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TRANSPORT AND ELECTRICITY INFRASTRUCTURES AND ECONOMIC GROWTH AND DEVELOPMENT IN SELECTED SUB-SAHARAN AFRICAN COUNTRIES

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ABSTRACT: *Economic postulations suggest that the interrelationship between changes in incomes, capital and labour which can be substituted into macroeconomic neoclassical and steady-state growth theories drives economic development. Arising from the above economic axiom, this study investigated the impact of transport and electricity infrastructures on economic development and growth in sub-Saharan Africa. The study used panel data from fifteen (15) sub-Saharan African countries. Panel data were obtained from statistical bulletins of the various countries and World Bank Indicators (WBI) from 2000-2022. Data obtained were analyzed via descriptive, diagnostic and inferential statistics. Specifically, the fixed and random effects regression revealed that while there is a significant relationship between transportation and electricity infrastructures and economic growth, an insignificant relationship was found between transportation and electricity infrastructures and economic development in the selected sub-Saharan African countries. Based on the findings, it was recommended among others that governments in sub-Saharan Africa needs to increase their contributions and support for electricity and transportation infrastructures; this can be done by increasing budgetary allocation for critical infrastructures in countries of sub-Saharan Africa.*

KEYWORDS: Transport infrastructure; Electricity infrastructure; Economic development; Economic growth; Critical infrastructure; Sub-Saharan Africa

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INTRODUCTION

Infrastructure development has been well documented in the economic literature as a critical factor driving economic growth (Munnell, 1990; Estache, 2006; Jabu, 2015; Alina, Yan, &Michail, 2021). Development in whatever dimension cannot result in good healthy living in the absence of critical infrastructure like information and telecommunications, transportation system, energy supply, water and sanitation, health care, housing and education to complement human effort. Infrastructures raises growth quality, which reduces economic disparity and poverty levels (Orubu, 2020). Direct investment in infrastructure is capable of promoting positive externalities in terms of making available production facilities and at the same time lowering costs associated with trade transactions and generating employment opportunities for the people.

Conversely, a deficiency of infrastructure constitutes a serious hindrance to sustainable growth and development and possibly worsens the poverty level (Fatai, Omolara, &Taiwo, 2016; Ekeocha, Ogbuabor& Orji, 2021). Economic research on infrastructural development has witnessed increased interest from scholars in recent times, and some have expressed support for the symmetric impact of infrastructure on economic growth (Levoli et al. 2019; Nugraha et al. 2020). These studies have maintained that infrastructure development through resource investment directly affects economic development. And that the only avenue a country can explore to attain a reasonable growth potential is to commit resources to the provision of infrastructures such as good roads, functional railway networks, water, electricity, information and telecommunication (ICT), schools, houses, and hospitals (Odiri, 2020, Odiri, 2019; and Odiri, 2016).

Most sub-Saharan African countries are experiencing restricted growth due to sluggish infrastructure development. Resources channelled to the provision of infrastructure services were largely inadequate and sub-optimal (Calderón&Servén, 2008; Azolibe&Okonkwo, 2020). However, funds directed to the provision of infrastructures were either embezzled or diverted to less productive needs which are susceptible to corruption. This, however, created a lacuna in the infrastructure development process. More so, sub-Saharan Africa is ranked at the bottom of all developing regions in terms of infrastructure development, hence, the strategic emphasis on infrastructure is hardly surprising.

The literature suggests that some intrinsic features of Africa's economies may enhance the potential role of infrastructure for the region's economic development in particular, a large number of Africa's landlocked countries, home to a major proportion (about 40 percent) of the region's overall population, and the remoteness of most of the region's economies from global market centres (Elbadawi, Mengistae&Zeufack, 2006; and Ighodaro, 2019). These geographic disadvantages result in high transport costs that hamper intra and inter-regional trade, (Elbadawi, Mengistae & Zeufack, 2006; Behar & Manners, 2008; Ebuh, 2019). However, the interesting part of the story is that these geographic disadvantages do pose an insurmountable obstacle to development, for they can be offset with good transport and communications facilities (Limao & Venables, 2001).

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The question this study addresses is that after several years of this proclamation and infrastructure development is not at an optimal level in the sub-Saharan region and government infrastructure development investment measures taken so far, has there been any significant improvement in the region in terms of infrastructural developmental drives in promoting the economic livelihood of the populace? Thus, this study critically evaluates the role of certain infrastructure development (transportation and electricity) in economic development in sub-Sahara Africa. Establishing evidence that indeed these critical infrastructures contribute to economic growth and development will help sub–Saharan Africa and the donor community in channelling resources towards this direction to foster growth and development.

