 United States Dollar (USD) at independence to USD6500 around the year 2012. The country has experienced a fastest growth rate with an average of a real per capita GDP of 8.7% from 1996 to 2001 and this had fallen to 4.6% per annum average between 2001 and 2006. The growth in GDP has been erratic between 2008 and 2014 with the following growth rates: 3% (2008), 3.7% (2009), 10.8% (2010), 6.1% (2011), 4.2% (2012) and 5% (2013). The growth in per capita GDP in 2014 was 4.3% with an expected fall in the years 2015 and 2016 being 3.6% and 3.4% respectively [9]. The annual averages were 7.5% (1980 – 1990),

3.2% (1990-2000) and 3.5% (2000-2008), according to [10]. Data shows that the key contributors to GDP are construction (33.2%), manufacturing (23.5%), and mining (22.9%) while electricity and water contribute 21% around 2011. Evidence [11] also shows that average annual growth rates have declined since 1975 as follows: 13% (1975-80), 10.1% (1980-85), 9% (1985-1990), 4.2% (1990-95), 8.1% (1995-2000), 5.2% (2000-05), and 3% (2005-10). Thus both annual and average growth rates have declined which suggests the need to explore other sources or drivers of growth like consumption of electricity.

The growth rate of the economy of Botswana is affected by external shocks to the heavy reliance on diamond revenue as a key driver of economic activity. The contribution by mining to GDP is expected to fall by 65% in the year 2022 and being zero from the 2028 onwards. The country has seen the poverty situation being worse because of persistent droughts as a result of poor rains over the years. [12] argues that the economy has failed to diversify away from reliance on minerals and the levels of poverty are still high. The country offers good investment opportunities as it endeavors to offer fewer restrictions on new investors. The drive to improve foreign direct investment levels have been used as a way of attracting new technology in to the industry. There are possibilities of positive growth in Botswana due to the stable political environment, strong and effective legal judiciary and the country is still enjoying single digit inflation was 2.8% in April and May 2016 which was 3% lower than it was during the same period in 2015 [13]. Good governance has seen the majority of the population benefiting from the flows of diamond revenue since the 1980s. The country leadership is focusing on finding other possible sources of growth following the revelation that diamond production may not be the driver of growth beyond the year 2020. Growth has been driven by the diversification of exports which resulted in the government increasing its development budget. This is what has explained the country's graduating into a middle income status. Similarly, [11] shows that the country has experienced rapid growth through exploitation of minerals, rising incomes and living standards. The country has built up a good reputation with regard to governance, economic policy making and political stability.

The Botswana Power Corporation (BPC), a wholly government owned entity, supplies most of the electricity in the country especially in urban centres. It is responsible for the generation, transmission and distribution of electricity in the country. The generation of electricity in the country started around 1985 with a coal powered station at Morupule. BPC owns and operates the power station at Morupule in which the current plant in operation supplies 132 megawatts. Before this the country relied mainly on imports from Eskom in South Africa. Challenges were felt around 2008 when electricity demand started to outstrip supply in South Africa which results in less wattage being exported to Botswana and other countries within the region. The customer base of BPC in the whole country is around 136000 units. Shortfalls from coal generated power are met by electricity from diesel power generators and solar [14]. One of the key issues in Millennium

Development goals, for Botswana, is the expansion of access to energy services while protecting the environment. The country's primary energy sources are wood, electricity, petroleum products and aviation gas while solar, biogas and biodiesel is supplying less than one percent. The energy resources are dominated by coal reserves which are estimated to be around 212 billion tonnes. The level of usage of coal is around one million tonnes each year while more than half of this is being used for power generation. The consumption of electricity is increasing over the past years while the use of wood is nose diving. The country relies heavily on imports for electrical power but of late the neighboring countries are also experiencing huge local demand [15]. The hope was for the country to reduce its imports from Eskom South Africa once the project of building Morupule B plant was complete but this is still work in progress. Thus the main challenge is the fact that the level of imported electricity available from neighboring countries has fallen which means measures should be put in place to increase domestic production. The Morupule B station was a government initiative to ease import levels and it would increase capacity to 600 megawatts. Botswana has been very much endowed with solar, coal, biogas, and wood fuel yet their level of use is far below that of their availability [16, 17, 18].

