Exploring Economic Growth Potential through Infrastructure collaboration: the case of Kenya and Sudan

The Horn Economic and Social Policy Institute (HESPI)

Working Paper 01/15

Haile Kebret Taye (PhD)

May 2015

Financed by: THE AFRICAN CAPACITY BUILDING FOUNDATION | FONDATION POUR LE RENFORCEMENT DES CAPACITES EN AFRIQUE

©2014 The Horn Economic and Social Policy Institute (HESPI)

1st Floor, Teklu Desta Building, Addis Ababa, Ethiopia

Published by the Horn Economic and Social Policy Institute

All rights reserved

For additional information on the Horn Economic and Social Policy Institute, please visit the following: www.hespi.org

The Horn Economic and Social Policy Institute

Exploring Economic Growth Potential through Infrastructure collaboration: the case of Kenya and Sudan

Haile KebretTaye*

HESPI **Working Paper 01/15**

***The views expressed in this paper are those of the author and do not necessarily reflect those of Horn Economic and Social Policy Institute at which the author works as the Research Director.**

The Horn Economic and Social Policy Institute (HESPI)

HESPI is a non-profit, non-political research institute that conducts economic, social and policy oriented research to promote high quality policy analysis and advisory services to assist African governments, the private sector and other stakeholders with a special focus on the IGAD sub-region. HESPI conducts commissioned studies and interacts with principal institutions and entities to address the challenges the region faces. HESPI's focus also covers institutional capacity building and instilling values for better management of social and broad based sustainable economic growth aimed at prosperous future for the region.

Table of Contents

Abstract iv
1. Introduction 1
2. The Economies of Kenya and Sudan: A Short Overview 3
3. Literature Review 6
4. Methodology 9
5. Data, Estimation Results and Conclusions 10
   5.1. Estimation 10
   5.2. Estimation Results 11
   5.3. Estimation Result 14
   5.4. Conclusion and Implications 14
References 16
Appendix 18

Abstract

African countries have been actively seeking both bilateral collaboration and continental unity since the 1950s. Such efforts focused on trade in finished goods but less on infrastructure collaboration. The objective of this study is to (a) examine the impact of hydropower consumption on economic growth in Kenya and Sudan, as a case study; and (b) indirectly infer its potential to strengthen economic cooperation among African countries if and when such mutual benefits pave the way via infrastructure collaboration. This is based on the rationale that such mutual benefits generate an incentive compatible engagement that will have the potential for countries to lock-in such benefits.

The approach used is a basic growth model in which output (GDP) is determined by capital, labor. Energy is also included as an additional input to the two conventional inputs. To estimate this model, a co-integration approach using an auto regressive distributive lag (ARDL) model and data from 1971 to 2012 is used.

The results seems to support the hypothesis that energy consumption is an input to economic

growth as a complement to the conventional factors of production; it suggested that the direct impact of a unit increase in hydroelectric consumption on GDP growth of Kenya and Sudan in the long-run is about 0.7% and about 0.6%, respectively. Similarly, its contribution is less in the short-run than in the long run but it is still likely to boost growth by about 0.34 and 0.24 per cent, respectively.

All trade theories suggest that the basis for sustained trade linkages among countries is gains from trade transactions. Hence mutual gains from infrastructure linkages are expected to both boost further economic linkages and ultimately strengthen regional integration, in countries such as Ethiopia, Kenya and Sudan.

Key words: Infrastructure Collaboration, Economic growth, Energy Consumption, Regional Integration

JEL: E2, O5, F15

1. Introduction

African countries have been actively seeking both bilateral collaboration and continental unity since the 1950s. The geographical proximity, cultural affinity, similar colonial experience and the economic circumstances they find themselves in have evoked the need to seek collaboration at some level. Following independence, most African leaders focused on establishing close cooperation in many spheres to combat the socio-political and economic challenges they faced in the continent leading to seeking economic and political unity at a continental level. As a recent study (Programme for Infrastructure Development in Africa, PIDA, 2012, P. 7) noted:

”***Integration was a goal of the continent’s leaders in the struggle for independence. Kwame Nkrumah established the short-lived United States of Africa in the late 1950s followed by the Organization of African Unity (1963–2002), which was succeeded by the AU (2002–present). The process of economic integration gained traction with the 1991 Abuja Treaty that established the African Economic Community. Its article 28 proposed the creation of the RECs as the building blocks of African integration with continental integration to be achieved by 2028”.***

In the last fifty years or so, the ideals of close economic and political cooperation have continued an abated even though the actual political ties that have been created and economic relationships formed (particularly trade flows) are still wanting, despite repeated declarations of intent. Regional integration in Africa (as was in other parts of the world) was rekindled since the 1980s. More specifically, this interest has intensified in Africa starting the Abuja Treaty of 1991.To demonstrate that intention, African leaders have signed various protocols and declarations to the effect of establishing and maintaining some form of regional integration agreements of one form or another.

We all know the extent of progress that has been made in terms of trade flows, the strengths and weaknesses of the regional blocks that exist and the factors that have contributed to that outcome[i]. Arguably, one of the reasons for the poor performance in the extent of trade flows in particular and the overall regional integration in general is the absence of clear and immediate incentive compatible gains for such an effort[ii]. What is of interest to note is that, despite the grand ideals of continental unity, no effort has been made to promote infrastructure cooperation given the high potential to collaborate on such activities and the acute shortage of such facilities in many African countries. Instead all regional integration groupings are initiated, processed and set up via government declarations with little or no input from the private sector and the general public and all focused on trade in goods and services (i.e. final products and no intermediate goods or services like infrastructure).