LITERATURE REVIEW

Critical Infrastructure

The meaning of infrastructure has been shifting from one focusing on physical fixed assets such as roads, airports, sea ports, telecommunications systems, water distribution systems and sanitation (what might be called 'public utilities'). It now often embodies notions of softer types of infrastructure such as information systems and knowledge bases (Button, 2002). In general, infrastructure can be categorized into 'hard' infrastructure and 'soft' infrastructure. The former refers to physical structures or facilities that support the society and economy, such as transport (ports, roads and railways); energy (electricity generation, electrical grids, gas and oil pipelines); telecommunications (telephone and internet); and, basic utilities (water supply, hospitals and health clinics, schools, irrigation, etc.).

The latter refers to non-tangibles supporting the development and operation of hard infrastructure, such as policy, regulatory, and institutional frameworks; governance mechanisms; systems and procedures; social networks; and transparency and accountability of financing and procurement systems (Bhattacharyay, 2008). Broadly defined, therefore, infrastructure refers to all basic inputs into and requirements for the proper functioning of the economy. Despite this, there are two generally accepted categories, namely, economic and social infrastructure. Economic infrastructure is also, at a given point in time, part of an economy's capital stock used to facilitate economic production or serve as inputs to production (e.g. electricity, roads, and ports) (Maitri& Sarkar, 2010). This helps to produce items that are consumed by households (e.g. water, sanitation and electricity).

Economic infrastructure can further be subdivided into three categories: utilities (power, piped gas, telecommunications, water and sanitation, sewerage and solid waste disposal), public works (roads and water catchments in dams, irrigation and drainage) and other transport sub-sectors (railways, waterways and seaports, airports and urban transport systems). In this study, two (2) critical infrastructures were employed – transportation and electricity infrastructures.

- *Transportation Infrastructure*

Transportation infrastructure will promote economic growth by promoting the movement of goods. The roles of transportation include mobility of labour and capital, transport reduces the rigorous immobility of certain factors of production, the economics of large scale production, discouragement to monopoly and industrial development. The importance of transport infrastructure to economic development is that its impact on the level of economic

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growth is significant. Transport infrastructure saves time and costs in the operation stage, expands product sales and market and reduces enterprises' inventory capital.

Transportation infrastructure has an enormous impact on sustainable development. To identify multiple impacts of transportation infrastructure and show emerging trends and challenges, Wang et al. (2018), presented a scient metric review based on 2543 published articles from 2000 to 2017 through co-author, co-occurring and co-citation analysis. In addition, the hierarchy of key concepts was analyzed to show emerging research objects, methods and levels according to the clustering information, which includes title, keyword and abstract. The results provide researchers and practitioners with an in-depth understanding of transportation infrastructure's impacts on sustainable development by visual expression.

- *Electricity Infrastructure*

Electricity is an essential part of modern life and it is vital in all economies. Electricity is a key factor of production for companies which from research have substitutability with other factors of production and may constrain output when unavailable. Most States use energy to deliver key public services including health care and education. Between 2008 and 2012, the region's total primary energy consumption increased by only 0.9 per cent from 10.23 Q Btu's to 10.32 Q Btu's. In 2012, the region consumed only about 1.9 per cent of world energy consumption. Furthermore, only about 32 per cent of Sub-Saharan Africans have access to electricity (World Bank Development Indicator 2015).

The 2012 estimates indicate that the 49 countries in Sub-Saharan Africa, with a combined population of nearly 1 billion people, actually generate 389,000 gigawatt-hours (GWh) of electricity (of which South Africa's share is 239,000 GWh or 61 per cent), amounting to only 1.8 per cent of the world's total electricity output and about 78 per cent of South Korea's (ACBF, 2016). The region's installed electricity generation capacity is approximately 70 GW, with a deficit of about 70 GW (World Bank data). However, about 25 per cent of that capacity is not operational because the plants are ageing or in a state of disrepair, an indication of underinvestment in the energy sector over time. That situation has led to decreased efficiency, higher maintenance costs, and frequent power outages (KPMG, 2014).

The number of days per year of outages in the region ranges from 6 (South Africa) to as much as 182 (Democratic Republic of the Congo), with each outage averaging between 4.15 hours in South Africa and 19.31 hours in Angola (Eberhard et al., 2011). In most economies, a good portion of power generation is from hydropower stations, coal, and gas power plants. The more expensive thermal generation (using diesel turbines) is used in many countries to boost supply in times of low base-load generation. To meet suppressed demand, to provide additional capacity, and to support projected economic growth, installed electricity production capacity should grow by more than 7 GW per year (Eberhard et al., 2011). Sub-Saharan Africa suffers from acute lack of access to electricity (Bazilian et al., 2012) with approximately 580 million people unable to access this power source (IEA, 2010).

Current access to electricity is a little more than 20 per cent (Banerjee et al., 2008), and indeed, Banerjee et al. (2008), further posit that fewer than 40 per cent of African countries will have access by 2050. However, Calderon et al. (2018) estimate that people with access to electricity grew from 14 per cent in 1990 to about 35 per cent in 2014. Foster and BriceñoGarmendia (2010) and Estache and Garsous (2012) conclude that power or energy

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production presents the largest infrastructure gap for Africa, requiring nearly 40-60 per cent of infrastructure investment.