There is another power station in Orapa which produces 90 megawatts and it was operated with diesel in which the government spent around P7000 per megawatt per month in fixed costs which was used for the purposes of meeting the demand for 17000 liters of diesel used by the two turbines per hour. This cost of fuel would translate to P29 million over a period of three years. The station was later converted in 2012 to use coal bed methane which drastically reduced the costs per kilowatt hour to 20 United States (US) cents which is 14 US cents less than what it used to be. The power station at Orapa has managed to free up power demand from the national grid (14, 19). According to the United Nations Development Programme (UNDP) report of 2012 the most used resources are petrol (33%), coal and electricity (25%) and diesel (12%). In Botswana the demand for energy is greater than its supply but the country has what it takes to meet its own demand. Currently the country uses biomass at levels below other comparable countries in the region which uses more than 80-90% of primary energy sources. At least 90% of the available wood biomass is mainly used in the rural areas.

The generation and distribution of electricity from 2005 to 2014 can be summarized as follows (see table 1): the level of contribution from electricity generated at home was erratic which was around 30% in 2005, and fell continuously until the end of 2011 after which a rise in electricity generated was noted as a result of developments which were taking place at Morupule B station. Currently locally generated electricity contributes at least 60% to national demand and this could have been more had the Morupule B power station been completed. As of 2013 the contribution of electricity generated to distribution was around 48% and there is still potential for an increase which is vital for economic growth.

Table 1: electricity generated, imported and distributed in Botswana

Year	Generation	Import	Distribution	% contribution of generated electricity to distribution
2005	866 615	1 975 069	2 841 685	30.5
2006	794 271	2 206 951	3 001 223	26.5
2007	624 746	2 518 565	3 143 311	19.9
2008	587 286	2 727 938	3 315 223	17.7
2009	443 918	2 792 730	3 236 648	13.7
2010	456 972	3 088 080	3 545 052	12.9
2011	303 374	3 169 068	3 472 442	8.7
2012	703 213	2 999 797	3 703 010	19
2013	1 681 497	1 820 940	3 502 437	48
2014	1 869 074	1 117 614	2 976 688	62.5

Source: [20]

3 Literature review

This section has been divided into three subsections covering the conceptual definition, theoretical framework and the empirical literature.

3.1 Conceptual framework

The demand for electricity represents a form of infrastructural demand. Infrastructure is a concept that embodies social and economic infrastructure. The former encompasses hospitals, schools and other social amenities, while the later includes all forms of network utilities such as electricity, water, communication and transport networks. In the literature, infrastructure is conceptually considered to be a complementary input for economic growth. The relationship between economic growth and infrastructure can be conceptualized by assuming a Cobb Douglas production function and applying the neoclassical growth model to allow the inclusion of infrastructure input which is combined with the augmented capital and labor inputs [21, 2]. This is presented in a mathematical model as follows:

$$Q_t = f[K_t, L_t, T_t, I_t (\text{electricity, other in frastructure})] \dots \dots \dots (1)$$

Where Q_t represents Gross Domestic Output produced in any given year t , L_t, T_t, I_t are the inputs into the national production representing labor force, technology and infrastructure in year t . The infrastructure input embraces all forms of infrastructure including electricity. The model provides that changes in any of the factor inputs including electricity should affect the level of national output. This study specifically focuses on the relationship between electricity consumption, one of the inputs for national output, and economic growth.

Electricity consumption takes place at both the commercial and non-commercial levels. However, in both levels electricity consumption is expected to have a positive effect on economic activity [23]. Commercially, electricity is demanded for use as a source of energy in primary, secondary and tertiary industries. The non-commercial consumption takes place at the household level, but still has an indirect effect on total productivity to national output [24]. In the current study, both commercial and non-commercial consumption of electricity are considered to be important factors affecting economic growth. Similarly, [25] found that there is cointegration between electricity consumption and economic growth in selected African countries. Elasticities, however showed that electricity was both a luxury and necessity in different countries.

3.2 Theoretical framework

The literature identifies four strands explaining the relationship between economic growth and electricity consumption namely the conservation, growth, feedback and the neutrality hypotheses [26]. The policy implications for each of these strands are hugely different from one another. Proponents of the conservation hypothesis believe that the link between growth and electricity is unidirectional causal relationship that flows from growth to electricity [7, 25]. [27] suggests that an economy that satisfies the conservation hypothesis is not likely to benefit much from electricity subsidization as part of a policy instrument that is meant to stimulate economic growth.

