East African Journal of Social and Applied Sciences (EAJ-SAS)
Vol.3, No.1 Publication Date: May. 20, 2021
ISSN: (Online) 2714-2051, (Print) 0856-9681
The current issue and full text archive of this journal is available at: http//www.mocu.ac.tz

Cite this article as: Katobesi, J. K (2021). The Effect of Electrification on Total Factor Productivity (TFP) in Africa, *East African Journal of Social and Applied Sciences,* 3(1), 21-33.

THE EFFECT OF ELECTRIFICATION ON TOTAL FACTOR PRODUCTIVITY (TFP) IN AFRICA

Joseph Kulwa Katobesi
Department of Economics and Statistics
Moshi Co-operative University - Tanzania
Emails: katobesi02@gmail.com

ABSTRACT
Various studies that began around 1950s indicate positive impacts of electrification on productivity during the early stage of economic development. Nonetheless, there is no well-established relationship between electrification and productivity for the matured or world developed economy. Thus, because Africa is in the stage of economic development, this research aims to examine at whether electrification has a positive impact on productivity growth. The study examines the impact of electrification on Total Factor Productivity growth in Africa for the period between 2000-2010. Methodologically quantitative research approach was adopted then, documentary review was used where simple Cobb-Douglas approach and regression analysis was used to analyse relevant documents for this study. In Cobb-Douglas approach, the study estimated differences in Total Factor Productivity (TFP) across countries and in the regression analysis that encompasses Pooled Ordinary Least Square (OLS), Fixed and Random Effect, the study analysed the impact of electrification on productivity growth and level. The results of the fixed effect model show the evidence in favour of the Schurr's hypothesis that, electrification has a positive impact on productivity growth in Africa. But, the evidence on productivity level is found when energy-related variables are excluded from the model which provides support for the argument that more electricity-intense production method increase productivity. The study therefore, recommends that in Africa, policy makers should put more emphasis in electricity-intense production, in order to cope with the industrial electricity demand arising from increased productivity.

Keywords*: African Countries, Electrification, Total Factor Productivity, Industry, developing economy.*
Paper type*: Research paper*
Type of Review: *Peer Review*

1. INTRODUCTION

In the early 20th C, Schurr (1960) hypotheses that, electrification of industries in the United State contributes significantly on labour and productivity growth. The theory was further applied in various studies include Berndt (1983), Devine (1983) and Jorgenson (1984). These studies involved Schurr's hypothesis to examine at whether electrification has significant impacts on productivity growth via technical progress. The study reflects the association between electricity and adoption of new capital equipment and machinery driven using this new form of energy. Thus, substantial impacts on electrification experienced during that early stage of economic development induced the productivity growth in the U.S. manufacturing industries. Nevertheless, there is no well-established relationship between electrification and productivity growth for the developed economy. Completed recently research study reveals that, the impact of electrification is less effective on productivity growth for the developed economy[1]. Thus, this brings a notion that, the theoretical nexus between electrification and productivity growth is mainly applicable to the emerging or developing economy. Then what is the effect of electrification on productivity growth for the emerging or developing economy? In fact, all these above induce the study to test whether electrification is applicable to economies at the early stage of economic development.

The study chose Africa as the objective to examine whether electrification has a positive impact on productivity growth based on areas on that, Africa is in the stage of economic development, thus, analysing the impact of electrification could provide awareness about the more electricity-intense production methods to induce the growth performance. In fact, little studies have done to verify the impacts of electrification on productivity growth in Africa. To summarize the empirical analysis of this study, the researcher, first, began by estimating the TFP from human capital-augmented Cobb-Douglas production. Secondly, following the Berndt, (1983) empirical study on electrification and productivity growth, the study calculated electrification "$Elec_{it}$" as the proportion of total energy consumption (donated by Energy) taken the terms of total electricity consumption (donated by Electric) i.e. ,$Elec_{it}$ = Electric/Energy. Thirdly, the estimated TFP was regressed onto a measure of electrification and other control variable. The regression analysis encompasses pooled OLS, fixed and random effect models. Thus, the fixed effect model yields the evidence in favour of the Schurr's hypothesis that electrification has a significant positive impact on productivity growth in Africa.

This study is organised as follows: Section 2 reviews existing literature regarding the impact of electrification on productivity growth, section 3 discusses the theoretical nexus between electrification and productivity in Africa, section 4 discusses the methodology adopted and presents the results and section 5 is the summary and concluding remarks.