Africa has the potential to generate 937 TWh (terawatt hours) per year, constituting one-tenth of the world's total. Additionally, Africa is endowed with abundant solar and wind renewable energy resources empirically, Horvat et al. (2020) demonstrated the positive influence of investments in infrastructure projects on economic and human development in East African countries. Similarly, Ouédraogo (2010) found the existence of an equilibrium relationship and feedback hypothesis between electricity consumption and economic growth in Burkina Faso, while Solarin and Shahbaz (2013) found similar patterns between urbanization and electricity consumption in Angola.

In the United Arab Emirates, Shahbaz et al. (2014) validated the existence of a co-integration and feedback hypothesis between electricity consumption and carbon dioxide emissions, while Karanfil and Li (2015) obtained similar results among Organization of Petroleum Exporting Countries (OPEC) member economies. Contrary to these studies, Akinwale et al. (2013) did not find any evidence in support of the feedback hypothesis in Nigeria and the study attributed this to low level of electricity consumption due to low generation/distribution

Economic Growth and Development

The term development in human society is relative and a multi-dimensional process. For radical scholars like Walter Rodney, the term is viewed first from the individual level, which implies increased skill and capacity, greater freedom, creativity, self-discipline, responsibility and material well-being which is more relative to this study. The second is at; the level of social groups, it implies an increasing capacity to regulate both internal and external relations and the mode of production level. (Rodney, 1982). It is important to note that in every human society, there are minimum expectations that all members share. And they are: access to universal qualitative education, and equal opportunity for all members in the public domain where competition is based on merit and upheld against all odds (Aliyu, 2013).

Economic growth and economic development before now sometimes depended on what subject matter was in focus and used interchangeably, maybe due to their strong relationship and symbiosis. In the current literature, scholars have succeeded in separating the two concepts. According to Mbah and Amassoma (2014), Economic growth is quantitative being measurable and objective, while economic development is a non-quantitative measure of a growing economy. However, they maintained that growth and development go paripassu at least during the early stages of growth where whenever there is growth, there is likely to be development and concluded that 'growth and development are interwoven and at such are considered synonymous by some writers.

Furthermore, it is known that economic growth and economic development are quite distinct and different, especially with the experiences of many Less Developed Countries (LCDs) in Africa and Latin America including India where there was noticeable rapid economic growth but a general deterioration in the quality or standard of life of the citizens. Economic development is considered as a 'passage from, lower to higher stage of life which implies change' (Kindle Berger & Herrick, 1958). Peshkin and Cohen (1967) as cited in Rufus and Bufumoh (2017) noted that economic growth was equated with development and was generally considered as the fundamental objective of the decolonised states of Asia and Africa.

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Based on this perception they asserted that development implies: improvements in material welfare especially for persons with the lowest Incomes, the eradication of poverty with its correlates of illiteracy, disease and early death, and change in the composition of inputs and outputs that generally include shifts in the underlying structure of production away from Agricultural towards Industrial activities, the organisation of the economy in such a way that productive employment is generally among the working age population rather than the situation of a privileged minority and the correspondingly greater participation of broad-based groups in making decisions about the direction, economic and otherwise in which they should move their welfare.

Thirwall (2005) noted the broadening of the notion of development to include social and economic objectives and values that societies strive for. They emphasised the issue of low food consumption and higher unemployment resolution with a combination of growth in GDP and equitable distribution of income as prerequisites for economic development. Development must be defined in terms of progressive and eventual elimination of malnutrition, diseases, illiteracy, squalor, unemployment and inequalities. We were taught to take care of GDP because it will take care of poverty but let us reverse this and take care of poverty. After all, it will take care of the GDP. In other words, there shouldn't be any concern as regards the content of GDP more than its rate of increase. Hitherto, Gopinath, (2008) highlighted that there is a significant potential to raise the per capita standard of living of people where there is a sustainable development culture with available infrastructure facilities.

Theoretical Framework

The underpinning theory is the endogenous growth model which was propounded by Roman in 1990 and forms the basis of this research. According to traditional macroeconomic neoclassical theory, steady-state growth is fueled by exogenous factors, such as population dynamics and technological advancements. Let us recall the production function used in the neoclassical growth model.

$$Y = f(K, L, T) \quad \text{eq1}$$

Where Y = National output (at constant price), K = Stock of capital, L = Labour supply and T = the scale of technological progress. Let us assume for the time being that technology remains constant, then the growth rate depends on K and L. The production function then takes the following form;

$$Y = f(K, L) \quad \text{eq2}$$

Solow model assumes a Cobb – Douglas type of production function of homogeneous degree one, which means a constant return to scale. Given the assumption of constant return to scale, the increase in national output (ΔY) due to the increase in K and L can be obtained as follows;

$$\Delta Y = \Delta K \,.MP_K + \Delta L.\, MP_L \quad \text{eq3}$$

Where MP_K and MP_L denote the Marginal physical product of capital (K) and Labour (L), respectively. By dividing both sides of equation 3.3 by Y, we get the growth rate of the national product ($\Delta Y/Y$)