Even though the leaders upheld these ideals, they have not put the relevant incentive structures in place and the changes necessary to bring about regional and ultimately continental integration. More importantly, it seems, the ingredients or preconditions of continental cooperation were (due to cross border conflicts, for instance) glossed over for long with a detrimental effect on the progress of regional integration. Arguably, some of the key ingredients that could have maintained a rapid progress of regional integration and ultimately continental unity may include expanding infrastructure (roads, irrigation facilities, power grids, energy sources, communication and network lines), exploration of natural resources, developing joint bilateral projects, sharing common facilities to boost trade in goods and services. Such collaboration probably could have created an incentive for countries to pursue mutually beneficial political and economic ties and lock-in their gains.

There seems to be some recognition of late the need and the importance of collaboration along the lines stated above, even though concrete action is still lacking. That is, it is still insignificant in terms of effort and not much has happened yet in term of real infrastructure collaboration either at bilateral or regional levels in all regions of Africa except in few spots. The plant in the process of construction by a joint effort of Burundi, Rwanda and DRC on the Ruzizi is a case in point. The recent attempt by some countries to exploit their potential and create, share, and collaborate in some infrastructure projects that include power supply, irrigation, road facilities and telecommunication are crucial both in the short-term and long-term

In that context, the DRC and Ethiopia (believed to be with highest potential in the region to generate hydro power) plan to generate substantial renewable energy using hydroelectric power. This is expected to, at least, "quadruple' Ethiopia's power generation within the First (2010-2015) program period. And Ethiopia plans to share some of that energy to neighbouring countries. The main objective of this short note is therefore, to assess the likely impact of such energy on the economies of the two countries, Kenya and Sudan and quantify its potential to serve as a catalyst for future collaboration by locking in these mutual benefits, if any.

As will be discussed, the direction of Causality between energy consumption and GDP growth has yet to be settled in the literature.It is also worth noting that conventional growth theories do not directly include energy as a factor of production. The contribution of this study or objective is, then, to (a) contribute to the existing debate regarding the link between energy consumption and economic growth; (b) quantify possible economic effects of energy consumption on economic growth using Kenya and Sudan, as a case study; and (c) assess the extent to which such infrastructure collaboration has the potential to serve as a catalyst to lock-in future collaboration that is likely to facilitate stronger trade ties and ultimately economic integration.

The paper is organized as follows. After this introductory note, section two will briefly outline some salient features of the Kenyan and Sudanese economies, particularly their energy structure. The third section will briefly review the literature related to energy consumption and economic growth. Section four will examine the methodology to be used to assess the contribution of energy consumption to economic performance. The fifth section will Present and analyze the results of the study and infer its implications for future collaboration in general and infrastructure linkages in particular.

2. The Economies of Kenya and Sudan: A Short Overview

The economies of the two countries slightly vary in terms of their level of income despite their reliance on extracting raw natural resources. The mainstay of the Kenyan economy is agriculture while that of Sudan has benefited from the discovery of oil in recent years.

In terms of the economies recent performance, according to World Bank figures, the Kenyan and Sudanese economies grew by 4.7 and -6 percent, respectively in 2013. It is worth noting that Sudan had had remarkable economic growth mainly because of the oil bonanza until 2010 but following the secession of South Sudan in 2011, the Sudanese economy contracted by around 10 percent and registered a significant decline in 2013. During the same year the registered inflation was 37.4% in Sudan and 5.7% in Kenya. On the other hand, real GDP per capita in Sudan was USD 1753 and in Kenya 994.

In terms of the structure of their economies, the largest sector in both Kenya and Sudan is the service sector. Manufacturing constitutes a significant share of GDP in both Kenya and Sudan, the share of the service sector in both countries, however, seems to have remained almost stagnant in the last fifteen years. Sudan's external sector (as measured by the current account balance) improved in recent years, thanks to the export of oil; similarly Kenya's external position also improved, partly owing to the HPICs initiative, in which the current stock of debt accumulated, as a percent of the GNI is very significantly reduced.

What are of interest to note in relation to the issue at hand are:

(1) There has been a concerted effort in Ethiopia to boost hydroelectric power generation in recent years that intends to provide some electric grids to neighboring countries including Kenya and Sudan, among others;

(2) Partly due to the more advanced stage of the manufacturing sector in Kenya and overall development there seems to be a need for additional electric power expressed by various Kenyan and Sudanese government officials; and

(3) This potential and revealed interest in infrastructure trade seems to defy the miniscule level of intra-regional trade (save the undocumented border trade), that takes place between the three countries as is the case in all IGAD member countries. In relative terms, the exports of Ethiopia and Kenya to IGAD member countries is relatively high (between 15 to 20% of their total) but their imports from the various countries of IGAD member countries is very small (less than 2% of their total from the rest of the world). This probably is partly due to the relative size of their economies and the relatively larger diversity of products traded. The above observations suggest the need to explore the extent of collaboration in infrastructure trade and ultimately strengthening further collaboration in other areas that would likely facilitate faster and stronger economic integration.

Due to the recent large initiatives to generate energy (mainly hydroelectric power), Ethiopia has started and plans to export energy to neighboring counties. It has started exporting to Djibouti and Sudan and signed an agreement to do so with Kenya. Demand and supply permitting, Ethiopia also plans to further expand that coverage to other countries once the Renaissance Dam (on the Nile River) is completed, expected to generate around 6ooo kwh of electric city.

Both what has been exported and what is planned to be exported are a very small ratios of the respective countries' total energy consumption, but the linkages and long-term economic benefits they generate cannot be underestimated. Hence, what is being already exported, regardless of its size relative to demand, and the initiative to create railway links between the countries in the region are complementary initiatives to enhance regional integration. It is to be noted that despite the various declarations and agreements to speed up regional integration, not much has happened yet in terms of actual trade flows. Intra-regional trade registered in almost all the regional blocks since 2000 has been less than 10 percent of their total trade and in the Eastern and Southern Africa regional block (COMESA) it was only about 6.7 percent. Such an approach to further strengthen the benefits that countries could garner / secure is likely to be rewarding as it is, at least in principle, incentive compatible with locked-in mutual interests. Sharing infrastructure resources is, therefore, a promising start for countries to both strengthen their economic ties and ultimately achieve regional integration as long as it boosts each countries growth prospects.

