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EXTERNAL FINANCING POLICIES AND SUSTAINABLE ENERGY DEVELOPMENT IN AFRICA: EVIDENCE FROM SUB-SAHARA AFRICAN COUNTRIES

Afees Oluwashina Noah * and David, Oladipo Olalekan**

ABSTRACT

Energy is a fundamental pillar for economic advancement, particularly in high-growth economies. However, Sub-Saharan Africa (SSA) is facing a worsening energy crisis compared to other regions globally. These energy sector challenges not only affect people's living standards but also hinder economic growth, employment prospects, and investments in the region. Despite having abundant energy resources, SSA struggles to adequately power its homes and businesses, necessitating the exploration and utilization of these resources to their full potential. The persistent energy crisis can be attributed to the inability of energy organisers to comprehend the complex macroeconomic elements that shape the development of energy. Nonetheless, substantial external financing has been absorbed by the sector in the past two decades. This study explores the influence of external financing policies, namely official development assistance, private participation in infrastructure, and foreign direct investment, on energy development within selected SSA nations from 1990 to 2021. Using the panel autoregressive distributed lag model, the empirical findings suggest that official development assistance hampers energy development in SSA, while foreign direct investment and private participation in infrastructure influence energy development in the long run. These outcomes imply that policymakers in SSA need to focus more and prioritize domestic financial development to ensure increase investment toward achieving sustainable energy development.

Keywords: Energy Development, Foreign Direct Investment, Private Participation in Infrastructure, Official Development Assistance, External Financing

1. INTRODUCTION

The significance of energy in global contexts as a crucial resource in human progress cannot be overstated. Ateba, Prinsloo, and Fourie emphasize its

pivotal role as a fundamental requirement for propelling social advancement and industrial competitiveness. Furthermore, energy is essential in fostering socio-economic advancement[1]. Various facets beyond energy are involved in the development process, including the advancement of education and labour markets, the provision of financial services to facilitate capital investment, the modernization of agriculture, and the establishment of infrastructure for water, sanitation, and communication. Empirical studies demonstrate a clear link between energy availability and economic growth. Without enhancements in energy supply, both economic expansion and socioeconomic progress will be adversely affected[2]. In particular, the progress observed in developed nations across North America and Europe can be attributed to the use of contemporary sources of energy. The requirement for energy continues to surge due to factors such as urbanization, economic composition, industrialization, and expansive growth within these economies. Consequently, this phenomenon has led to a widening disparity between supply and demand for energy in the energy domains of less economically developed countries (LEDCs). This challenge is exacerbated by considerable intermittency in energy availability, despite the presence of abundant resources like oil, hydroelectric power, solar energy, and coal.

Nonetheless, despite the imperative for enhanced and sustainable energy accessibility, the issue of energy inequality continues to persistently grow. Evidence has shown that the enhancement of energy development presents a worldwide challenge, extending beyond specific regions to encompass virtually every nation across the globe, all of which are confronted with the necessity to either establish new or enhance existing energy infrastructures. For instance, a staggering 759 million individuals worldwide remain devoid of access to electrical power, while an additional 2.6 billion lack the means to

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** School of Economic Sciences, North-West University, Vanderbijlpark Campus, South Africa (ORCID: 0000-0002-9922-9504)

1 Ateba Benedict Belobo, Prinsloo John, and Fourie Erika, 'The Impact of Energy Fuel Choice Determinants on Sustainable Energy Consumption of Selected South African Households' (2018) 29(3), 51-56, Journal of Energy in Southern Africa <DOI: http://dx.doi.org/10.17159/2413-3051/2018/v29i3a4714> accessed 15 July 2023.