2. LITERATURE REVIEW

Historical investigations of the relationship between electrification and productivity in the U.S. economy have primarily been focused on the breakthrough period of the electrical motor from the 1890s to the 1920s. For example, Devine (1983) in his work on "From shafts to wires: Historical perspectives of electrification" has clearly explained the productivity effects that arose from the electrification of industry, when steam and water powered prime movers were eliminated by electric motors that first drove groups of machines and later individual machines. The study demonstrates that, the uses of electric motors did not only reduce costs in productivity systems but also improvements in electric energy productivity, as well as labor and capital productivity. In addition, the electric motors had effects on electric light which improved the working conditions. Thus, the study shows the new electric power technology in the early 20th century played an important role in the substantial U.S. industries productivity growth.

However, Berndt (1983) in his calculations indicates that, the effect of electrification on multifactor productivity growth for the period 1958-1977 was small. This implies that, electrification is less effective for the matured or developed economy. Berndt argues that, effect of electrification on productivity growth depends critically on whether technical change is energy using, saving or neutral. Thus, when

[1] Berndt, Ernst R. (1983): "Electrification, Energy Quality and Productivity Growth in U.S. Manufacturing" working Paper, 1421-83

technical change is energy-neutral increases in energy quality have no effect on multifactor productivity growth. In his calculations, Berndt assumed that: Firstly, no further relative electrification took place after 1958, i.e., the ratio of electricity per energy remained constant. Secondly, the absolute level of electricity remained constant while energy increased. And the results revealed small impact of electrification on multifactor productivity growth.

Schurr (1985) in his work of "Productive efficiency and energy use" demonstrates the long-term trends relationships between energy use and the overall productive efficiency of the American economy. He discovered that, the distinct acceleration of the productivity growth in the American economy that began after the First World War was due to the rapid growth in the use of electrified unit drive in the manufacturing industries. His argument was that, innovative energy using technologies were the sole cause of rapid improvements in overall productive efficiency. He said that "The quality of particular energy forms (i.e., electricity) played a critical part in improving the overall efficiency of production". However, the study revealed that, the substantial improvement in energy efficiency since 1973 has been accompanied by a marked slowdown in productivity growth and even actual productivity declines.

David (1990) in his work associated the productivity increase in the first decades of the 20th century with a delayed effect of the introduction of the electric dynamo in the 1880s. David argues that, the transformation of industrial processes by new electric power technology was a long-delayed and far from automatic business. Thus, the factory electrification did not reach full fruition of its technical development nor have an impact on productivity growth in manufacturing before the early 1920s. But, in the early 20th century outward, more than half of factory mechanical drive capacity had been electrified. Thus, the U.S. manufacturing industries experienced the substantial productivity growth.

Furthermore, Berndt (1990) in his work demonstrated that, converting solid fuels in electricity form implies that the average quality of aggregate energy has improved. The adoption of the new equipments and knowledge in the manufacturing industries depend critically on the rate of diffusion. Thus, using the new technical equipments and knowledge for electricity production will improve the productivity growth in Africa where countries are passing through the early stage of economic development. For example, Treichel (2005) in his work on "Tanzania's growth process and success in reducing poverty" suggests that, improving the operations of electricity may further increase the momentum for the productivity growth in Tanzania.

On the other hand, the effects of changing energy prices and energy availability on economic growth and productivity have been the focus of much recent research. Jorgenson (1981) in his work on "Relative prices and Technical change" analysed the character of technical change in a wide range of industries covering the whole of the U.S. economy. He discovered that, in most U.S. industries for the period between1953-1974, technical change has been energy-using, which implies that energy price increases reduce the rate of multifactor productivity growth, ceteris paribus.

Jorgenson developed further study in 1984 on "The role of energy in productivity growth." He examined the role of electrification and the utilization of nonelectrical energy in productivity growth. The study indicates that: - Firstly, an improvement in the productivity growth is stimulated by a decrease in price of electricity. Secondly, an improvement of productivity growth in the wider range of industries is strongly influenced by the greater utilization of nonelectrical energy. However, the study demonstrates that, oil shocks in the mid-1970and 1979s increased the real energy prices that resulted in the substitution of capital, labour, and materials inputs for inputs of electricity and nonelectrical energy, thereby reducing energy intensity of production.

Furthermore, Classical economists did not recognize energy as a factor of production in the production process and neither did the Neoclassical. However, today, economists like Shahid, (2006) found out in his work on "Economic growth with energy" that not only does energy serve as a factor of production; it also acts as a booster to growth of a nation. Many economists agree that there is a strong correlation between electricity use and economic development. Morimoto, R., and Hope, (2001) have discovered, using Pearson correlation coefficient, that the economic growth and energy consumption in Sri Lanka are highly correlated. Shahid (2006) agrees that there is a departure from the neoclassical economics which include only capital, labour and technology as factors of production to one which now includes energy as a factor of production. He went further to say that energy drives the work that converts raw materials into finished products in the manufacturing process. Kanti *et al*., (2020) cited that, inadequacy of the essential infrastructure such as electricity can limit provision of healthcare service.