Conversely, an economy that satisfies the growth hypothesis would need policies that promote the consumption of electricity in order to stimulate economic growth. The growth based hypothesis depicts a unidirectional causal relationship that flows from electricity consumption to economic growth. This was found to be the case for Cameron, Ethiopia, Kenya and Mozambique [25]. Similarly [28] found that electricity consumption boost growth in the long run. Thus, the hypothesis assumes electricity consumption to be one of the key inputs to the national production function. To a discipline such as development finance it is vital for policy makers to establish the strand that a particular economy holds. This is because financial resources needed for pushing development agendas are scarce in any economy and thus the need to allocate them effectively. For instance, subsidies for electricity are not necessary for a country that exhibits signs of the conservation hypothesis. However, conservationist policies that slow electricity

consumption would hamper the prosperity to economic growth when an economy meets the condition of a growth hypothesis.

The neutrality hypothesis provides that electricity consumption is a small part of the components that forms real GDP and thus should not drive economic growth in a significant way [29]. The hypothesis implies that energy-boosting policies that seek to improve electricity consumption would not help to improve economic growth. Conversely, energy-conserving policies that seek to slow down energy consumption, including electricity, would not impact negatively economic growth. The feedback hypothesis holds that there is some interdependence between electricity consumption and economic growth. If a Granger-causality test is to be carried out, the feedback hypothesis should be proved by the presence of bidirectional causality in the results for the tests. Therefore, electricity consumption and economic growth are seen as complementing one another in such a way that if consumption in reduced growth decreases as well, and likewise when growth increases consumption would increase [25, 30]. The opposite is true in both cases. Policies directed at improving electricity consumption would not adversely affect economic growth, but would rather enhance growth.

3.3 Empirical literature

The study of the electricity consumption and economic growth nexus has received much attention by researchers in the previous decades [26]. Literature in this area has grown rapidly beginning from Kraft and Kraft's seminal work in 1978. The main theme of focus has been whether electricity consumption is a key variable that influences growth. Greater understanding has been called for by academics to discover the implications of different energy policies. This includes policy choices regarding the decision on whether to introduce electricity subsidies or to allow market reforms that attract private investors in this sector. More particularly, policy makers have been interested in understanding the effects of energy conservation agendas on economic performance. Conservation policies are pro-green regulations that seek to protect the physical environment. Such debates have all centered around the impact of electricity on growth and the causal relationship between these two variables. Researchers to date have produced mixed results regarding the outcome of the causal relationship. The variation in the results reported by researchers could be attributed to different methodologies employed in the studies and country-specific characteristics. For purposes of easy of analysis some researchers have divided their studies according to developing and developed countries [29, 31]. Other studies have been categorized according to regions whilst others according to country-specific case studies [32, 33, 7]. Table 2 below summarizes some selected studies with respect to the development status of countries. For each of these studies, the period of study, methodology used, country studied and the results obtained have been highlighted.