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$\Delta Y = \Delta K\ (MP_{K\,/}\ Y)\ K/K + \Delta L\ (MP_L / L)\ L/L$ eq4

By rearranging the term, we get;

$\Delta Y/Y = \Delta K/K\ (K.MP_{K/}\ Y) + \Delta L/L\ (LMP_L / Y)$ eq5

Thus, $MP_{K.}\ K / Y + MP_L.\ L / Y = 1$ eq6

Let $(MP_K.\ K) / Y$ in eq (3.6) be denoted by **b**, then $(MP_L.\ L) / Y = 1 – b$. By substituting these values in eq (3.5), growth rate $\Delta Y/ Y$ can be written as;

$\Delta Y / Y = b\ (\Delta K / K) + (1 – b)\ \Delta L / L$ eq.7

When the technological problem is introduced to the neoclassical model and the resulting growth rate of output is denoted by $\Delta T / T$. Eqn (2.10) can be written as;

$\Delta Y / Y = b\ (\Delta K /K) + (1 – b)\ \Delta L / L + \Delta T / T$ eq.8

The equation above shows the interrelationship between changes in income, change in capital and labour which can be substituted into the variables of analysis such as infrastructural development and human development. With the right infrastructural facilities as mentioned, people want to see real infrastructural facilities and development that create an enabling and stimulating environment where economic activities are operational with an adequate level of technological advancement and rapid capital formation.

RESEARCH METHODS

This study employed the ex post facto research design. The relevant concepts in the choice of research design are dependent and independent variables, extraneous variables, confounded relationships, and hypothesis testing (Panneerselvam, 2010). This study used panel data analysis via random effects regression as follows:

$GDP = \propto_0 + \propto_1 ES_{it} + \propto_2 EXP_{it} + U_t$ eq9

$GDP = \propto_0 + \propto_1 TRit + \propto_2 EXPit + Ut$ eq10

$HDI = \beta_0 + \beta_1\ ESit + \beta 2EXPit + Ut$ eq11

$HDI = \beta_0 + \beta_1 TRit + \beta 2EXPit + Ut$ eq12

Where: GDP = Gross Domestic Product; HDI = Human Development Index TR = Transportation Infrastructure Index; ES = Electricity Infrastructure Index; EX = Export (used as a control variable). Data were sourced African Infrastructural Development Bulletin, World Bank Indicators, World Bank Publication, World Development Indicator (WDI), etc. The period under review is from 2000-2021 and data of the respective variables were sourced for 15 sub-Saharan African countries - Nigeria, Ghana, Mauritius, South Africa, Kenya, Burkina Faso, Malawi, Tanzania and Uganda. Benin Republic, Ethiopia, Rwanda, Eswatini, Zambia and Angola. Data obtained were analysed via descriptive, diagnostic and inferential statistics

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RESULTS AND DISCUSSION

Table 1a: Summary Statistics

Variables	Mean	Std. Dev.	Min. Value	Max. Value
ANGOLA				
GDP	10.725	0.3520	9.9511	11.137
HDI	0.4979	0.0882	0.3750	0.5970
ES	3.3660	1.9253	1.0100	6.6600
WS	46.950	9.1029	34.590	61.430
ICT	5.4415	4.5666	0.0900	12.820
TR	2.4960	0.7701	1.8800	4.4100
CINFR	13.855	4.4326	7.3000	20.650
EXP	9.9713	2.1965	0	10.844
BENIN REPUBLIC				
GDP	9.9701	0.2080	9.5465	10.247
HDI	0.4711	0.0533	0.4140	0.5300
ES	0.3056	0.1769	0.0800	0.7500
WS	43.146	6.6919	32.780	53.290
ICT	5.9005	4.7168	0.2200	15.340
TR	5.4978	0.7605	4.8500	7.2240
CINFR	12.674	3.2323	8.2500	17.400
EXP	9.3217	0.2557	8.8605	9.6298
BURKINAFASO				
GDP	9.9743	0.2501	9.4725	10.295
HDI	0.3661	0.0629	0.2960	0.4520
ES	0.7413	0.5473	0.2600	2.0800
WS	46.182	9.7525	29.430	62.790
ICT	4.4773	4.6077	0.0800	13.930
TR	12.610	2.1721	10.660	17.357
CINFR	14.777	2.7164	11.260	20.340
EXP	8.7981	1.9701	0	9.8173
ETHIOPIA				
GDP	10.517	0.4150	9.8949	11.103
HDI	0.4071	0.0715	0.2870	0.4980
ES	0.9000	0.5820	0.2500	1.8400
WS	23.484	11.434	6.0400	45.070
ICT	2.7507	3.5761	0.0300	9.5140
TR	1.7129	0.3355	1.0710	2.2400
CINFR	5.4242	3.4818	0.3700	11.450
EXP	5.1300	5.0224	0	10.019
GHANA				
GDP	10.452	0.4061	9.6974	10.898
HDI	0.5731	0.0442	0.5050	0.6320
ES	6.5673	3.1431	2.7700	18.000
WS	56.739	15.850	36.890	81.140
ICT	9.1328	8.4582	0.2000	26.230
TR	10.422	3.2120	5.2090	16.260
CINFR	20.495	7.2681	10.680	31.810
EXP	9.9643	0.3549	9.3809	10.408