Some research studies revealed the causal relation between electricity and economic growth in Africa. For example, Wolde (2006) examined the relationship between electricity consumption and economic growth in 17 African countries. The results of the study show that, 9 countries out of 17 had a positive relationship between electricity and real Gross Domestic Product per capita. Also, Odhiambo, N. (2009) in his work on "Electricity consumption and economic growth in South Africa" found the bidirectional causality between electricity consumption and economic growth. The results implied that country is entirely dependent on electricity for its economic growth in South Africa. He recommended that, electricity infrastructures should be expanded in order to cope with the increasing demand exerted by the country's strong economic growth and rapid industrialization programme.

Moreover, Jumbe (2004) examined the relationship between electricity consumption and economic growth in Malawi for the period 1970-1999. The findings of the study indicate that, a country is not entirely dependent on electricity for its economic growth in the short run but highly dependent in the long run. It is estimated that, about 1% permanent rise in the GDP in Malawi would cause a 0.25 percent permanent growth in the electricity consumption in the long run.
Recent studies have shown the causal relationship between electricity supply and economic growth. For instant, Shafique *et al.,* (2021) revealed that electricity productions play a significant role in Pakistan's economic growth.

Additionally, Dalia (2018) stated that, a higher level of electricity generation needed for achieving high and sustainable economic growth is vital. The higher electricity generation can be provided through investing in clean technologies and renewable energy resources, such as wind and solar energy. Marius *et al.,* (2018) recommended to policy makers that, the Government should aim at increasing energy efficiency and promoting the production and consumption of green energy. In Tanzania Context electric power supply has been monopolised to one company namely Tanzania Electric Supply Company (TANESCO) which acts as shield electricity consumers from higher tariffs hence low productivity (Magema 2020). Jamiu A. and Husam R. (2020) showed a long-run relationship from economic growth, energy consumption, and CO2 emissions to urbanization. The study suggests that the policymakers in Mexico, Indonesia, Nigeria, and Turkey countries should develop an energy conservation policy that will enhance the potential growth of their economy. Raynold R. and Syden M. (2020) examined the causal relationship between electric power consumption, energy consumption and economic growth in Zimbabwe during the period 1970-2014. The findings indicate that electric power consumption has impact on economic growth while energy consumption was found to have no impact on economic growth.

Generally, the interrelation between electrification and productivity growth is not clearly identified in the African studies. Studies did not examine the impact of electrification on productivity instead the correlations presence between electricity consumption and productivity growth. The study has seen how Schurr (1960) identified the impact of electrification on productivity when he associated the productivity growth with innovative energy using technologies. The quality-electricity played a critical part in improving the overall efficiency of production in the U.S. manufacturing industries in the early 20th century. This paper, therefore clearly analysed the impact of electrification on productivity growth in Africa. In the next session, a brief picture on the theoretical nexus between electrification and productivity in Africa was given.

3. THEORETICAL NEXUS BETWEEN ELECTRIFICATION AND PRODUCTIVITY IN AFRICA: HISTORICAL PERSPECTIVE

Electrification is defined as the proportion of total energy consumption taken in terms of electricity consumption (Berndt, 1983). It is an indispensable component of any effort to improve electricity productivity. As discussed in the previous sections that, when technical change is energy-using, increase in energy quality (electrification) improves productivity growth. Also, swathe study revealed that, economic development of the African countries depends critically on the quality-electricity production. Thus, an improvement in the productivity growth is induced by a decrease in price of electricity and quality-electricity production. Nevertheless, empirical studies demonstrate that, poor-quality of electricity and high electricity costs have been the factors hindering the growth performance in the African countries. Karekezi and Kimani, (2002) identified some of the challenges that have been facing electricity power sector in Africa include: -costly small-scale power systems that lead to higher transmission and distribution costs, unreliable power supply, low-capacity utilization and availability factor, deficient maintenance and poor procurement of the spare parts among other problems. Thus, due to the mentioned challenges above, energy resources that are well endowed in Africa are grossly underutilized (Iwayemi, 1998).

Escribano *et al.*, (2010) in his work on the impact of infrastructure quality on firm productivity in Africa shows how poor quality-electricity has been affecting the productivity growth in Africa. The study indicates that, poor-quality electricity provision is not only affecting the productivity growth of the poor countries but also some of the growing faster countries such as Botswana, Namibia and Swaziland. Thus, electricity is considered as a severe or an obstacle in the firm's productivity growth. Some other factors that are identified as the sources of poor-quality electricity production include: - Firstly, a geographical constraint where electricity is mainly generated through hydroelectric power stations, availability and reliability of power is highly dependent on weather conditions. Thus, during periods of poor rainfall or heavy flooding, power shortages and disruptions can be a frequent occurrence. Secondly, non-renewable energy-based power inception which is the most expensive means for making electricity could be exacerbated by increase in fuel price. Moreover, the poor performance of electricity companies in Africa is further linked to various factors, including political interference in utility policy, higher investment costs and lower profitability of extending service to rural areas, corruption and less domestic funds available to dedicate to electrification efforts (Raluca & Douglas, 2013; Onyeji *et al*., 2012).