2 European Investment Bank 'Energy Finance in Sub-Saharan Africa' (Boulevard Konrad Adenauer, L-2950 Luxembourg, 2018) <https://www.eib.org/attachments/country/ energy_finance_in_sub_saharan_africa_en.pdf> accessed 3 August 2023.

employ clean cooking fuels and technologies. Furthermore, over 3 billion individuals worldwide still use kerosene and conventional solid fuels for cooking, culminating in considerable detrimental impacts on health, the environment, and the economy. This reliance on conventional fuels for household cooking contributes to over 4.3 million preventable deaths per year worldwide[3]. However, the energy-related challenges are particularly heightened within developing nations, with a prominent emphasis on Africa, and most especially the SSA region.

Africa stands as the continent with the most limited energy access on a global scale. Approximately 600 million individuals within Africa, constituting 43% of the continent's inhabitants, do not currently connect to electricity[4]. This corresponds to nearly double the entire population of the United States. Additionally, Africa stands alone as the sole region experiencing a surge in the utilization of unclean cooking fuels, with an increase of nearly 50% since 2000. Collectively, the count of individuals in Africa deprived of access to clean cooking fuels exceeds 930 million[5]. Within SSA, the most substantial inadequacy in infrastructure lies within the power sector. This deficit in access is primarily centred in the region, where a notable 570 million individuals still lack electricity connectivity[6]. The 48 nations situated in SSA (home to around one billion people) produce approximately equivalent energy to that of Spain (which has a population of 45 million)[7].

The predicament concerning clean cooking is even more dire in this area, as more than 80%, accounting for 894 million individuals, grapple with the absence of clean cooking fuels and technologies. Nearly half of this

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[3] Bellur Sharmila, Mathew Paul and Besnard Juliette 'Access to Clean Cooking and Electricity: Righting the Policy Balance in Sub-Saharan Africa and Fragile Settings' (World Bank, Washington, DC. 2022) http://hdl.handle.net/10986/37956

[4] World Bank 'The World Bank in Africa' (International Bank for Reconstruction and Development - International Development Association 2023) <https://www.world bank .org/en/region/afr/overview> accessed 3 August 2023.

[5] Chandler Ben, Tsirodimitri Maria and Orkopoulou, Stella 'Addressing Africa's Energy Deficit: Climate Change, Renewables, and Gas' (Mo Ibrahim Foundation, 2022) <https://mo.ibrahim.foundation/sites/default/files/2022-09/energy-transition.pdf> accessed 15 August 2023.

[6] Bellur Sharmila, Mathew Paul and Besnard Juliette 'Access to Clean Cooking and Electricity: Righting the Policy Balance in Sub-Saharan Africa and Fragile Settings' (World Bank, Washington, DC. 2022) http://hdl.handle.net/10986/37956

[7] European Investment Bank 'Energy Finance in Sub-Saharan Africa' (Boulevard Konrad Adenauer, L-2950 Luxembourg, 2018) <https://www.eib.org/attachments/country/energy_finance_in_sub_saharan_africa_en.pdf> accessed 3 August 2023.

population resides within fragile, conflict-ridden regions[8]. The persistent failure to address this extensive lack of clean cooking facilities imposes significant economic burdens and curtails human productivity across the region's populace. This negative impact is disproportionately shouldered by women and children, manifested through untimely deaths and illnesses. Surprisingly, comprehensive clean-cooking strategies are deficient in the majority of SSA countries. In instances where such strategies are present, their execution is feeble, often hindered by inadequate funding, rendering even minor advancements difficult to achieve[9] [10].

Notwithstanding these obstacles, both individual SSA nations and the entire African continent hold the promise to surmount these challenges through the effective harnessing of the region's natural resources. The area boasts a wealth of energy resources that, if utilized adeptly, can alleviate these crises. The continent possesses a staggering 10,000 terawatts of potential solar power, a hydroelectric capacity of 350 gigawatts, a wind power potential of 110 gigawatts, and an additional geothermal capacity of 15 gigawatts. Notably, this calculation does not incorporate coal and gas reserves, which also offer the potential to supply cost-effective electricity across the continent[11]. SSA faces a hindrance in energizing its residences and enterprises due to the absence of both the technical expertise and financial capabilities required to tap into these abundant resources. Unless the region successfully navigates the path to fully harnessing and optimizing these substantial energy reserves, it could encounter challenges in effectively addressing its energy crisis. Historically, energy investment expenditures have predominantly relied upon