Both Kenya and Sudan have small but relatively fast growing economies in the region and relatively young population. As a percentage of GDP, the service sector has been the most dominant since 2000, but their manufacturing sectors are also on the rise, constituting about 20 and 6 percent of GDP, respectively. Their economic needs coupled with a young and growing population in both countries with all its implications for urbanization with its attendant lifestyle changes, their need for more energy is likely to grow in the foreseeable future. Their respective economies (as measured by GDP) also grew by about 5 percent since 2000. According to 2005 figures, electric power consumption (kWh per capita) in Sudan was 85.2 and in Kenya it was 144.3. While this is relatively high compared to that of Ethiopia (36.7%), it is still low compared to an African average.

It is important to put these figures in the African context. Most of the relevant indicators for both Kenya and Sudan suggest that there is both low level of energy production and consumption both in absolute terms and relative to an African average. For instance, the capacity of both Kenya and Sudan in generating electricity from various possible sources (both renewable and non-renewable) is currently limited while the actual and particularly the potential is on the increase. Over the last twenty three years (1990-2013), average energy consumption per capita in both Kenya and Sudan was less than the African average. More importantly, GDP per unit of energy use (PPP $ per kg of oil equivalent) is only about 3.4 and 5.5. And electricity production from renewable sources, excluding hydroelectric (as % of total) averaged about 17.2 and 16.7 in Kenya and Sudan, respectively. In terms of utilization, energy use (kg of oil equivalent) per $1,000 GDP (constant 2011 PPP) averaged about 240.8 in Kenya and about 77.7 in Sudan (see Table 1, for more energy related data for both countries).

Table 1. A Profile of the Energy Sector in Kenya and Sudan (Average 1990-2013)

Indicators	Kenya	Sudan
Electricity production from coal sources (% of total)	0	60.81653
Electricity production from oil, gas and coal sources (% of total)	22.00152	8.99E+08
Electricity production from hydroelectric sources (% of total)	60.81653	0
Electricity production from renewable sources, excluding hydroelectric (% of total)	17.18195	16.73598
GDP per unit of energy use (PPP $ per kg of oil equivalent)	3.400463	5.521505
Energy imports, net (% of energy use)	16.73598	240.8253
Alternative and nuclear energy (% of total energy use)	5.521505	14530.12
Fossil fuel energy consumption (% of total)	16.65438	11240.95
Energy use (kg of oil equivalent) per $1,000 GDP (constant 2011 PPP)	240.8253	77.74252
Energy use (kt of oil equivalent)	14530.12	4.3E+09
Electric power consumption (kWh per capita)	132.4261	69.29336
Energy use (kg of oil equivalent per capita)	450.5985	387.8551
GNI per capita growth (annual %)	0.417656	4.142868
GDP per capita growth (annual %)	0.285462	2.228047
GDP growth (annual %)	3.138057	5.31138
Access to electricity (% of population)	18.5	22.00152

Source: World Development Indicators (World Bank, 2013)

As noted by UNECA's (2014, p. 167) report the need for more available energy is high in almost all the countries of the region. "Energy consumption within the sub-region is expected to increase significantly during the coming years. This increase will be triggered mainly by the current level of energy consumption (3 percent of world average consumption), rapid population growth and the expansion of the economies of the region".

Despite the recent optimism regarding the potential to generate significant hydroelectric power in some African countries (the Renaissance Dam in Ethiopia and the Grand Inga Dam in the Democratic Republic of Congo, which are expected to generate about 6000 and 39,000 MW, respectively, when completed) the overall power supply in Africa is neither sufficient nor evenly distributed. For Instance, in 2005 about 550 TWh of hydroelectric power was generated. 42% of the total (230Twh) was produced in South Africa with a population of about 5.5% averaging about 4500 kwh per capita, while 27% of the total (150 Twh) was produced by five Northern African countries (Egypt, Algeria, Morocco, Tunisia and Libya) constituting about 16.7% of the population with a share of about 1000 kwh per capita. The remaining 31% of the total (170 Twh) was produced by inter-tropical Africa with a population of 77.8%, averaging about 250 kwh per capita. Both in terms of availability and distribution, therefore, the potential for additional energy need is huge.

According to World Development (2012) Indicators, the size of the population with access to electricity (% of population) is 22% in Sudan and 19% in Kenya. And in terms of the sources, Energy imports (net % of energy use) in Sudan constitutes 241% and in Kenya it is 17%. Ethiopia is also likely to benefit from the trade by securing significant foreign exchange. More importantly, all the countries are likely to further strengthen their economic and political ties which is likely to further strengthen the realization of regional integration.

The crucial question is then what are the specific contributions of any increases in the electric consumption to economic growth in the countries of interest? That is, beyond the obvious contributions of electricity for mundane daily use, what is the linkage of energy consumption and economic growth? This question is crucial since it is only if countries are lock-in in mutually beneficial exchange that their economies relations will last and strengthen. Short of such an incentive compatible exchange, the probability of a strong economic linkage that leads to further regional integration is weak to the say the least.

Efforts to increase future collaboration will depend on the mutual benefits that all countries in Africa realize from their involvement in such trading arrangements. Even though there is potential to collaborate in other economic areas (as seems to have started in joint cross-border roads, railways etc) the most prominent seems to be sharing electric power as already started with Sudan (importing about 100 kt) and an agreement with Kenya to that effect. The crucial question is then, how smooth would this collaboration be and what would be its effect on the economies of the two (Kenya and Sudan) countries? It should be noted that Electric power consumption (kWh per capita) increased by about 174% in Sudan and by about 19% in Kenya between 2005/09 and 2010/12. On the other hand, Electricity production from hydroelectric sources declined by about 100 and 58 percentage points, respectively, during the same period. Given Ethiopia's ambitious initiatives to generate significant hydroelectric power, the existing demand and supply seems to coincide to boost trade in infrastructure.