However, the significant impacts of electrification on productivity have been noted in some countries. Recently completed study in Africa shows that, electrification has extended business hours, community meetings and social activities that have improved the quality of life and the productivity in Tanzania (Kooijman, 2010). Before electrification, businesses were closed early and if necessary, they were forced to use candles or kerosene lamps for lighting as the results many enterprises such as welding stopped operating. In fact, the usage of electrical lighting is cheaper than traditional lighting sources and delivers a much better lighting quality. That, in turn, might contribute to extended working hours, more customers or higher quality products. All these effects lead directly or indirectly to higher productivity in the sense that less input is needed to produce the same output. Thus, this increased productivity might either lead to higher profits for the firm owner or higher incomes for workers.

Moreover, Fedderke, (2006) in his work on "Infrastructure and growth in South Africa" show that, electricity generation is positively related to labour productivity and productivity growth. The findings of the study reveal that, for the measure of electrical power generation, 1% increase in quality-electricity infrastructure measure is associated with an increase of approximately 0.04 percentage points of productivity growth. Meaning that, improvements of quality-electricity would not only reduce transmission and distribution costs but also improvements of productivity growth in South Africa. Odhiambo (2009) in his study suggested that, electrification in South Africa should be improved in the Manufacturing industries to improve productivity growth.

In addition, the overall effect of electricity on productivity varies across countries. Um *et al.*, (2013) in his work on "Infrastructure and Economic Growth in the Middle East and North Africa Policy" reveals that, countries that have invested significantly larger amount in energy infrastructure than most developing countries (possibly as a result of abundant oil resources or as a result of below cost tariffs of electricity) have a significant impact on the productivity growth. The findings of the study indicate that, the Middle East and North Africa have positive impacts on the productivity growth but lower returns. Thus, lower return implies to the higher levels of investment and the subsequent diminishing returns effect, as well as lack of institutional and pro-market reforms in the key countries. Generally, a look at the electrical power industry in Africa reveals a number of trends in common to the most African countries. Thus, this paper provides a way forward to the African energy-policymakers on how to improve efficient electricity generation.

4. RESEARCH METHODOLOGY

The study adopted quantitative research approach that attempts to collect quantifiable information through Documentary review for statistical analysis of the data on energy. Data on energy were obtained from the International Energy Agency 2011. The agency provides various energy-related data. Electricity data was available from 1992 to recent years for some African countries (approximately one third of the full sample), but it is only available from the year 2000 for most African countries. This research included many countries at cost of sample periods for some reasons. First, most of the countries for which longer time span of data is available belong to the upper-income class in Africa area. This may raise a problem of sample selection bias. As discussed in the previous sections, the theoretical nexus between electrification and productivity is mainly applicable to the early stage of economic development. For the matured or developed economy, in fact, there is no well-established relationship between electrification and productivity. Thus, selecting the sample based on the data availability over longer periods is highly likely to distort the estimation results in a serious way. Second, many African countries have experienced political turmoil by which the economies might experience structural break. Thus, including data of longer time period may cause incorrect estimates. Finally, cross-country variation is more important than time variation in the current regression as the TFP growth is not very variable over time. Thus, the study put priority on ensuring cross-sectional sample units. As a result of such considerations on the sample selection, the data set includes 49 countries and covers periods from 2000 to 2010.

1.1 Estimation of the Total Factor Productivity (TFP)

The study relies on simple Cobb-Douglas approach and regression analysis where the TFP was used as a measure of productivity. The TFP of a country i at time t was estimated from Cobb-Douglas production function as shown in equation 1.

$$Y_{it} = K_{it}^{\alpha}(A_{it}H_{it})^{1-\alpha} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where K_{it} denotes the stock of physical capital and H_{it}represent the amount of human capital-augmented labor. $A_{it}$is a labor-augmenting measure of productivity, that is, total factor productivity. It is assumed that human capital-augmented labor is produced as follows:

$$H_{it} = \exp[\phi(E_{it})]\, L_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

whereE_{it} denotes years of schooling and L_{it} is labor input. In this specification of production function of human capital, the derivative $\phi^{'}(E_{it})$ is interpreted as the rates of return to schooling. the production function is written in terms of output per worker, $y_{it} \equiv Y_{it}/L_{it}$.

$$y_{it} = \left(\frac{K_{it}}{Y_{it}}\right)^{\alpha/(1-\alpha)} h_{it}A_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where$h_{it} \equiv H_{it}/L_{it}$ is human capital per worker. Then, TFP is calculated as residual.