Source: Researcher's Computation (2023)

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Table 1b: Summary Statistics

Variables	Mean	Std. Dev.	Min. Value	Max. Value
KENYA				
GDP	10.629	0.3301	10.103	11.054
HDI	0.5399	0.0325	0.4810	0.5810
ES	2.6873	0.7633	1.2900	3.6300
WS	42.900	9.0899	32.030	58.730
ICT	12.656	13.442	0.2300	43.420
TR	7.4483	3.2701	4.6300	12.190
CINFR	17.328	7.1403	7.8900	27.520
EXP	9.8800	0.2174	9.4381	10.141
MALAWI				
GDP	9.8714	0.1986	9.3975	10.119
HDI	0.4527	0.0492	0.3740	0.5190
ES	1.8943	0.5991	0.6700	2.6300
WS	59.154	5.7440	48.130	67.940
ICT	2.7071	2.6524	0.1100	8.0900
TR	5.0765	0.7274	3.7300	6.2550
CINFR	16.352	3.5106	11.5100	22.840
EXP	8.6056	1.8847	0	9.2162
MAURITIUS				
GDP	9.9711	0.1647	9.6640	10.168
HDI	0.7567	0.044	0.6810	0.8170
ES	33.616	6.2146	24.560	42.960
WS	93.241	11.766	61.500	99.800
ICT	29.234	16.485	6.0000	58.669
TR	36.138	0.8546	34.672	38.400
CINFR	62.884	13.252	42.100	80.440
EXP	9.6903	0.1297	9.4546	9.8599
NIGERIA				
GDP	11.450	0.2883	10.841	11.759
HDI	0.4969	0.0347	0.4390	0.5430
ES	2.7039	0.4218	1.7400	3.5900
WS	47.346	12.013	35.710	59.220
ICT	9.0793	7,4196	0.0600	25.450
TR	5.4563	0.4113	4.8900	6.3300
CINFR	16.280	5.5124	8.6100	24.530
EXP	10.257	2.2492	0	11.165
RWANDA				
GDP	9.7393	0.2763	9.2935	10.124
HDI	0.4692	0.0637	0.3400	0.5340
ES	0.3895	0.2235	0.1100	0.7700
WS	62.172	9.4000	51.510	79.630
ICT	5.0054	4.8570	0.0800	13.560
TR	12.600	1.0004	11.138	13.788
CINFR	17.952	2.9621	13.560	22.660
EXP	8.8375	0.4387	8.0462	9.4761

Source: Researcher's Computation (2023)

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Table 1c: Summary Statistics

Variables	Mean	Std. Dev.	Min. Value	Max. Value
SOUTH AFRICA				
GDP	11.491	0.1612	11.110	11.660
HDI	0.6695	0.0324	0.6290	0.7140
ES	74.892	6.1369	59.720	85.640
WS	85.053	4.6095	78.190	93.980
ICT	28.671	20.595	4.6600	76.938
TR	15.674	4.1107	12.730	23.190
CINFR	64.757	13.745	45.880	81.670
EXP	10.926	0.1806	10.552	11.132
ESWATINI				
GDP	9.5410	0.1627	9.1560	9.6890
HDI	0.5242	0.0631	0.4440	0.6150
ES	7.2056	4.1665	2.9300	13.940
WS	63.886	10.959	43.860	78.310
ICT	8.1682	5.5016	0.8700	16.750
TR	9.5139	1.6100	7.5800	13.160
CINFR	21.089	5.0631	13.220	29.120
EXP	8.8429	1.9291	0	9.3298
TANZANIA				
GDP	10.512	0.2541	10.126	10.879
HDI	0.4854	0.0482	0.3980	0.5490
ES	35.709	21.456	18.880	78.700
WS	31.598	10.886	23.880	56.750
ICT	5.3920	4.3294	0.1100	13.860
TR	3.3914	1.1521	2.6020	8.2800
CINFR	9.7156	3.5193	5.1700	16.220
EXP	9.7322	0.2740	9.1601	10.067
UGANDA				
GDP	10.274	0.3091	9.7664	10.658
HDI	0.4839	0.0423	0.3940	0.5250
ES	1.1382	0.2272	0.6400	1.6300
WS	47.563	6.1125	37.350	59.800
ICT	5.5326	4.3353	0.1200	12.198
TR	8.5436	1.3349	5.4900	10.019
CINFR	16.454	4.1712	10.470	22.640
EXP	9.4334	0.3497	8.8193	9.8056
ZAMBIA				
GDP	10.164	0.3039	9.5563	10.473
HDI	0.5162	0.0533	0.4180	0.5750
ES	12.730	1.2304	10.870	15.790
WS	47.395	3.8077	42.790	56.230
ICT	6.1179	4.9353	0.2200	14.331
TR	8.1861	1.4834	4.7100	12.140