In what follows, after a brief survey of the literature in the next section, an attempt will be made to assess the extent to which the additional power that will be imported from Ethiopia is likely to affect the economic performance of both Kenya and Sudan. There have been many studies both time series and cross section covering both developed and developing countries that have explored this issue. This study is structured along those lines.

3. Literature Review

The various studies that have been undertaken demonstrated that there is a relationship between energy consumption and GDP but the direction of causality has not been settled yet (Ageel, 2001). Many writers that included Hwang et el (1991), Kraft and Kraft (1978), Menyah and Yemane (2010), and Melike (2012) investigated the direction of causality between energy consumption and GDP growth. While most studies noted that the variables are related but evidence whether energy consumption causes (in the Grange sense) GDP growth or vice versa is mixed. Some of the authors found a unidirectional causality others found a bi-directional causality and still few others found no Granger causality between the variables. A lot of explanations have been given for the mixed results ranging from data quality to specification issues.

These mixed results, according to Bildirici (2012, p.2) led to four hypotheses regarding the relationships between energy consumption and economic growth. These are the Neutrality, feedback, conservation and growth hypotheses. The Neutrality Hypothesis states that energy consumption and economic growth do not Granger cause one another. But the feedback hypothesis argues that there is a bi-directional causality that runs from energy consumption to economic growth and vice versa. The conservation hypothesis asserts that the causality runs from economic growth to energy consumption, thereby making economic growth independent of energy consumption. Alternatively, the growth hypothesis states just the opposite by noting that the causality runs from energy consumption to economic growth which implies that a country's economic performance is dependent on the level of energy that is consumed. Hence in such cases energy is taken as input of production that is essential in the production process.

As was the case for developed countries, the results for African countries have also been mixed, even though the number of studies carried out is relatively limited. As reported in Table 2, while some studies are based on time series others are based on panel data. For instance, a study by Lee (2005) that included countries like Kenya and Ghana found that causality runs from energy consumption to economic growth. Similarly, Welde-rufael (2005) used data from 1971 to 2006 to examine the relationship between energy consumption and economic growth using an ARDL model in 19 African countries and Welde-rufael (2009) for 17 African countries and found mixed results (see Table 2). Odhiambo (2010) for three African countries and Esso (2010) for seven African countries using data from 1970 to 2007, among others, also examined the direction of causality between energy consumption and economic growth.

In addition to variations in the direction of causality between energy consumption and economic growth some authors also found mixed results depending on the type of energy used. That is, whether the source of the energy used is coal, fossil fuel, hydropower generated electricity or petroleum. Ageel (2001, p. 109) in a study for Pakistan concluded, "economic growth leads to the growth in petroleum consumption, while in the case of the gas sector, neither economic growth nor gas consumption effect each other, however, in the power sector it has been found that electricity consumption leads to economic growth without feedback". A summary table for many African countries detailing the countries included, time period covered, the methodology used and the results obtained is reported below.

Table 2: causality Literature on energy consumption in African Countries

Author(s)	Country	Period	Methodology	Main Variables	causality
Conservation hypothesis					
Wolde-Rufael (2006)	Cameroon, Gabon, Ghana, Nigeria, Senegal, Zambia, Zimbabwe	1971-2001	ARDL (Toda Yamamamoto)	GDP, Electricity consumption	Y → EC
Wolde-Rufael (2005)	Algeria, Democratic Republic of Congo, Egypt, Ghana and Ivory Coast	1971-2001	ARDL (Toda Yamamamoto)	GDP, Electricity consumption	Y → EC
Esso (2010)	Congo Ghana	1970-2007	Threshold cointegration approach	GDP, Electricity consumption	Y → EC
Growth Hypothesis					
Lee (2005)	Sub-Saharan Africa Kenya and Ghana	1971-2001		GDP, Electricity consumption	EC → Y
Wolde-Rufael Y.(2006)	Benin, Congo, Tunisia	1971-2001	ARDL (Toda Yamamamoto)	GDP, Electricity consumption	EC → Y
Odhiambo (2009)	Tanzania	1971-2006	ARDL)-bounds testing approach	GDP, Electricity consumption	EC → Y
Belloumi, 2009	Tunusia	1971–2004	Granger causality, VECM	GDP, Electricity consumption	EC → Y (in SR)
Ozturk, A. Acaravci (2011)	Egypt Saudi Arabia		ARDL	GDP, Electricity consumption	EC → Y(in LR)
Quedraogo (2010)	Burkina Faso	1968-2003	ARDL	GDP, Electricity consumption	EC→Y
Kebede, Kagochi, Jolly (2010)	20 Sub-Saharan Africa	1980-2004	Atomic Energy Agency Energy Demand Projection (MAED) model	GDP, Electricity consumption	EC→Y
Feedback hypothesis					
Ebohon (1996)	Nigeria, Tanzania	1960-1984 1960-1981	Granger Causality	GDP, Electricity consumption	EC←→Y
Belloumi, 2009	Tunisia	1971–2004	Granger causality, VECM	GDP, Electricity consumption	EC←→Y (in LR)
Ouedraogo (2010)	Burkina-Faso	1968-2003	Bound test	GDP, Electricity consumption	EC←→Y
Esso (2010)	Ivory Coast	1970-2007	Threshold cointegration approach	GDP, Electricity consumption	EC←→Y
Nondo et.all (2010)	19 African countries (COMESA)	1980-2005	Panel VEC, Granger Causality Tests	GDP, Electricity consumption	EC←→Y (in LR)
Jaunky(2006)	16 African countries		Panel VEC, Granger Causality Tests	GDP, Electricity consumption	EC←→Y
Neutrality hypothesis					
Wolde-Rufael (2006)	Kenya	1971-2001	Bound test (Toda Yamamamoto)	GDP, Electricity consumption	none
Wolde-Rufael (2006)	Sudan	1971-2001	Bound test (Toda Yamamamoto)	GDP, Electricity consumption	none
Huang, Hwang, Yang(2008)	in the low income group	1972-2002	Panel VAR, GMM-SYS	GDP, Electricity consumption	none
Esso (2010)	Cameroon, Nigeria, Kenya, South Africa	1970-2007	Threshold cointegration approach	GDP, Electricity consumption	none

Source: Adopted from Bildirici (2012), Table 1, p. 4.