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[8] Bellur Sharmila, Mathew Paul and Besnard Juliette 'Access to Clean Cooking and Electricity: Righting the Policy Balance in Sub-Saharan Africa and Fragile Settings' (World Bank, Washington, DC. 2022) http://hdl.handle.net/10986/37956

[9] Sustainable Energy for All initiative (SEforAll) and Wallace Global Foundation 'Opening Doors: Mapping the Landscape for Sustainable Energy, Gender Diversity and Social Inclusion' (SEforALL, Vienna, and Washington, DC. 2017) <https://www. seforall.org/sites/default/files/Opening_Doors-Full.pdf> accessed 3 August 2023.

[10] Hosier Richard, Kappen Jan, Hyseni Besnik, Tao Nuyi, Usui Kenta 'Scalable Business Models for Alternative Biomass Cooking Fuels and Their Potential in Sub-Saharan Africa' (World Bank, Washington, DC. 2017) < http://hdl.handle.net/10986/28595> accessed 3 August 2023.

[11] Africa Development Bank 'Light up and power Africa: A new deal on Energy for Africa' (Africa Development Bank Group 2019), <https://www.afdb.org/en/the-high-5/light-up-and-power-africa-%E2%80%93-a-new-deal-on-energy-for-africa> accessed 3 August 2023.

funding from the national governments within many SSA nations. Meanwhile, domestic financing remains the principal avenue for infrastructure funding, drawing from public funds as delineated in yearly capital budgets[12]. Nevertheless, even with notable domestic allocations toward energy initiatives, a notable shortfall remains evident. The considerable limitations imposed by tight budgetary considerations and the presence of competing expenditure priorities have rendered it exceptionally challenging for these nations to earmark the requisite resources for funding the essential energy infrastructure needed to elevate their quality of life[13].

This highlights the fact that solely relying on limited national government funds and domestic private investment will not suffice to address SSA's energy crisis. A comprehensive solution necessitates considering alternative financing sources as supplementary measures. The focus is now increasingly shifting towards the potential role of external funding to support sustainable energy development in SSA. However, despite a substantial influx of external financing into the region in the last 20 years, SSA remains confronted with a significant infrastructure shortfall. The central question revolves around evaluating the extent to which the increased influx of external funding translates into improved energy accessibility within SSA. To contribute to the body of research already in existence, the present study delves into the link between external financing policies (FDI, ODA, and PPI) and sustainable energy development in SSA and understanding the direction of causality between these two factors.

Even though there are studies that have examined the determinants of various energy indicators[14] [15] [16] [17] [18], there are very few studies that considered the link

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[12] Infrastructure Consortium for Africa (ICA) 'Annual Report: Financial Commitments and Disbursements for Infrastructure in Africa' (Tunis, Tunisia: ICA Secretariat 2010) https://www.icafrica.org/fileadmin/documents/2011/ICA_AR_2010_final_optimised.pdf accessed 15 July 2023.

[13] Africa Development Bank 'Light up and power Africa: A new deal on Energy for Africa' (Africa Development Bank Group 2019), <https://www.afdb.org/en/the-high-5/light-up-and-power-africa-%E2%80%93-a-new-deal-on-energy-for-africa> accessed 3 August 2023.