Data used to construct TFP is obtained from PWT (Penn World Table) 7.1 and schooling data is obtained from Barro-Lee's educational data set. Unfortunately, the PWT does not provide data of physical stocks. Following Hall and Jones (1999), assigned 1/3 to physical capital share α. The rates of return to human capital are assigned following Psacharopoulos (1994) and Hall and Jones (1999): 13.4 % for the first four education, 10.1% for the next four years, and 6.8 percent beyond 8 years.

The study is interested in the long-run growth. Thus, TFP and energy-related data are filtered using Hodrick-Prescott filtering method to minimize cyclical variations.[2]

4.2. Estimation Results

The estimation model is indicated in equation 4: -

$$\Delta \ln TFP_{it} = c_i + \beta \cdot Elec_{it} + \gamma^{'}X_{it} + \delta^{'}Z_{it} + u_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

where: $\Delta \ln TFP_{it}$ is the growth rate of the TFP and $Elec_{it}$ represents electrification, as expressed by the ratio of total electric consumption to total energy consumption. X_{it} denotes the vector of control variables that might affect productivity growth. The study included four variables into the list of the control variables: investment-to-GDP ratio, capital-output ratio, government expenditure-GDP ratio, openness as represented by the ratio of foreign trade (import plus export) to GDP and population growth. Finally, Z_{it} captures the effects of other energy-related variables: the ratio of oil consumption to total energy consumption, growth of per-capita electric demand and growth of per-capita energy demand.

The model encompasses three types of panel analysis models depending on the assumption on the intersection parameterc_i. First, this study assumed that the intersection coefficient is constant across countries so that the model collapses into a pooled regression model. The estimation results are reported in Table 1.The study estimated the regression model (4) using growth rate of TFP (left panel) or level of TFP (right panel) as dependent variable. The model (1) and (3) only include electrification and control variables and the model (2) and (4) add other energy-related variables. The results do not appear to support the Schurr's Hypothesis: electrification has only positive effects on productivity growth at 10% significance level in the model (1) and it has negative impacts on productivity level in the model (3) and (4).

The lack of evidence in favour of the hypothesis may just reflect incorrect estimates caused by heterogeneity of the intersection coefficient. The study considered fixed effect model and random effect model. The study performed Hausman test and the results indicate that the fixed effect model is always more preferred specification than the random effect model, which implies that the estimates by the pooled regression model yields omitted variable bias. Nonetheless, the inverse matrix of difference

[2]The estimation results with raw data are basically the same even if significance level is slightly lower.

between two asymptotic variances is not positive definite for model (2)[3] and the model (3) fails to meet the asymptotic assumptions of the Hausman test. Thus, the study reports the results from the random effect model for robustness.

The estimation results of the fixed effect model are reported in Table 2and present some evidence in favour of the Schurr's hypothesis. The left panel reveals that electrification has statistically significant impacts on the TFP growth at 5% or 10% significance level. Especially, the value of coefficients β increases and its p-value decreases dramatically when all the variables are included into the estimation model. For the effects of electrification on productivity level, on the other hand, evidence in favour of the hypothesis is found when other energy-related variables are excluded from the model. The findings of the study are supported by Schurr's hypothesis that, electrification has a significant effect on Total Factor Productivity.

The effects of energy-related variables other than electrification are also worth noting. Note that the current hypothesis implies that more electricity-intense production method increases productivity. This in turn implies that, a country increases productivity through transferring from other types of energy uses to electricity. Thus, the study expects that other types of energy intensity would decreases productivity. The results of growth effects are consistent with this expectation. The findings of the study are supported by Dalia (2018) that, the higher electricity generation can be provided through investing in clean technologies and renewable energy resources, such as wind and solar energy.

Oil is another important energy type in African countries and in other world. The coefficient of oil-use intensity as expressed by the ration of oil consumption to total energy consumption is negative and statistically significant. For the productivity level regression model, on the other hand, the coefficient on oil-use intensity has a positive sign, but it is statistically insignificant. The implication of the findings reveals that, African countries should change the formation of energy inputs toward electricity away from liquid fuels (Marius *et al.*, 2018). The effects of electricity demand per capital on productivity growth and level are significantly negative, which appears to be inconsistent with common economic sense.[4] On the other hand, per-capital energy demand has significant positive impacts on productivity growth and level.