Table 2: Summary of selected studies

Researcher(s)	Employed Methodology	Period	Country	Results: hypothesis satisfied
<i>(a) Studies carried out on developed countries</i>				
[6]	Granger causality	1947-1974	USA	
[34]	Granger causality	1950-1976	USA, Poland and UK	Neutrality hypothesis
[35]	Cointegration tests and Granger causality	1948-1994	USA	Growth hypothesis
[36]	Error Correction Model	1950-1992	German, France, Japan, & Turkey	Growth hypothesis
			Italy	Conservation hypothesis
			USA, UK & Canada	Neutrality hypothesis
[37]	Leveraged bootstrap simulation	1965-2000	Sweden	Conservation hypothesis
[38]	Generalized Method of Moment System	1972-2002	Developed countries as per the World Bank	Neutrality hypothesis
[39]	Toda-Yamamoto tests	1959-2006	USA	Neutrality hypothesis
[40]	Panel Granger causality	1981-2007	25 OECD countries	Feedback hypothesis
[41]	One-way random effect, panel causality tests	1997-2007	27 European countries	Neutrality hypothesis
[42]	Autoregressive Distributed Lag bound test	1965- 2009	Portugal, Italy, Greece, Spain and Turkey	Feedback hypothesis
<i>(b) Studies carried out on newly industrialized countries</i>				
[43]	Johansen-Juselius	1955-1990	India, Pakistan	Growth hypothesis
		1960-1990	Indonesia	Conservation hypothesis
		1955-1990	Malaysia	Neutrality hypothesis
		1960-1990	Singapore	Neutrality hypothesis
		1955-1991	Philippines	Neutrality hypothesis
[44]	Granger causality	1952-1995	India	Conservation hypothesis
[45]	Granger causality	1950-1997	India	Conservation hypothesis
[27]	Error correction model & Toda-Yamamoto	1971-2002	Saudi Arabia	Growth hypothesis
[46]	Granger causality	1954-2006	Philippines and Singapore	Conservation hypothesis
[47]	Pedroni panel cointegration	1990-2006	Albania, Belarus, Bulgaria, Czech Republic, Latvia, etc	Neutrality hypothesis
[48]	OLS	1978	China	Growth hypothesis
[49]	Structural VAR	1960-2009	India	Growth hypothesis
[50]	Maximum entropy bootstrap	1971-2007	China	Neutrality
<i>(c) Studies on Less Developing Countries</i>				
[51]	Granger causality	1960-1984	Nigeria & Tanzania	Feedback hypothesis
[52]	Granger causality & Error correction model	1970-1999	Malawi	Feedback hypothesis
[53]	Threshold cointegration	1970-2007	Ivory Coast, Congo and Ghana Cameroon, Nigeria, Kenya, South Africa	Feedback hypothesis Conservation hypothesis Neutrality hypothesis
[54]	Autoregressive distributed lag bounds test, Granger causality	1972-2006	South Africa & Kenya Congo	Growth hypothesis Conservative hypothesis
[55]	Panel unit root, Panel cointegration and Granger causality	1980-2008	15 West African States	Growth hypothesis

4 Methodology

4.1 Data and Econometric modeling

The study employs time series data collected from [56]. Electricity consumption, being measured in kilowatt hours, embodied both commercial and domestic use and GDP growth are the main variables of interest in this research. The study covered a 34 yearly period spanning from 1980 to 2014. After collection of data econometric estimation discussed in 4.2 below was done using software called STATA version 12. The study focuses on assessing a causal relationship between GDP growth and electricity consumption. In pursuit of this we conducted some preliminary tests to check for unit root to see if the data is stationary for each of the two variables. For time series data, the widely used test is the augmented Dickey-Fuller (1979). The stationarity status of the data helped to determine the eventual modeling which was employed in the study. If the results from the unit root tests shows that each of the two variables have a unit root at their own levels, then the data is differenced and if they become stationary at their first difference, this proves that the variables are integrated of order one. This would mean that the two variables have a long run relationship, which can be examined using co-integration procedures. The vector error correction model (VECM) was estimated after determining the lag order and the number of cointegrating equations as done by [57].

5 Results and Discussion

5.1 Descriptive statistics

Table 3: Descriptive statistics

Stats	gdggrowth	fdi	ser	cpi	gfcf	epc
max	15.791	13.455	79.980	16.428	43.406	1563.512
min	-8.504	0.038	18.537	6.559	15.501	528.520
mean	4.490	3.534	57.294	9.704	29.835	1035.556
range	24.294	13.417	61.443	9.869	27.905	1034.992
sd	4.209	3.326	22.730	2.632	5.988	364.777
skewness	-0.387	1.300	-0.494	0.944	0.110	0.135
kurtosis	4.945	3.998	1.621	3.285	2.789	1.519
N	35	35	35	35	35	35

Table 3 shows a summary of the major descriptive statistics for all the variables used in the VECM model. The average values for GDP growth, FDI and secondary school enrolment are 4.48, 3.53 and 57.29 respectively, while for CPI, GFCF and electricity power consumption are 9.70, 29.83 and 1035.56. This means average growth patterns have been low during the period though it remained positive. The average growth in consumption patterns was high compared to other variables. On assessing skewness, the data indicates that GDP growth and

secondary school enrollment are negatively skewed, while the rest of the variables were positively skewed. Negatively skewed implies the variables generally increased for the period of study and vice versa for the positively skewed variables. For instance, GDP growth and secondary school enrolment significantly increased while electricity power consumption decreased towards the end of the period of study in Botswana. Secondary school enrolment and electricity power consumption were the most volatile variables as shown by their high standard deviation values. Kurtosis for each variable is way above zero indicating that they all have leptokurtic distributions, which also shows non-normality in the data.