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CINFR	19.438	3.4148	14.420	26.040
EXP	9.7003	0.3744	8.9352	10.061

Source: Researcher's Computation (2024)

In this section, the summary statistics (Table 1a-c) were analysed in terms of the country after which an aggregate and cross-sectional analysis was done. First, the summary statistics for Angola showed that GDP is 10.725 while HDI is 0.4979; also, ES is 3.3660, WS is 46.950, ICT is 5.4415, TR is 2.4960, CINFR is 13.855 and EXP is 9.9713. The results for Angola suggest a slow in economic growth which was caused by poor critical infrastructure. Second, the summary statistics for the Benin Republic showed that GDP is 9.9701 while HDI is 0.4711; also, ES is 0.3056, WS is 43.146, ICT is 5.9005, TR is 5.4978, CINFR is 12.674 and EXP is 9.3217. The results for Benin Republic suggest a slow in economic growth which was caused by poor critical infrastructure.

Third, the summary statistics for Burkina Faso showed that GDP is 9.9743 while HDI is 0.3661; also, ES is 0.7413, WS is 46.182, ICT is 4.4773, TR is 12.610, CINFR is 14.777 and EXP is 8.7981. The results for Burkina Faso suggest a slow in economic growth which was caused by poor critical infrastructure. Fourth, the summary statistics for Ethiopia showed that GDP is 10.517 while HDI is 0.4071; also, ES is 0.9000, WS is 23.484, ICT is 2.7507, TR is 1.7129, CINFR is 5.4242 and EXP is 5.1300. The results for Ethiopia suggest a slow in economic growth which was caused by poor critical infrastructure. Fifth, the summary statistics for Ghana showed that GDP is 10.452 while HDI is 0.5731; also, ES is 6.5673, WS is 56.739, ICT is 9.1328, TR is 10.422, CINFR is 20.495 and EXP is 9.9643. The results for Ghana suggest a slight increase in economic growth which was caused by more investments in critical infrastructure by the Ghanaian government.

Sixth, the summary statistics for Kenya showed that GDP is 10.629 while HDI is 0.5399; also, ES is 2.6873, WS is 42.900, ICT is 12.656, TR is 7.4483, CINFR is 17.328 and EXP is 9.8800. The results for Kenya suggest a slight increase in economic growth which was caused by more investments in critical infrastructure by the Kenyan government. Seventh, the summary statistics for Malawi showed that GDP and HDI had experienced slight growth; this situation was so for ES, WS, ICT, TR, CINFR and EXP. The results for Malawi suggest a slight increase in economic and development growth which was caused by investments in critical infrastructure.

Eighth, the summary statistics for Mauritius showed that GDP and HDI had experienced increased growth; this situation was so for ES, WS, ICT, TR, CINFR and EXP. The results for Mauritius suggest an increase in economic and development growth which was caused by investments in critical infrastructure. Ninth, the summary statistics for Nigeria showed that GDP and HDI had experienced slight growth; this situation was so for ES, WS, ICT, TR, CINFR and EXP. The results for Nigeria suggest an increase in economic and development growth which was caused by investments in critical infrastructure. Tenth, the summary statistics for South Africa showed that GDP and HDI had experienced increased growth; this situation was so for ES, WS, ICT, TR, CINFR and EXP. The results for South Africa suggest an increase in economic and development growth which was caused by investments in critical infrastructure.

Eleventh, the summary statistics for Eswatini showed that GDP and HDI had experienced slight growth; this situation was so for ES, WS, ICT, TR, CINFR and EXP. The results for

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Eswatini suggest a slight increase in economic and development growth which was caused by investments in critical infrastructure. Similar situations were found for Tanzania, Uganda and Zambia for all the variables of GDP, HDI, ES, WS, ICT, TR, CINFR and EXP. The results for, Tanzania, Uganda and Zambia suggest a slight increase in economic and development growth which was caused by poor investments in critical infrastructure.