4. Methodology

The methodology in this paper starts with the basic growth literature by specifying that output (GDP) is determined by capital, labor and hypothesizing that energy is used as an additional input to the two conventional inputs (labor and capital). To estimate this model, a co-integration approach using an auto regressive distributive lag (ARDL) model popularized by Pesaran, Shin and Smith (2001) is used. In the estimation process the steps that are taken include the following: examining the properties of data using tests for stationarity, carrying out the bounds test for co-integration, estimating the long-run and short run parameters of the model.

The specification used to estimate the long-run version of the model is presented in equation (1).

$$Log(GDP_t) = \alpha_0 + \lambda_1 Log(GDP_{t-1}) + \lambda_2 Log(K_{t-1}) + \lambda_3 Log(L_{t-1}) + \lambda_4 Log(E_{t-1}) + \varepsilon_t \text{..........................} 1$$

Where:

Log (GDP)	= log of GDP for either Kenya or Sudan;
LOG (K)	=log of Capital stock;
LOG (L)	= log of labor force employed;
LOG (E)	= log of electricity used in production;

α is a constant;

t=time subscript, λ_i 's are respective coefficients; and ε is an error term.

The specification in equation (1) is the standard growth model with the addition of hydropower as an input in the production process. It is expected to capture the extent to which it contributes to economic growth in the two countries. A priori one would expect that capital stock (K) and labor (L) would positively contribute to GDP while energy consumption (E) is ambiguous since it has registered mixed results in previous studies, as noted in the literature review. This is despite the consensus that all various forms of energy consumption exhibited clear linkages to economic growth in most studies.

Applying the ARDL procedure involves the following steps before the final estimation of the model is undertaken. First, a unit root test is carried out using an augmented Dickey Fuller test, among others, to ensure that the variables are stationary; it has to be noted that pre-testing is not necessary if the bounds test is to be carried out but ensuring that all the variables are integrated of order one or zero is important; second, a co-integration test is performed using unrestricted vector autoregressive approach to ensure that (a) there indeed is a long-run relationship among the variables and (b) to determine the order of integration or there is only one unique long-run relationship among the variables; and, third, the ARDL bounds test is carried out to test if it passes the F-test criteria indicting that there indeed is long-run relationship among the variables that are either I(0), I(1) or that are mutually co-integrated.

Accordingly, the results of the stationarity test is reported in Appendix 1. All the variables of interest are I(1) suggesting that they only become stationary after first differencing. As reported none of the variables are stationary in levels even at 10% while all the variables are stationary at 1% after differencing once. It is important to note that as Baek and Koo (2009, p.6) noted, "the robust results for the ARDL model typically rely on the two assumptions of erogeneity of explanatory variables and the existence of a unique long-run relationship among the variables". That is, this is ensured if the explanatory variables are exogenous and there is a co-integration among the variables. This is important because in the absence of these two conditions we cannot guarantee the existence of a unique equilibrium relationship between GDP growth and the explanatory variables of interest. After testing the general properties of the variables, a co-integration test is also carried out to that effect (reported in Appendix 2). Both the Trace and Eigenvalue statistics indicate that not only are the independent variables and GDP co-integrated but there is one unique co-integration. The data used in the study is mainly compiled from World Development Indicators (2013).The data series used was mainly chosen for its consistency among the variables and across the countries selected.

5. Data, Estimation Results and Conclusions

5.1. Estimation

To strengthen the absence of spurious regression and exploit the long-run and short-run effects a bounds test is carried out to check whether it passes the F-test. As many authors demonstrated, the use of a bounds test is justified for a variety of reasons. As, for instance Akkoyunlu et al (2010, p.2), noted, "first the bounds testing approach has broad applicability since the repressors can be of different and/or mixed order of integration, e.g. the variables can be ether integrated of order one (technically I(1), of order zero [I(0)], or mutually co-integrated. This is a great advantage since the unit root tests regarding the order of integration of the relevant variables yield inconclusive results….Second, the procedure is based on the unrestricted error correction model, which permits joint estimation of long and short-run effects. …Joint estimation has better statistical properties than the two step Engel-Granger procedure that pushes the short-run dynamics into the error term. Third, the bounds testing procedure performs rather well in small samples…..In small samples, application of the more popular Full Information Maximum Likelihood method (Johansen,1995) is problematic".

In line with the above justifications, equation (2) is estimated to check whether the variables are co-integrated or not by testing the hypothesis that $\lambda_1 = \lambda_2 = \lambda_3 = 0$.In the bounds testing, the F-statics is then compared with the tabulated critical values (as tabulated by Pesaran et al, 2001). Further Narayan (2005) noted that critical values tabulated by Pesaran et al. (2001) are inappropriate for small samples, like ours. He instead suggested an alternative tabulation that takes the sample size into account while the decision procedures remain the same. That is, if the estimated F-statistics is below the lower value of the critical values, we cannot reject the hypothesis of no co-integration between the variables. But if the computed value is greater than the upper bound of the critical value we reject the hypothesis of no co-integration between the variables of interest. Pesaran et al (2001) noted a case in which the estimated value falls between the lower value (I(0)) and upper value (I(1)). In that case the outcome is inconclusive.