5.2 Results on Stationarity tests

In order to deal with the problem of non-stationarity in time series data, we performed the modified Dickey Fuller test proposed by [58] and as discussed by [59]. The results in Table 4 show that all variables, with the exception of GDP growth are integrated of order 1. GDP growth is stationary at its own level. This means our variables can be useful in doing estimations as there is no possibility of giving spurious results.

Table 4: Modified Dickey Fuller Results

Variable	Integration order	DF-GLS tau Test Statistic	Level of Significance
GDP growth	I(0)	-3.639	5%
Fdi	I(1)	-4.697	1%
Ser	I(1)	-4.561	1%
Cpi	I(1)	-3.599	1%
Gfcf	I(1)	-6.572	1%
Epc	I(1)	-3.738	5%

5.3 Determination of maximum lag order

In using the VECM we need to determine the number of lags to include in the model. Based on the Akaike Information Criterion (AIC), Hannan-Quinn information criterion (HQIC) and Schwarz Bayesian information criterion (SBIC) the maximum number of lags were found to be four (4). The results are presented in Table 5.

Table 5: Selection of Maximum lag order

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-691.201				6.2e+12	46.48	46.5697	46.7603
1	-667.819	46.763	36	0.108	1.5e+13	47.3213	47.9488	49.283
2	-641.615	52.407	36	0.038	4.0e+13	47.9744	49.1398	51.6175
3	-594.101	95.028	36	0.000	5.0e+13	47.2068	48.9101	52.5313
4	-56.8675	1074.5*	36	0.000	3.16223*	13.7912*	16.0324*	20.7972*

5.4 Johansen tests for cointegration

We also tested for the number of cointegrating equation as provided by [57]. Results of the Trace Statistics in Table 6 indicate that there are two cointegrating vectors at 5% level of significance. This means we have two equations that are explaining the relationship between the variables in the long run.

Table 6: Johansen tests for Cointegration

Maximum rank	parms	LL	eigenvalue	trace statistic	% critical value
0	114	-595.9328		964.7690	94.15
1	125	-157.17999	1.00000	87.2634	68.52
2	134	-132.87619	0.80215	38.6558*	47.21
3	141	-123.60691	0.46095	20.1173	29.68
4	146	-117.70698	0.32519	8.3174	15.41
5	149	-115.16145	0.15608	3.2263	3.76
6	150	-113.54828	0.10196		

5.5 Results of the Vector Error Correction Model

Table 7: The vector error correction model

Variable	Beta	Standard Error	Z Statistic	P> Z
GDPgrowth	1			
Epc	0.04544	0.025084	1.81	0.070**
Cpi	-1.934595	0.6099462	-3.17	0.002*
Gfcf	0.1046181	0.1046181	0.53	0.596
Ser	-0.4475194	0.2682118	-1.67	0.095**
Constant	-2.865732			

Significant at 10% (**), 5% (*)

The VECM was used to determine the existence of a long run relationship between economic growth and electricity consumption. Results of the model are presented in Table 7 and all variables marked in asterisks are statistically significant at 1% and 10% level. Electricity consumption, inflation and human capital are important in explaining long run economic growth in Botswana. The results support the growth hypothesis, which suggest that electricity consumption positively influences growth. Our findings augur well with those of several researchers highlighted earlier in Table 2 [35, 43, 36, 49, 50]. Inflation and human capital, serving as control variables, have both revealed that they negatively impact on long run growth. [60] found a similar relationship for 119 countries and concluded that inflation hurts economic growth in the long run. Similarly, [61] concluded using 43 developing countries that excessive investment in education becomes unproductive in the long run.

6 Conclusions and Policy Recommendations

The paper examined the presence of the long run relationship between economic growth and electricity consumption using the Vector Error Correction Model in the case of Botswana. The study uses annual time series data covering the period 1980 to end of 2014. Using the Johansen tests for cointegration, the study reveals the existence of the long run relationship between the two variables. Electricity consumption emerged as the long run driving force explaining GDP growth. This means that electricity consumption is important as an input in the production function for Botswana. The results show that as consumption of electricity increases the rate of growth in GDP increases over the long term. In this study we therefore argue that as consumption of electricity increases there is potential to employ more factors of production in the energy sector, labor productivity increases as workers use automated and electrically powered machines. Again there is potential for the industry to develop faster as firms use machinery easily, and other sectors like education, health benefit as well which increases long run growth. Human capital and inflation were found to be important control variables in explaining this long run relationship. Thus we suggest the need to maintain low inflationary pressures on the economy and develop human capital that is industry relevant for the country to advance growth efforts.