The effects of the control variables are consistent with previous studies or economic theory with a few exceptions. Previous studies such as Barro (1991) show that government intervention is negatively associated with economic growth rate or investment. The current result is consistent with them: the government expenditure ratio has a negative impact on the TFP growth level and the estimated coefficients are statistically significant. Investment rate is positively associated with TFP level but negatively associated with TFP growth. Neoclassical theory of growth says that investment has no growth effects in terms of long-run equilibrium growth. The current estimation uses the filtered data to focus on long-run relation and the result is consistent with the theory. However, capital-output ratio has negative signs in all the models. This may be caused by multicolinearity with investment ratio.

[3] In this case, STATA package calculates the Moore-Penrose generalized inverse matrix.

[4] We estimate the models without electricity demand, but there are no substantial differences from what is reported in the current study.

The direction of the effects of openness is also as expected: countries more open to foreign trades can achieve high level and growth of productivity. Population growth has negative impacts on level of productivity, whereas it has positive impacts on growth of productivity. The growth effect is consistent with the prediction of endogenous growth theory, but the level effect is not: higher population growth makes more people to use new technology. For comparison and robustness of the results, table 3 reports the estimation results for the random effect model. No substantial differences are found from the results even though marginal significance level of the effects of electrification is higher little bit. Thus, the conclusion from the results of the fixed effect model does not need any substantial modifications.

Table 1: Estimation results: Pooled OLS

	Growth Effects		Level Effects	
	(1)	(2)	(3)	(4)
Constant	-0.012 (0.252)	-0.006 (0.535)	8.424 (0.000)	3.069 (0.908)
Investment/GDP ratio	-0.022 (0.383)	-0.069 (0.002)	1.146 (0.008)	0.975 (0.030)
Capital/output ratio	0.001 (0.826)	0.005 (0.033)	0.089 (0.060)	0.105 (0.036)
Government Expenditures ratio	0.002 (0.942)	0.068 (0.009)	-3.492 (0.000)	-2.757 (0.000)
Openness	0.015 (0.029)	0.007 (0.257)	0.443 (0.000)	0.385 (0.002)
Population Growth	0.620 (0.005)	0.697 (0.001)	-19.634 (0.000)	-19.017 (0.000)
Electric/energy Ratio	0.125 (0.078)	-0.011 (0.864)	-11.773 (0.000)	-12.890 (0.000)
Oil/energy Ratio	-	-0.003 (0.056)	-	-0.153 (0.000)
Electric demand* Growth	-	0.059 (0.006)	-	-0.010 (0.158)
Energy demand** Growth	-	0.303 (0.000)	-	0.003 (0.825)
F-statistic	2.54 (0.020)	15.97 (0.000)	45.07 (0.000	32.78 (0.000)

* For the model of level effect, ratio of energy consumption to real GDP is used.

** For the model of level effect, year is used.

Table 2. Estimation results: Fixed effects

	Growth Effects		Level Effects	
	(1)	**(2)**	**(3)**	**(4)**
Constant	0.064 (0.002)	0.177 (0.000)	8.363 (0.000)	-12.861 (0.001)
Investment/GDP ratio	-0.170 (0.000)	-0.184 (0.000)	0.660 (0.000)	0.149 (0.263)
Capital/output ratio	-0.028 (0.000)	-0.019 (0.000)	-0.273 (0.000)	-0.234 (0.000)
Government Expenditures ratio	-0.134 (0.184)	-0.331 (0.000)	-0.220 (0.415)	-0.140 (0.590)
Openness	0.043 (0.013)	0.124 (0.000)	0.083 (0.072)	-0.003 (0.956)
Population Growth	1.079 (0.000)	1.142 (0.000)	-1.376 (0.062)	-1.133 (0.109)
Electric/energy Ratio	0.284 (0.078)	1.105 (0.000)	1.021 (0.019)	-0.254 (0.601)
Oil/energy Ratio	-	-0.060 (0.000)	-	0.035 (0.179)
Electric demand* Growth	-	-0.040 (0.033)	-	-0.019 (0.003)
Energy demand** Growth	-	0.598 (0.000)	-	0.011 (0.000)
F-statistic	13.65 (0.000)	31.550 (0.000)	53.98 (0.000	44.930 (0.000)
Housman test	36.65 (0.000)	125.19 (0.000)	-34.10	22.8 (0.007)

* For the model of level effect, ratio of energy consumption to real GDP is used.