The bounds testing (combining the short-run and long-run) is presented in Equation (2), below:

$$\Delta \log(GDP_t) = \alpha_0 + \sum_{i=1}^{n} \beta_1 \Delta \log(GDP_{t-1}) + \sum_{i=1}^{n} \beta_2 \Delta \log(K_{t-1}) + \sum_{i=1}^{n} \beta_3 \Delta \log(L_{t-1})$$

$$+ \sum_{i=1}^{n} \beta_4 \Delta \log(E_{t-1}) + \beta_7 ECM_{t-1} + \lambda_1 \log(GDP_{t-1} + \lambda_2 \log(K_{t-1}) + \lambda_3 \log(L_{t-1}) + \lambda_4 \log(E_{t-1}) + . + \varepsilon_t \text{............(2)}$$

As noted in Appendix 3, the computed F-values for both Kenya and Sudan exceed the upper critical values tabulated by both Pesaran et al. (2001, p. 300), Table CI (iii), and Narayan (2005, p. 1988). It is of interest to note that the estimated values exceed, particularly, the critical values tabulated by Narayan (2005, p. 1988) for a sample size of 35 and 3 repressors. This suggests that there indeed is a co-integration between the variables included in equation (2).

5.2. Estimation Results

The next step is to estimate the co-integration model and infer the long-run and short-run elasticities. To do that either Canonical Co-integrating Regression (CCR), Fully-Modified OLS (FMDOLS) or Dynamic OLS (DOLS) will be employed. This is because these techniques seem to be more appropriate in the case of short samples. More specifically, among these candidates, the study used a FMOLS as the results are more robust. The estimated long-run models is reported below.

Table 2A: Long-Run Growth Model for Kenya

Dependent Variable: LOG(KENGDP)

Method: Fully Modified Least Squares (FMOLS)

Included observations: 37 after adjustments

Cointegrating equation deterministic: C

Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth =4.000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(K_KEN(-1))	0.075808	0.014506	5.225918	0.0000
LOG(L_KEN(-1))	0.082070	0.029713	2.762079	0.0093
LOG(E_KEN(-1))	0.698461	0.010320	67.68300	0.0000
C	8.935898	0.427139	20.92034	0.0000
R-squared	0.996505	Mean dependent var		27.35566
Adjusted R-squared	0.996187	S.D. dependent var		0.370442
S.E. of regression	0.022875	Sum squared resid		0.017268
Long-run variance	0.000461			

Table 2B: Long-Run Growth Model for Sudan

Dependent Variable: LOG(SDNGDPT)

Method: Fully Modified Least Squares (FMOLS)

Sample (adjusted): 1973 2009

Included observations: 37 after adjustments

Cointegrating equation deterministics: C

Long-run covariance estimate (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(K_SDN(-1))	0.169371	0.021435	7.901520	0.0000
LOG(L_SDN(-1))	-0.191056	0.075411	-2.533517	0.0162
LOG(E_SDN(-1))	0.566072	0.038898	14.55261	0.0000
C	10.72204	1.047550	10.23535	0.0000
R-squared	0.984457	Mean dependent var		23.04427
Adjusted R-squared	0.983044	S.D. dependent var		0.477186
S.E. of regression	0.062138	Sum squared resid		0.127415
Long-run variance	0.004289			

As could be seen in Tables 2A and 2B, the coefficients for both Kenya and Sudan are robust viewed in terms of their basic attributes. That is, even though the appropriate diagnostic tests will be reported later, all have the expected signs (except the labor force in Sudan), a reasonably high coefficient of variation, high T-statistics and acceptable coefficients. To emphasize just the last point, the direct impact of a unit change in energy consumption will lead to about 0.7% growth in GDP in Kenya and about 0.6% in Sudan. (note that since they are in logs they could be directly interpreted as elasticities).

And the short-run impacts are reported in Tables 3A and 3B, for Kenya and Sudan, respectively. Here again except the negative coefficient of the labor force in both countries (which is not consistent with theory), all the attributes of the models are reasonable. In particular, in addition to the basic attributes, the adjustment coefficient is also of the right sign and with an acceptable feedback process. About 50% and 40% of any deviation is corrected within a year in Kenya and Sudan, respectively. The perverse sign of the labor force variable warrants some comment. It is possible that this might be either due to the poor labor force data that is used (owing to unavailability of well-structured data series) or due to less scarce and unskilled nature of the labor force in both countries as is the case in similar economies. If the latter is the case it might be suggesting the well-known surplus labor hypothesis in the face of limited capital inputs..

Table 3A: Short-Run Growth Model for Kenya

Dependent Variable: D(LOG(KENGDPT))

Method: Least Squares

Sample (adjusted): 1973 2009

Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.017591	0.005468	3.217270	0.0030
D(LOG(K_KEN(-1)))	0.062257	0.019037	3.270258	0.0026
D(LOG(L_KEN(-1)))	0.014169	0.034965	0.405245	0.6880
D(LOG(E_KEN(-1)))	0.345046	0.093332	3.696974	0.0008
KEN_ECM(-1)	-0.558863	0.153771	-3.634377	0.0010

R-squared	0.488413	Mean dependent var	0.036377
Adjusted R-squared	0.424464	S.D. dependent var	0.023686
S.E. of regression	0.017969	Akaike info criterion	-5.075215
Sum squared resid	0.010333	Schwarz criterion	-4.857524
Log likelihood	98.89149	Hannan-Quinn criter.	-4.998469
F-statistic	7.637599	Durbin-Watson stat	1.556033
Prob(F-statistic)	0.000194		

Table 3B: Short-Run Growth Model for Sudan

Dependent Variable: D(LOG(SDNGDPT))

Method: Least Squares

Sample (adjusted): 1973 2009

Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOG(K_SDN(-1)))	0.206967	0.026376	7.846783	0.0000
D(LOG(L_SDN(-1)))	-0.053742	0.066524	-0.807850	0.4250
D(LOG(E_SDN(-1)))	0.255394	0.050593	5.047960	0.0000
SDN_ECM(-1)	-0.435202	0.113790	-3.824609	0.0006

R-squared	0.555075	Mean dependent var	0.048746
Adjusted R-squared	0.514627	S.D. dependent var	0.055066
S.E. of regression	0.038364	Akaike info criterion	-3.581591
Sum squared resid	0.048569	Schwarz criterion	-3.407438
Log likelihood	70.25944	Hannan-Quinn criter.	-3.520194
Durbin-Watson stat	1.715417		

5.3. Estimation Result

Further, the result seems to support the hypothesis that energy consumption is an input to economic growth as a complement to the conventional factors of production;

Accordingly, the direct impact of a unit increase in hydroelectric consumption on the GDP growth of Kenya and Sudan in the long-run is about 0.7% and about 0.6%, respectively. Similarly, its contribution is less in the short-run than in the long run but it is still likely to boost growth by about 0.34 and 0.24 per cent, respectively.