The policy implications for our findings imply that the growth hypothesis holds in Botswana. Considering that financial resources for further developing goals are scarce our results provide direction on the best way to use them. Policymakers in the country should continue with and rather develop instruments that encourage more electricity consumption. This can be possible by providing electricity subsidies for firms that are in areas like mining and agriculture which are critical for growth. This is against the background that in the case of Botswana mining is one of the key pillars for revenue generation and the economy is also an agrobased

economy. Electricity subsidies have been found to benefit medium and large scale agricultural producers [62]. Thus the Botswana government needs to assess the ease with which farmers at all levels can easily connect to the national grid so as to reap the benefits of the subsidy. This is notwithstanding the fact that subsidies may be costly and they can distort pricing signals in the economy which affect efficiency. However, subsidies tend to improve the social safety net for the poor and therefore they a possible avenue to promote development where benefits outweigh costs. Thus, we argue that, improved electricity consumption is likely to increase economic growth in the long run.

References

- [1] Haller, Alina-Petronela, “Concepts of Economic growth and Development. Challenges of crisis of knowledge”, *Economy Trans-disciplinarity Cognition* 15 (1), (2012), pp.66–71.
- [2] S. Mbulawa, “Effect of macroeconomic variables on economic growth in Botswana, *Journal of economics and sustainable development*, 6(4), (2015), pp 68 – 77.
- [3] E. Dava, “Trade liberalization and economic growth in the SADC: A difference in difference analysis”, IESE conference paper no 8, (2012).
- [4] P. K. Biwott, E. Moyi and D. Khainga, “Trade liberalization and economic growth: the role of regulatory policies”. *Journal of World Economic Research*. Vol. 2(3), (2013), pp 45-57.
- [5] T. Eicher and O. Rohn, “Institutional determinants of economic performance in OECD countries- An institutions climate index”. CESifo DICE Report, Ifo Institute- Leibniz Institute for Economic Research at the University of Munich, vol. 5(1), (2007), pp. 38-49.
- [6] J. Kraft and A. Kraft, “Note and Comments : On the Relationship between Energy and GNP”. *The Journal of Energy and Development* 3: (1978), pp 401-403.
- [7] M. E. Bildirici, T. Bakirtas and F. Kayikci, “Economic growth and electricity consumption: Auto regressive distributed lag analysis”. *Journal of Energy in Southern Africa*, Vol. (23) 4, (2012), pp 29-45.
- [8] S. T. Chen, H.I. Kuo and C. C. Chen, “The relationship between GDP and electricity consumption in 10 Asian countries”, *Energy Policy*, vol. 35, (2007), pp. 2611–2621.
- [9] G. J. Honde and F. G. Abraha, “Botswana country report”, (2015). Retrieved from: <http://www.africaeconomicoutlook.org> (Accessed 20 September 2015)
- [10] J. C. Leith, “Why Botswana Prospered. Montreal”, McGill-Queen’s University Press, 2005.
- [11] K. Jefferis, “Whither the Botswana economy? Trends and choices for the coming decades”, *Botswana Society Public Forum Series*, 20 April 2011. Available at: <http://www.econsult.co.bw> (Accessed on 15 July 2016).