** For the model of level effect, year is used.

Table 3: Estimation results: Random effects

	Growth Effects		Level Effects	
	(1)	**(2)**	**(3)**	**(4)**
Constant	0.014 (0.356)	-0.012 (0.519)	8.354 (0.000)	-12.187 (0.001)
Investment/GDP ratio	-0.111 (0.001)	-0.127 (0.000)	0.668 (0.000)	0.174 (0.205)
Capital/output ratio	-0.009 (0.031)	-0.006 (0.112)	-0.263 (0.000)	-0.228 (0.000)
Government Expenditures ratio	-0.065 (0.239)	0.034 (0.515)	-0.377 (0.168)	-0.288 (0.275)
Openness	0.034 (0.003)	0.043 (0.000)	0.102 (0.030)	0.026 (0.575)
Population Growth	0.949 (0.000)	1.078 (0.000)	-1.531 (0.043)	-1.314 (0.071)
Electric/energy Ratio	0.166 (0.164)	0.227 (0.038)	0.847 (0.056)	-0.228 (0.641)
Oil/energy Ratio	-	0.001 (0.834)	-	0.020 (0.423)
Electric demand* Growth	-	0.018 (0.312)	-	-0.017 (0.006)
Energy demand** Growth	-	0.355 (0.000)	-	0.010 (0.000)
Wald chi2(6)	46.79 (0.000)	194.180 (0.000)	297.84 (0.000)	368.440 (0.000)

* For the model of level effect, ratio of energy consumption to real GDP is used.
** For the model of level effect, year is used.

5. SUMMARY AND CONCLUDING REMARKS

Various studies that began around 1950s indicate positive effects of electrification on the productivity during the early stage of economic development in the United States' industries. However, there was no well-established relationship between electrification and productivity growth for the matured or developed economy. Therefore, this study aimed to test whether electrification is applicable to economies at the early stage of economic development. Specifically, the study analysed the impacts of electrification on productivity in Africa for the period between 2000-2010.Total Factor Productivity was estimated from human capital-augmented Cobb-Douglas production function and its level or growth rate was regressed onto a measure of electrification and other control variable. The regression analysis encompasses pooled OLS, fixed and random effect models. However, the estimation results of the pooled model did not appear to support the Schurr's Hypothesis. Thus, this study performed the Hausman test to check whether (Fixed or Random Effect) is suitable to accept. The Hausman test results indicate that, fixed effect model is always more preferred specification than the random effect model. The results are presented in some detail in the body of the paper. In this final section, the study focused on the major conclusions that emerge from the analysis.

Firstly, the focus was to test whether electrification is applicable to economies at the early stage of economic development, especially in African Countries. The study showed a significant impact of electrification on productivity growth and its level. Nevertheless, evidence on productivity level was found when other energy related variables (i.e., oil-use intensity, electricity and per-capital energy demand) are excluded from the model. The estimated results reveal that, 10 % increase in electrification is associated with 11.05 (10.21) % increase in productivity growth (Level), respectively. Thus, increase in electrification is more effective in developing economies such as Africa. This study, therefore, recommend that, Africa should ensure that, the available energy resources such as gas and water are transformed using technology to obtain sufficient electricity power for industrial production growth.

Secondly, the significant impacts of the energy-related variables were also considered. As stated in the current hypothesis that more electricity-intense production method increases productivity, the results show that, oil-use intensity decreases the productivity growth. Thus, changing of energy formation inputs toward electricity will not only improve productivity growth but also energy productivity growth. The implication of the findings reveals that, African government should discourage the use of liquid fuels instead electrification is recommended for the sake of improving productivity at low costs. More emphasis is given to African policy makers that more electricity-intense production should be improved in order to cope with the industrial electricity demand arising from increased productivity.

Moreover, the effects of control variables other than electrification or energy related variables are also worth noting. The results of the analysis demonstrate that, government expenditure and investment ratio have a significant negative impact on productivity growth. The reason behind is that, the declining growth rate is the diminishing returns to capital for the developing countries which is not as strong as in the capital-rich countries. Thus, the growth rate of the developing countries tends to converge to the steady state. To conclude this paper, the results on openness and population growth implying the following: - Firstly, if countries are more open to foreign trade can achieve high productivity level and growth rate. Secondly, population growth has a negative and positive impact on the productivity level (growth), respectively. The growth effect is consistent with the prediction of endogenous growth theory, but the level effect is not which implies that, higher population growth makes more people to use new technology.

REFERENCES

Anam *et al.,* (2021). Causality Relationship Between Electricity Supply and Economic Growth*:* Evidence from Pakistan*. Energies* 13(4**),** 837.

Barro, R. J. (1991). Economic Growth in a Cross Section of Countries, Quarterly *Journal of Economics* 106(2), 407-443.

Berndt, E. R. (1983). Electrification, Energy Quality and Productivity Growth in U.S. *Manufacturing, working Paper* No. 1421-83.

Berndt, E. R. (1990). Energy Use, Technical Progress and Productivity Growth: A Survey of Economic Issues, *The Journal of Productivity Analysis* 2(3), 67-83.

Dalia, M. I. (2018). *Investigating the causal relationship between electricity consumption and sectoral outputs: evidence from Egypt*. DOI: 10.1007/s41825-018-0009-8.