Impact of a change in Energy consumption on GDP growth	Country	Short Run		Long-Run	
		1%	10%	1%	10%
	Kenya	0.34	3.4	0.7	6.9
	Sudan	0.24	2.5	0.6	5.5

We can roughly translate the above results in term of unemployment reduction or new jobs created. Using law as a rule of thumb. In Kenya a 1% increase in GDP will decrease unemployment by 0.17 percentage points or generate employment for about 2.9 million people in the short-run. But in the long-run it will decrease unemployment by 0.35 percentage points or create employment for about 6.1 million additional workers.

Similarly in Sudan, a 1% increase in GDP will decrease unemployed by 0.12 percentage points or increase employment for 1.4 million People in the short-run or decrease unemployment by 0.30 percentage points or generate additional employmentfor about 3.6 million people in the long-run.

5.4. Conclusion and Implications

The objective of the study has been to (a) examine the impact of hydropower consumption on economic growth in the Kenya and Sudan, as a case study; and (b) infer how likely it is to generate further cooperation among countries involved if and when such mutual benefits pave the way for further collaboration in other sectors in general and infrastructure in particular.

This is based on the rationale that such mutual benefits generate an incentive compatible engagements that will have the potential for countries to sustain the momentum than simple trade in goods and services.

Therefore, the main direct impact and inference that could be drawn from this study are:

a. The direct impact of collaboration in exchange of power grids from Ethiopia on both the Kenyan and Sudanese economies is appreciable;

b. Other things being equal, all countries have an incentive to continue with such collaboration;

c. Based on this experience they ae likely to explore other areas in which they could collaborate and work towards balancing their intra-country transactions, when possible; and

d. Such exchanges lock-in the collaboration between countries which is likely to pave the way for stronger intra-regional trade and ultimately regional integration.

All trade theories suggest that the basis for sustained trade linkages among countries is gains from trade transactions as has been the motive or intention for countries to sign several agreements including intra-regional trade. Hence mutual gains from infrastructure linkages such hydroelectric power will be expected to both boost further linkages in other economic activities and ultimately strengthen regional integration. This is because once countries lock-in such benefits they have an incentive to further collaborate since their benefits become interdependent on each other.

The crucial message is therefore, energy consumption significantly contributes to GDP growth, but most importantly, infrastructure collaboration is not only essential for economic performance but also a catalyst and probably the best avenue for future regional and ultimately continental integration.

References

Ageel, A. (2001) 'The Relationship between Energy Consumption and Economic Growth in Pakistan', *Asia-Pacific Development', Journal,* 8 (2): 201-110.

Ethiopian Electric Power Corporation. (2012).*Strategic Plan Summary*. Vil. 13, September. Granger, C.W.J. (1988) 'Some Recent Developments in Concept of Causality', *Journal of Econometrics.* 39: 199-211.

___________________ (1969), 'Investigating causal Relations by Econometrics Models and Cross Spectral Method', *Econometrica*,.37:.424-438.

Hwang, Dennis-B.-K., Gun-Burel (1991), 'The Causal Relationship between Energy and GNP: the Case of Taiwan Province of China'. *Journal of energy and Developmen,* 16: 219-26.

Kraft, J. and A. Kraft (1978), 'On the relationship between energy and GNP', *Journal of energy and Development*, 3: 401-403.

Lee, C. C. (2005), '*Energy Consumption and GDP in Developing Countries: A Co-integrated Panel Analysis', Energy Economics,* 27: 415-427.

Melike, B. (2012) 'Economic Growth and Electricity Consumption in Africa and Asia: MS-VAR and MS-Granger Causality Analysis', http://mpra.ub.uni-muenchen.de/40515, MPRA Paper NO. 401515, August.

Menyah, Kojo and Yemane W. (2010), ' Energy Consumption, Pollutant and Economic Growth in South Africa', *Energy Economics.* 32: 1374-1382.

Ministry of Finance and Economic Development (MoFED) (2010), '*Growth and Transformation Plan (GTP)* Document: 2010/11 – 2014/15**.**

Narayan, P.K. (2005) 'The Saving and Investment Nexus for China: Evidence for Cointegration Tests', *Applied Economics*, 37: 1979-1990.

Narayan, P.K. and Smyth R. (2005), 'Electric consumption, employment and Real Income in Australia: Evidence from Multivariate granger causality Tests', ***Energy Policy.*** 33:109-16.

Odhiambo, N.M. (2009), 'Electricity consumption and economic Growth in South Africa: A Trivariate Causality Test', *.Energy Economics*, 37: 617-622.

Pesaran, H., Shin and R. Smith (2001), 'Bounds Testing Approaches to the Analysis of Level Relationships', *Journal of applied Econometrics*, 16: 289-326.

Raiz, T. (1984), 'Energy Consumption and Economic Growth', *.Pakistan Development Review*, 23: 431-53.

Ratnasiri, H. P. G. S. (2007), 'The Main Determinants of Inflation in Sri Lanka: A VAR based Analysis'. Central Bank of Sri Lanka Staff Studies. 39 no. 1 & 2.