- [12] B. Malema, "Botswana's formal economic structure as a possible source of poverty: Are there any policies out of this economic impasse?" PULA: Botswana Journal of African studies, 26(1), (2012), pp 51-69.
- [13] Statistics Botswana, Consumer Price Index, Statistics Botswana, (2016). Available at <http://www.cso.gov.bw> (Accessed on 15 July 2016)
- [14] BPC, "Botswana Power Corporation annual report", 2012.
- [15] N. Majelantle, "Botswana Statistical Year Book 2010", Available at <http://www.bitc.co.bw/sites/> (Accessed on 15 June 2016).
- [16] USAID , "Electricity supply Industry of Botswana: General information for potential investors", USAID, Washington, USA, (2012). Available at <http://www.usaid.gov> (Accessed on 12 August 2016).
- [17] R. Grynberg, "Coal exports and the diversification of Botswana's economy, BIDPA publication series". (2012), Available at http://www.bidpa.bw/img_upload/pubdoc_46.pdf (Accessed on 02 August 2016)
- [18] K. Jefferis, B. Basele and S. Sejo, "Economic review, Econsult, Fourth quarter October – December 2015", (2015). Available at <http://www.econsult.co.bw/> (Accessed on 02 June 2016).
- [19] Tlou Energy, "Orapa power station report – Botswana Power Corporation". Available at <http://www.tlouenergy.com> (Accessed on 20 June 2016).
- [20] Statistics Botswana, Consumer Price Index, Statistics Botswana, (2014). Available at <http://www.cso.gov.bw> (Accessed on 15 July 2016)
- [21] R. J. Barro and X. Sala-i-Martin, "Economic growth". 2nd Ed., The MIT Press. Cambridge, Massachusetts, 2004.
- [22] P. Sahoo, and R.K. Dash, "Infrastructure development and economic growth in India". Journal of the Asia Pacific Economy. 14(4), (2009), pp 351-365.
- [23] G. Gupta and N. C. Sahu, "Causality between electricity consumption and economic growth: empirical evidence from India". MPRA Paper No. 22942, (2009).
- [24] N. Bottini, B. Pels and M. Pisu, "Improving infrastructure in the United Kingdom". Organization for Economic Co-operation and Development. Economics Department: ECO/WKP 62 (2015).
- [25] M.B. Bildirici, "The analysis of relationship between economic growth and electricity consumption in Africa by ADRL method", Energy Economics Letters, 2013, Vol. 1, No.1, (2013), pp.1-14.
- [26] Ozturk, "A literature survey on energy-growth nexus". Energy policy 38: (2010), pp 340-349.
- [27] M. Mehrara, "Energy Consumption and Economic Growth: The Case of Oil Exporting Countries". Energy Policy, 35, (2007), pp 2939-2945.
- [28] S. O. Oshota, "Electricity consumption and economic growth in Nigeria: Evidence from Bounds test", The empirical econometrics and quantitative economics letters, 3(4), (2014), pp 66-77.
- [29] J. E. Payne, "A Survey of the Electricity Consumption-Growth Literature", Applied Energy 87: (2010), pp 723–731.

- [30] G. Abdoli, Y. G. Farahani and S. Dastan, "Electricity consumption and economic growth in OPEC countries: A cointegrated panel analysis", 39(1), (2015), pp 1-16.
- [31] Economic Consulting Associates, "Correlation and causation between energy development and economic growth". UK: DFID, 2014.
- [32] P. K. Adom, "Electricity consumption-economic growth nexus: The Ghanaian case". *International Journal of Energy Economics and Policy*, 1(1), (2011), pp. 18-31
- [33] M. Masduzzaman, "Electricity consumption and economic growth in Bangladesh: Co-integration and causality analysis". *Global Journal of Management and Business Research*. Vol. (12) 11, (2012), pp 51-62.
- [34] S. H. Yu and J. Y. Choi, "The Causal Relationship between Energy and GNP : An International Comparison", *Journal of Energy and Development* 10(2), (1985), pp 249–272.
- [35] D.I. Stern, "Energy and economic growth in the USA. A multivariate approach", *Energy Economics* 15: (1993), pp 137–150.
- [36] U. Soytas and R. Sari, "Energy consumption and GDP: causality relationship in G-7 countries and emerging markets", *Energy economics*, Vol.25, (2003), pp.33-37.
- [37] Hatemi and M. Irandoust, "Energy Consumption and Economic Growth in Sweden: A Leveraged Bootstrap Approach, 1965-2000". *International Journal of Applied Econometrics and Quantitative Studies*, 4, (2005), pp 1-20.
- [38] N. Huang, M. J. Hwang and C. W. Yang, "Causal relationship between energy consumption and GDP growth revisited: a dynamic panel data approach", *Ecological Economics*, 67, (2008), pp 41–54.
- [39] J.E. Payne, "On the dynamics of energy consumption and output in the US". *Applied Energy* 86 (4), (2009), pp 575–577.
- [40] Belke, F. Dobnik and C. Dreger, "Energy Consumption and Economic Growth: New Insights into The Co-integration Relationship". *Energy Economics*, 33(5), (2011), pp 782–789.
- [41] N. Menegaki, "Growth and renewable energy in Europe: a random effect model with evidence for neutrality hypothesis". *Energy Consumption* 33, (2011), pp 257-263.
- [42] J. A. Fuinhas and A. C. Marques, "An ARDL Approach to the Oil and Growth Nexus: Portuguese Evidence". *Energy Sources, Part B*, 7(3), (2012), pp 282-291.
- [43] M. M. Masih and R. Masih, "A multivariate cointegrated modelling approach in testing temporal causality between energy consumption, real income and prices with an application to two Asian LDCs". *Applied Economics* 30 (10), (1998), pp 1287–1298.
- [44] S. Cheng, "Causality between energy consumption and economic growth in India: an application of co-integration and error correction modeling". *Indian Economic Review*, 34, (1999), pp 39-49.