David, P. A. (1990). The dynamo and the computer: an historical perspective on the modern productivity paradox, *American Economic Review* 80(2), 355-361.

Devine, W. D., Jr. (1983). From Shafts to Wires: Historical Perspective on Electrification, *The Journal of Economic History* 43(2), 347-372.

Escribano *et al.,* (2010). Assessing the Impact of Infrastructure Quality on Firm Productivity in Africa Cross-Country Comparisons Based on Investment Climate Surveys from 1999 to 2005. *Policy Research Working Papers*, *09*(86), 1–105.

Fedderke, J. (2006). Infrastructure and Growth in South Africa: *Direct and Indirect Productivity Impacts*. *WPS3989.*

Hall, R. E. and Jones, C. I. (1999). Why Do Some Countries Produce So Much More Output Per Worker Than Others? *The Quarterly Journal of Economics* 114 (1), 83-116.

Iwayemi, A. (1998). Energy Sector Development in Africa, Working paper No.43

Jamiu, A. and Husam, R. (2020): *Relationship Among Economic Growth, Energy Consumption, CO2 Emission, and Urbanization: Evidence from MINT Countries*.doi.org/10.1177/2158244020914648

Jorgenson, D. W. and Barbara M. F. (1981). *Relative Prices and Technical Change, ch. 2 in Ernst R. Berndt and Barry C. Field, eds., Modelling and Measuring National Resource Substitution*. Cambridge, MA: MIT Press.

Jorgenson, D. W. (1984). The role of energy in productivity growth, *Energy Journal,* 5(3): 11-26.

Jumbe, C. B. L. (2004). Cointegration and causality between electricity consumption and GDP: empirical evidence from Malawi, *Energy Economics* 26(1), 61-68.

Kanti, A. K., Kayunze, K. A. and Muhanga, M. I. (2020). Public-private partnerships in the provision of healthcare services for sustainable development in Tanzania: A systematic literature review, *East African Journal of Social and Applied Sciences* 2(2), 182-195.

Karekezi, S. and Kimani, J. (2002). Status of power reform in Africa: impact on the poor, *Energy Policy* 30(12), 923–945.

Kooijman, D., Annemarij, L. and Clancy, J. (2010). Impacts of electricity access to rural enterprises in Bolivia, *Tanzania and Vietnam, Energy for Sustainable Development,* 14(1), 14–21.

Marius, *et al., (*2018). *Renewable energy consumption and economic growth. Causality relationship in Central and Eastern European countries*.doi.org/10.1371/journal.pone.0202951.

Morimoto, R. and Hope, C. (2001). The impact of electricity supply on economic growth in Sri Lanka, *The Judge Institute of Management Research Paper* No.24.

Mgema, J. M. (2020). Essentials of Commerce in East Africa by Safdar Ali Butt. Cassell Publishers Limited, London, 270pp, *East African Journal of Social and Applied Sciences* 2(2), 325-329.

Odhiambo, N. M. (2009). Electricity consumption and economic growth in South Africa, A trivariate causality test, *Energy Economics* 31(5), 635–640.

Onyeji, I. Bazilian, M. and Nussbaumer, P. (2012). Contextualizing electricity access in sub-Saharan Africa, *Energy for Sustainable Development* 16(4), 520–527.

Psacharopoulos, G. (1994). Returns to Investment in Education: A Global Update, *World Development*, 22(9), 1325-1343.

Raluca, G. and Douglas, B. (2013). Connection Charges and Electricity Access in Sub-Saharan Africa. *Policy Research Working Paper* 6511.

Raynold R. and Syden M. (2020): Modelling Electric Power Consumption, Energy Consumption and Economic Growth in Zimbabwe: Cointegration and Causality Analysis. *American Journal of Economics* 10(5), 267-276.

Schurr, H. and Netschert, B. C. (1960). *"Energy in the American Economy 1850-1975"* Johns Hopkins Press for Resources for the Future. Baltimore.

Schurr, S. H. (1985). Productive Efficiency and energy use: An Historical Perspective, *Annals of Operations Research Paper* 2(1), 229- 238.

Shahid, M. (2006). *Munich Personal RePEc Archive Economic Growth with Energy*. *1260*.

Treichel, V. (2005). *Tanzania's Growth Process and Success in Reducing Poverty,* International Monetary Fund. Washington, DC.

Um, N *at el.,* (2013). *Infrastructure and Economic Growth in the Middle East and North Africa Policy.* doi.org/10.1596/1813-9450-5105.

Wolde, Y. R. (2006). Electricity consumption and economic growth: a time series experience for 17 African countries, *Energy Policy*. DOI:10.1016/j.enpol.2004.10.008