Furthermore, the highest GDP was recorded by South Africa (Mean = 11.491) and this was accompanied by Nigeria (Mean = 11.450) and the least by Eswatini (Mean = 9.5410); this implied that South Africa had experienced increased growth, followed by Nigeria and Eswatini, the least growth in terms of GDP. Notably, economic growth in the selected regions of sub-Saharan Africa was not too far or dispersed from each (as indicated in the standard deviation values) such that the economic growth rate ranged from 0.1612 to 0.4150 which was between South Africa and Ethiopia. It was further shown that Mauritius recorded the highest in terms of HDI (Mean = 0.7567); this was followed by South Africa (Mean = 0.6695); and Burkina-Faso recorded the lowest (Mean = 0.3661). This indicates that among the countries in sub-Saharan Africa, Mauritius had more investment in HDI compared to other countries of sub-Saharan Africa; this is not astonishing as less developed countries that seek economic growth need augmented investments in HDI to boost economic growth rates.

Rwanda, ES showed 0.3895, WS (62.172), ICT (5.0054), TR (12.600), 8.8375 (EXP); South Africa showed 74.892 (ES), 85.053 (WS), 28.671 (ICT), 15.674 (TR), and 10.926 (EXP); Eswatini recorded 7.2056 (ES), 63.886 (WS), 8.1682 (ICT), 9.5139 (TR), and 8.8429 (EXP); Tanzania had 35.709 (ES), 31.598 (WS), 5.3920 (ICT), 3.3914 (TR), and 9.7322 (EXP); Uganda recorded 1.1382 (ES), 47.563 (WS), 5.5326 (ICT), 8.5436 (TR), and 9.4334 (EXP); while Zambia had 12.730 (ES), 47.395 (WS), 6.1179 (ICT), 8.1861 (TR), and 9.7003 (EXP). In terms of the aggregate critical infrastructures, South Africa showed the highest (64.757), followed by Mauritius (62.884), and the least is Ethiopia (5.4242); the above results suggest that more of South Africa recorded improvements or increases in critical infrastructures, Mauritius the next while Ethiopia with the smallest among the countries of sub-Saharan Africa.

Table 2: Pearson Correlation Matrix

Stats.	GDP	HDI	ES	TR	EXP
GDP	1.0000				
HDI	0.3643	1.0000			
ES	0.3859	0.5620	1.0000		
TR	-0.1451	0.6469	0.3933	1.0000	
EXP	0.3292	0.3965	0.2380	0.1510	1.0000

Source: Researcher's Computation (2024)

Table 2 shows the results of the Pearson correlation matrix for the dependent, independent and control variables for the selected countries of sub-Saharan Africa from 2000-2022. It was found that ES and EXP *were* positively correlated to GDP and HDI except TR which is negatively correlated. This implies that there is a positive relationship between the critical infrastructures (ES) and GDP and HDI while TR had a negative relationship (r =-0.1451).

Table 3: Variance Inflation Factor

Variable	VIF	1/VIF

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Transportation (TR)	3.39	0.295251
Electricity (ES)	3.21	0.311116
Export (EXP)	1.12	0.891174
Mean VIF	1.93	

Source: Researcher's Computation (2024)

Table 3 shows the multicollinearity results for the aggregate panel data of the selected countries of sub-Saharan Africa. The mean VIF is = 1.93 and is not greater than the accepted mean VIF level of 10.0, indicating that there is a nonexistence of multicollinearity problems in the empirical models of the critical infrastructures variables and economic growth in the selected sub-Saharan African countries. Thus, the panel dataset is exceptionally reliable for conducting statistical inferences.

Table 4: Breusch-Pagan/Cook-Weisberg Test for Heteroscedasticity

Variable	Statistics	
Chi2(1)	0.54	
Prob. > Chi2	0.4611	

Source: Researcher's Computation (2024)

Table 4 shows the Breusch-Pagan/Cook-Weisberg test for heteroskedasticity for the aggregate panel data of the selected countries of sub-Saharan Africa. Heteroskedasticity according to Gujarati (2003) is a situation where the variance of the residuals is unequal over an array of measured variables. The Breusch-Pagan/Cook Weisberg chi2(1) is = 0.54, Prob. chi2 is =0.4611 and is greater than 0.05 per cent significance level indicating the nonexistence of a heteroskedasticity problem in the variables of the study. Thus, the result implies that the sample used in the panel data regression does not contain unequal variance and as such, there is evidence that the results are valid.