[14] Paramati Sudharshan Reddy, Bhattacharya Mita, Ozturk Ilhan and Zakari Abdulrasheed 'Determinants of Energy Demand in African Frontier Market Economies: An Empirical Investigation' (2018) 148, 123-133 Energy <https://doi.org /10.1016/j. energy.2018.01.146> accessed 15 July 2023.

between external financing policies and sustainable energy development, most especially in the context of SSA. Among the very few ones that looked into this can be found in the work of Amadou and Mariama[19], Wang, Jiaqi, and Zequn[20], and Chapel[21]. However, Amadou and Mariama paid too much attention to the indirect effects of FDI and ODA on energy development through governance indicators rather than their direct effects on energy development in SSA[22]. Also, both Wang et al. and Chapel only focus on ODA and renewable energy [23] [24]. The present study, therefore, improves the

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15 Bikrat, Fatiha and Mohamed Karim 'Key Determinants of Energy Demand: Case of Morocco' (2019) 11(5), 50-58, International Journal of Economics and Finance, <DOI: 10.5539/ijef.v11n5p50> accessed 3 August 2023.

16 Otsuka Akihiro 'Determinants of Energy Demand Efficiency: Evidence from Japan's Industrial Sector' (2020) 1-19, Energy Policy, <http://dx.doi.org/10.5772/intechopen.81482> accessed 15 July 2023.

17 Dokas Ioannis, Panagiotidis Minas, Papadamou Stephanos and Spyromitros Eleftherios 'The Determinants of Energy and Electricity Consumption in Developed and Developing Countries: International Evidence' (2022) 15, 1-30, 2558, Energies <https://doi.org/10.3390/en15072558> accessed 15 August 2023.

18 Dokas Ioannis, Panagiotidis Minas, Papadamou Stephanos and Spyromitros Eleftherios 'The Determinants of Energy and Electricity Consumption in Developed and Deve loping Countries: International Evidence' (2022) 15, 1-30, 2558, Energies <https://doi.org/10.3390/en15072558> accessed 15 August 2023.

19 Amadou Sy and Mariama Sow 'Does Good Governance Matter more for Energy Investment? Evidence from Sub-Saharan Africa' (2019) 28, AERC Supplement 1, i16 –i40, Journal of African Economies, <DOI: 10.1093/jae/ejy023> accessed 15 July 2023.

20 Wang Qiang, Guo Jiaqi, and Dong Zequn 'The Positive Impact of Official Development Assistance (ODA) on Renewable Energy Development: Evidence from 34 Sub-Saharan African Countries' (2021) 28, 532–542 Sustainable Produc tion and Consump tion, <DOI:10.1016/j.spc.2021.06.007> accessed 15 July 2023.

21 Chapel, Capucine 'Impact of Official Development Assistance Projects for Renewable Energy on Electrification in Sub-Saharan Africa' (2021) 152, 105784, World Development, <DOI:10.1016/j.worlddev.2021.105784> accessed 15 August 2023.

22 Amadou Sy and Mariama Sow 'Does Good Governance Matter more for Energy Investment? Evidence from Sub-Saharan Africa' (2019) 28, AERC Supplement 1, i16 –i40, Journal of African Economies, <DOI: 10.1093/jae/ejy023> accessed 15 July 2023.

23 Wang Qiang, Guo Jiaqi, and Dong Zequn 'The Positive Impact of Official Development Assistance (ODA) on Renewable Energy Development: Evidence from 34 Sub-Saharan African Countries' (2021) 28, 532–542 Sustainable Production and Consum ption, <DOI:10.1016/j.spc.2021.06.007> accessed 15 July 2023.

prior studies on the connection between external financing and sustainable energy development by considering different indicators of external financing policies (ODA, FDI, and PPI). In addition, this is also improved by considering new methodologies as well as extending the scope of the existing studies.

Four key sections comprise the remainder of the study. An extensive examination of external financing and its influence on energy is presented in Section 2 through a comprehensive literature review. Section 3 outlines the methodology that has been adopted to evaluate this relationship. Subsequently, Section 4 unveils the data and empirical outcomes derived from the utilization of the panel ARDL methodology to achieve the objectives. Lastly, in Section 5, the study is brought to a conclusion, accompanied by policy suggestions rooted in the discovered outcomes.