Shahbaz, Muhammad (2009), 'On Nominal and Real Devaluations Relations: An Econometric Evidence from Pakistan', *International Journal of applied econometrics an Quantitative Studies*, 9 (1): 85-108.

United Nations Economic Commission for Africa (UNECA) (2014), '*Energy Access and Security in Eastern Africa: Status and Enhancement Pathways'.*

Wolde-Rufael, Y. W. (2005), "Energy Demand and Economic Growth: The African experience', *Journal of Policy Modelling*, 27: 891-903.

Wolde-Rufael, Y. W. (2006), 'Electricity consumption and economic Growth: A time Series Experience for 17 African Countries', *Energy Policy*, 34: 1106-14.

Appendix

Appendix 1:Unit Root Test of Variables for both Kenya and Sudan

Variable	Critical values1% -3.632905% -2.9484 10% -2.612874					
	In levels		**1st difference**		**Decision**	
	Kenya	Sudan	Kenya	Sudan	Kenya	Sudan
Ln(GDP)	-0.56314	1.741124	-5.595522	-6.505001	I(1)	I(1)
Ln(K)	-0.153653	0.053718	-6.372762	-4.51399	I(1)	I(1)
Ln(L)	-1.734593	-1.61906	-6.262658	-5.983452	I(1)	I(1)
Ln(E)	-2.511568	0.477184	-5.527502	-5.11883	I(1)	I(1)

Appendix 2: Unrestricted Co-integration Rank Test Trace

Country	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Kenya: None * At most 1 At most 2	0.908658 0.601790 0.223885	65.28676 22.21019 5.636212	40.17493 24.27596 12.32090	0.0000 0.0891 0.4817
Sudan: None * At most 1 At most 2	0.618812 0.460830 0.284687	61.56902 32.63514 14.10339	54.07904 35.19275 20.26184	0.0093 0.0920 0.2824
Unrestricted Co-integration Rank Test Eigenvalues				
Kenya: None * At most 1 At most 2	0.908658 0.601790 0.223885	43.07657 16.57398 4.562192	24.15921 17.79730 11.22480	0.0001 0.0756 0.5411
Sudan: None * At most 1 At most 2	0.618812 0.460830 0.284687	28.93388 18.53175 10.05107	28.58808 22.29962 15.89210	0.0452 0.1548 0.3297

Trace & Max-eigenvalue tests indicates 1 cointegratingeqn(s) at the 0.05 level
*** denotes rejection of the hypothesis at the 0.05 level**
****MacKinnon-Haug-Michelis (1999) p-values**

Appedix3: Bounds Test for Co- integration Analysis

Statistics	F-Value	Comment
Computed F-statistics:	Kenya: 6.076409 Sudan: 5.124760	For 35 observations and 3regressors
Critical F-statistics at 5% (based on Narayan 2005	upper: 4.530	For 3regressors
Critical F-statistics at 5% (based on Pesaran et al -2001)	upper: 3.22	For 3regressors

Note**:**In both casesCritical Values are for unrestricted intercept and no trend, Narayan (2005, p. 1988) for 35 observations and Pesaran et al. (2001, p. 300), Table CI (iii), Case 111.

Appendix 4:Diagnostic Tests for the Short Run Model

Diagnostic tests	**A: Test statistics**	**B:Critical Value**	**Dicision Rule**	**Conclusion**
LM Test; serial correlation **Ho: No serial correlation**	**0.089**	0.1232	Reject H0 if A>B	Cannot reject the null hypothesis
	Sudan: 0.6563	0.7116	Reject H0 if A>B	Cannot reject the null hypothesis
Ramsey Reset Test H0: Model is correctly specified	**Kenya:** 0.80944	1.945	Reject H0 if A>B	Cannot reject the null hypothesis
	Sudan: 1.2675	3.00	Reject H0 if A>B	Cannot reject the null hypothesis
ARCH Heteroskedasticity H0: Homoskedasticity	**Kenya:** 0.0892	0.0941	Reject H0 if A>B	Cannot reject the null hypothesis
	Sudn: 0.729	0.738	Reject H0 if A>B	Cannot reject the null hypothesis
White Heteroskedasticity H0: Homoskedasticity	**Kenya:0.180** **Sudan**:0.640	0.195 0.750	Reject H0 if A>B	Cannot reject the null hypothesis

Recent Papers in Series

Working paper no.	Year	Author	Title
15/2	May 2015	Fredu Nega (PhD) and Edris Hussein (MsC)	Effects of Regional Trade Agreements on Strategic Agricultural Trade in Africa and Its Implications to Food Security: Evidence from Gravity Model Estimation
14/3	December 2014	Haile Kibret (PhD) and Edris Hussein (M.Sc)	Is the Ethiopian Birr Overvalued? A Sober Assessment
14/2	July 2014	Gashaw Tsegaye (MSc)	Microfinance Institutions in Ethiopia, Kenya, and Uganda
14/1	May 2014	Fredu Nega (Ph.D)	Composition of Growth and Alleviation of Income Poverty and Child Undernutrition in Sub-Saharan Africa
13/3	December 2013	Edris. H. Seid (M.Sc)	Regional Integration Trade in Africa: Augmented Gravity Model Approach
13/2	August 2013	Ali I. Abdi (Ph.D) and Edris H. Seid (M.Sc)	Assessment of Economic Integration in IGAD
13/1	March 2013	Ali I. Abdi (Ph.D) and Emerta A.Aragie (M.Sc)	Financial Sector Development in the IGAD Region
12/3	December 2012	Ali I. Abdi (Ph.D) and Emerta A.Aragie (M.Sc)	Economic Growth in the Horn of Africa: Identifying Principal Drivers and Determinants
10/3	May 2011	Ali I. Abdi (Ph.D) and Emerta A.Aragie (M.Sc)	Access to Finance in Africa and the Role of Development Banks