Table 5: GDP and Electricity and Transportation Infrastructures in sub-Saharan Africa

Variables	Model 1 Coeff. of FE	t-value	Prob.	Model 1 Coeff. of RE	t-value	Prob.
ES	0.0040	1.93	0.054	0.0016	0.83	0.408
TR	-0.0496	-8.62	0.000	-0.0608	-11.50	0.000
EXP	0.0614	4.93	0.000	0.0572	4.88	0.000
_cons.	10.1214	79.32	0.000	9.9588	82.43	0.000
F-value	43.46					
R-Sq. (within)	0.4521			0.4391		
R-Sq. (between)	0.6446			0.7946		
R-Sq. (overall)	0.4709			0.4957		
Wald Ch2(6)				332.30		
Hausman Test				Chi2(2) = 34.40		

Source: Researcher's Computation (2024)

Table 5 shows the fixed and random effects panel regression for critical infrastructures (ES and TR), economic growth (GDP) and export (EXP) of the selected sub-Saharan African countries. Using the random effect (RE) results, the coefficients are 0.0016 (ES), -0.0608 (TR) and 0.0572 (EXP); this suggests that the electricity and transportation infrastructures

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and exports of the selected countries of sub-Sahara Africa would lead to approximately 0.16% and 5.72% changes in economic growth (GDP). The overall R-squared showed that the electricity, transportation and export measures have a 49.6% predictive ability on gross domestic product; thus, indicating that other variables predict gross domestic product, which were not included in the model of the study. In addition, ES and EXP are carrying positive signs while TR is carrying negative signs; an indication that ES and EXP positively relate to GDP while TR negatively relates to GDP.

Besides, electricity and transportation infrastructures variables (ES and TR), export (EXP) and economic growth (GDP) were jointly significant for both FE (F, 6, 316 =43.46; F-Prob. = 0.0000 < 0.05), and RE (Wald Ch2(6) = 332.30; Prob.Ch2 = 0.0000 < 0.05) at 5% significance level; hence, electricity and transportation infrastructures jointly influence the level of gross domestic products of the selected sub-Saharan African countries. The FE is 43.46 (p-value=0.0000 < 0.05) and is significant, providing evidence that electricity and transportation infrastructures and export measures jointly influence economic growth (GDP) in sub-Saharan Africa.

Table 6: HDI and Electricity and Transportation Infrastructures in sub-Saharan Africa

Variables	Model 1 Coeff. of FE	t-value	Prob.	Model 1 Coeff. of RE	t-value	Prob.
ES	0.0004	1.81	0.071	-0.0004	-0.017	0.867
TR	0.0017	2.57	0.011	-0.0003	-0.05	0.962
EXP	0.0073	4.24	0.000	0.075	4.71	0.000
_cons.	0.3251	19.93	0.000	0.3009	19.36	0.000
F-value	139.84					
R-Sq. (within)	0.7347			0.7226		
R-Sq. (between)	0.7068			0.8559		
R-Sq. (overall)	0.7305			0.7535		
Wald Ch2(6)				993.72		
Hausman Test				Chi2(2) = 26.33		

Source: Researcher's Computation (2024)

Table 6 shows the fixed and random effects panel regression for electricity and transportation infrastructures (ES and TR), economic growth (HDI) and export (EXP) of the selected sub-Saharan African countries. Using the random effect (RE) results, the coefficients are -0.0004 (ES), -0.0003(TR) and 0.0075 (EXP); this suggests that electricity and transportation infrastructures and exports of the selected countries of sub-Sahara Africa would lead to approximately 0.04%, 0.03%, and 0.75% changes in HDI. The overall R-squared showed that electricity and transportation infrastructures and export measures have a 75% predictive ability on HDI; thus indicating that other variables predict HDI, which were not included in the model of the study. In addition, all the variables ES, TR and EXP are carrying positive signs; indicating that ES, TR and EXP positively relate with HDI.

Besides, electricity and transportation infrastructures variables (ES and TR), export (EXP) and HDI were jointly significant for both FE (F, 6, 316 =139.84; F-Prob. = 0.0000 < 0.05), and RE (Wald Ch2(6) = 993.72; Prob.Ch2 = 0.0000 < 0.05) at 5% significance level; hence, electricity and transportation infrastructures jointly influence the level of HDI of the selected sub-Saharan African countries. FE is 993.72 (p-value = 0.0000 < 0.05) and is significant, providing evidence that all the critical infrastructures and export measures jointly influence economic growth (HDI) in sub-Saharan Africa.

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CONCLUSION AND RECOMMENDATIONS

In the economics literature, there is the issue of limited research on critical infrastructures and economic growth and development particularly in sub-Saharan African countries in a single study. Aside from the above, most prior studies concentrated on economic growth as a measure of development. As far as this study is concerned, the researcher used both the Gross Domestic Product (GDP) and Human Development Index (HDI) for a detailed analysis. In addition, critical infrastructural indicators such as transportation and electricity supply were employed in the study. This approach is different compared to prior studies that employed fewer variables and also such as export was employed to boost all the variables.

The study concludes that while there is a significant relationship between transportation and electricity infrastructures and economic growth, an insignificant relationship was found between transportation and electricity infrastructures and economic development in the selected sub-Saharan African countries. Based on the findings, it was recommended among others that governments in sub-Saharan Africa needs to increase their contributions and support for electricity and transportation infrastructures; this can be done by increasing budgetary allocation for critical infrastructures in countries of sub-Saharan Africa

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