2. THE CONCEPT OF ENERGY INFRASTRUCTURE: A REVIEW OF THE LITERATURE

Energy infrastructure encompasses the tangible elements, organizational frameworks, policies, and rules that facilitate the generation, conveyance, and allocation of energy resources. This encompasses the entirety of energy origins, including oil, wind, solar, gas, coal, hydro, and nuclear. The essential of energy infrastructure lies in its pivotal function in bolstering economic expansion, social advancement, and ecological equilibrium. This is due to energy's foundational role as a critical input for nearly all economic pursuits and human necessities[25]. When used wisely, a variety of foreign financial sources known as "external financing" can help recipient countries advance. They include private commercial and non-commercial inflows, including those from non-governmental organizations, as well as official bilateral and multilateral sources[26]. Developing economies, especially those within SSA, are particularly vulnerable to the forces of rapid urbanization, economic

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[24] Chapel, Capucine 'Impact of Official Development Assistance Projects for Renewable Energy on Electrification in Sub-Saharan Africa' (2021) 152, 105784, World Development, <DOI:10.1016/j.worlddev.2021.105784> accessed 15 August 2023.

[25] International Energy Agency (IEA) 'Energy infrastructure' (2021) <https://www.iea.org/topics/energy-infrastructure> accessed 3 August 2023.

[26] Odedokun Matthew 'Sustainability of External Development Financing to Developing Countries' (World Institute for Development Economic Research - UNU-WIDER, Policy Brief No. 9, United Nations University, 2004) <https://digital library.un.org/record/536044> accessed 3 August 2023.

growth, and the ensuing megatrends linked to burgeoning populations. These circumstances inherently amplify the demand for meticulous energy strategizing and implementation. The importance of external funding sources for infrastructure development is becoming more and more apparent as governments struggle with resource constraints. They are becoming more important in enhancing government funding and ensuring the long-term viability of development initiatives[27].

Evidence from the previous studies on energy shows that most of the studies concentrated on the economic effect of energy infrastructure and facilities[28] [29] [30]. Others examined the determinants of energy consumption[31] [32]. Another area in energy studies that has been given consideration is the studies that investigated the determinants of energy demand[33] [34].

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[27] Gravito Luis, Haddon Jared, Alli Andrew and Usanase Alice 'Infrastructure Financing in Sub-Saharan Africa: Best Practices from Ten Years in the Field' (Boston Consulting Group and Africa Finance Corporation 2017) https://www.africafinlab.com/sites/default/files/2018-06/3_Infrastructure%20Financing%20in%20Sub-Saharan%20 Africa.pdf> accessed 3 August 2023.

[28] Lukoševičius, Ignas 'Electric Energy Sector's Infrastructure Impact on Econo mic Growth , Applied Economics: Systematic Research' (2021), <10.7220/ aesr.2335.8742.2020.14.1.1> accessed 15 July 2023

[29] Ogunjobi Olufemi, Eseyin Oluwasegun and Oladipo Olabisi Rasheedat 'Human Capital and Energy Infrastructure: Implications for Economic Growth in Nigeria' (2021) International Journal of Energy Economics and Policy, <DOI: 10.32479/ijeep.10066> accessed 3 August 2023.

[30] Zulfikar Zulfikar, Sofyan Syahnur and Shabri Abd Majid 'The Effect of Energy Consumption, Energy Resources, Economic Growth, and Road Infrastruc ture on Co2 Emissions in Indonesia' (2021) International Journal of Quantitative Research and Modeling, < 10.46336/ijqrm.v2i3.173> accessed 15 July 2023.

[31] Keho Yaya 'What Drives Energy Consumption in Developing Countries? The Experience of Selected African Countries' (2016) 91, 233–246, Energy Policy, <DOI :10.1016/j.enpol.2016.01.010> accessed 15 July 2023.

[32] Ogunsola Akindele John and Tipoy Christian Kakese 'Determinants of Energy Consumption: The Case of African Oil Exporting Countries' (2022) 10(1), 2058157, Cogent Economics & Finance, <DOI: 10.1080/23322039.2022.2058157> accessed 15 July 2023.