- [45] S. Ghosh, “Electricity Consumption and Economic Growth in India”. *Energy Policy* 30: (2002), pp 125-129.
- [46] S. Z. Chiou-Wei, C. Chen and Z. Zhu, “Economic Growth and Energy Consumption Revisited—Evidence from Linear and Nonlinear Granger Causality”. *Energy Economics*, Vol. 30, (2008), pp 39-49.
- [47] Acaravci, I. Ozturk, “Electricity consumption-Growth Nexus: Evidence from Panel Data for transition countries”. *Energy Economics*, Vol. 32(3), (2010), pp 604-608
- [48] Y. Fang, “Economic welfare impacts from renewable energy consumption: The China experience”. *Renewable and Sustainable Energy Reviews*, 15(9), (2011), pp 5120–5128
- [49] K. Tiwari. “Energy consumption, CO2 emissions and economic growth: A revisit of the evidence from India”, *Applied Econometrics and International Development*, 11 (2), (2011), pp 165-189.
- [50] A.T. Yalta and H. Cakar, “Energy consumption and economic growth in China: A reconciliation”, *Energy Policy*, 41, (2012), pp 666-675.
- [51] O. J. Ebohon, “Energy, economic growth and causality in developing countries: a case study of Tanzania and Nigeria”. *Energy Policy* 24, (1996), pp 447–453
- [52] C.B.L. Jumbe, “Co-integration and causality between electricity consumption and GDP: empirical evidence from Malawi”. *Energy Econ.* 26, (2004), pp 61–68
- [53] L.J. Ezzo, “Threshold co-integration and causality relationship between energy use and growth in seven African countries”. *Energy Economics* 30, (2010), pp 2391–2400
- [54] N. Odhiambo, “Energy consumption, prices and economic growth in three SSA countries: A comparative study”. *Energy Policy*, 38 (5), (2010), pp 2463-2469.
- [55] N. S. Ouedraogo, “Energy consumption and economic growth: Evidence from the economic community of West African States (ECOWAS)”. *Energy Economics*, 36, (2013), pp 637–647.
- [56] World Bank development indicators (2016): Retrieved from <http://data.worldbank.org/indicator/SP.POP.TOTL>
- [57] S. Johansen, “Likelihood based inference in cointegrated vector autoregressive models”, Oxford: Clarendon Press, 1995.
- [58] G. T. J. Elliott, G. Rothenberg and J. H. Stock, “Efficient tests for an autoregressive unit root”, *Econometrica* 64: (1996), pp 813–836.
- [59] J. H. Stock and M. W. Watson, “Introduction to Econometrics”. 3rd ed. Boston: Addison–Wesley, 2011.
- [60] G. M. Caporale and M. Skare, “Short- and Long-run Linkages Between Employment Growth, Inflation and Output Growth: Evidence from a Large Panel”. Brunel University London- Department of Economics and Finance. Working paper No. 11-17, (2011).

- [61] S. Devarajan, V. Swaroop and H. Zou, "The composition of public expenditure and economic growth". *Journal of Monetary Economics-Elsevier* Vol. (37), (1996), pp 313-344.
- [62] J. Varinder, "Political Economy of Electricity Subsidy: Evidence from Punjab", *Economic and Political Weekly*, 41 (38), (2006), pp. 4072-4080.