[33] Paramati Sudharshan Reddy, Bhattacharya Mita, Ozturk Ilhan and Zakari Abdulrasheed 'Determinants of Energy Demand in African Frontier Market Economies: An Empirical Investigation' (2018) 148, 123-133 Energy <https://doi.org/10.1016 /j.energy.2018.01.146> accessed 15 July 2023.

In the search for alternative sources of energy, certain researchers have also concentrated on the drivers of renewable energy[35] [36] [37] where they all reported that factors such as economic growth, population growth, governance, urbanization, and trade openness all influence renewable energy. However, even though there are several studies on energy, there is a dearth of studies on energy development and external financing factors. Although some studies have considered the impact of FDI on energy development[38] [39], many of them have paid little attention to other external financing policies like ODA and PPI most especially in SSA.

Thus, among the very few studies that focus on energy development and external financing policies (FDI and ODA) recently include the work of Amadou and Mariama that examines the interactions between institutional quality, financial development, and energy access for 46 SSA countries from 1996 to 2014, using descriptive and correlation analyses to analyze the data[40].

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[34] Bikrat, Fatiha and Mohamed Karim 'Key Determinants of Energy Demand: Case of Morocco' (2019) 11(5), 50-58, International Journal of Economics and Finance, <DOI: 10.5539/ijef.v11n5p50> accessed 3 August 2023.

[35] Gershon Obindah and Emekalam Peter 'Determinants of Renewable Energy Consum ption in Nigeria: A Toda Yamamoto Approach' (2021) 665, 1-10, 012005, International Conference on Energy and Sustainable Environment, <DOI:10.1088/1755-1315/665/ 1/012005> accessed 15 August 2023.

[36] Rashed Ahmed, Yong Chen-Chen and Soon Siew-Voon 'Determinants of Renewable Electricity Generation in Africa: A Focus on Foreign Direct Investment' (2022) 14, 370–403 Africa Review <DOI:10.1163/09744061-tat00006> accessed 15 July 2023.

[37] Lawal Adedoyin Isola 'Determinants of Renewable Energy Consumption in Africa: Evidence from System GMM' (2023) 16, 2136, Energies, <https://doi.org /10.33 90/en16052136> accessed 15 July 2023.

[38] Kwakwa Paul Adjei, Adusah-Poku Frank, and Adjei-Mantey Kwame 'Towards the Attainment of Sustainable Development Goal 7: What Determines Clean Energy Accessibility in Sub-Saharan Africa?' (2021) 3(3), 268-286, AIMS Press < https://www.aimspress.com/article/doi/10.3934/GF.2021014>

[39] Pan Xuanming, Dossou Toyo Amègnonna Marcel, Berhe Mesfin Welderufael and Kambaye Emmanuelle Ndomandji 'Towards Efforts to Promote Renewable Energy Development in Africa: Does Governance Quality Matter?' (2022) 0(0), 1-16, Energy & Environment <DOI: 10.1177/0958305X221120259> accessed 15 July 2023.

[40] Amadou Sy and Mariama Sow 'Does Good Governance Matter more for Energy Investment? Evidence from Sub-Saharan Africa' (2019) 28, AERC Supplement 1, i16 –i40, Journal of African Economies, <DOI: 10.1093/jae/ejy023> accessed 15 July 2023.

The results of their findings revealed that although good governance can increase domestic revenue, its influence on external funding sources differs. Except for political stability, good governance positively influences FDI in oil-importing countries but does not affect the attraction of FDI in oil-exporting nations. However, a favourable association was found between ODA and good governance. They also stated that improving governance has a great domestic influence, resulting in increased tax revenues.

Also, Wang, Guo, and Dong investigate the ODA impacts on the development of renewable energy across thirty-four Sub-Saharan African nations. Their findings unveiled that throughout the early phases of technological advancement and societal structural changes, ODA positively influenced renewable energy development. Nonetheless, when urbanisation and carbon dioxide intensity were beyond predefined limits, there was a downward trend in the effect of ODA on renewable energy development[41]. Similarly, Chapel investigates the influence of aid in renewable energy initiatives conducted across nineteen SSA nations, with a focus on the enhancement of electricity access within local communities. Employed diverse propensity score matching methodologies, and their findings revealed that these programs had a positive and significant influence on community electrification[42]. The same sample was used for a comparative analysis that contrasted the results of renewable and non-renewable energy initiatives. However, the effectiveness of these initiatives varied and was dependent on variables like the source, organization, the region's original state of development, and its location.

3. METHODOLOGY

3.1 Theoretical Framework and Model Specification

Evidence from most of the previous studies on energy has shown that either demand/consumption or supply theories are considered the theoretical

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[41] Wang Qiang, Guo Jiaqi, and Dong Zequn 'The Positive Impact of Official Development Assistance (ODA) on Renewable Energy Development: Evidence from 34 Sub-Saharan African Countries' (2021) 28, 532–542 Sustainable Production and Consump tion, <DOI:10.1016/j.spc.2021.06.007> accessed 15 July 2023.

[42] Chapel, Capucine 'Impact of Official Development Assistance Projects for Renewable Energy on Electrification in Sub-Saharan Africa' (2021) 152, 105784, World Development, <DOI:10.1016/j.worlddev.2021.105784> accessed 15 August 2023.

foundations of their studies[43] [44]. However, since the present study focuses on sustainable energy development in SSA, the objective is achieved by exploring the related theories in addition to the related empirical literature. These offer different perspectives on the major postulated determinants of energy development. Specifically, the empirical model for the present study follows the study of Da Silva *et al.*[45] and Pan *et al.*[46] with modifications which is stated as:

$$END_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 ODA_{it} + \beta_3 PPI_{it} + \varepsilon_{it} \text{ .....(1)}$$

where *END* represents sustainable energy development which is proxy by the energy use (kg), external financing policies (*FDI, ODA,* and *PPI*, all expressed as a percentage of GDP), ε is the residual, *i* is 43 SSA countries, and *t* represents the time from 2000 to 2021. Based on the theoretical and empirical evidence, it is anticipated that every explanatory variable will have a positive influence on sustainable energy development in SSA.

3.2 Analytical Techniques

A variety of statistical methods, such as panel data regression analysis, correlation analysis, and descriptive analysis, were used in this study. To validate the panel regression estimations, pre-estimation procedures like cointegration and unit root tests were performed. Panel ARDL model is employed in this study, a panel data regression technique that makes it

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[43] Kwakwa Paul Adjei, Adusah-Poku Frank, and Adjei-Mantey Kwame 'Towards the Attainment of Sustainable Development Goal 7: What Determines Clean Energy Accessibility in Sub-Saharan Africa?' (2021) 3(3), 268-286, AIMS Press < https://www.aimspress.com/article/doi/10.3934/GF.2021014>

[44] Rashed Ahmed, Yong Chen-Chen and Soon Siew-Voon 'Determinants of Renewable Electricity Generation in Africa: A Focus on Foreign Direct Invest ment' (2022) 14, 370–403 Africa Review <DOI:10.1163/09744061-tat00006> accessed 15 July 2023.

[45] Da Silva, Patrícia Pereira, Cerqueira Pedro André, and Ogbe Wojolomi 'Determinants of Renewable Energy Growth in Sub-Saharan Africa: Evidence from Panel ARDL' (2018) Energy, <DOI: 10.1016/j.energy.2018.05.068> accessed 15 August 2023.

[46] Pan Xuanming, Dossou Toyo Amègnonna Marcel, Berhe Mesfin Welderufael and Kambaye Emmanuelle Ndomandji 'Towards Efforts to Promote Renewable Energy Development in Africa: Does Governance Quality Matter?' (2022) 0(0), 1-16, Energy & Environment <DOI: 10.1177/0958305X221120259> accessed 15 July 2023.

possible to estimate the short- and long-run associations. This model was chosen because of its many benefits, such as its adaptability to varying sample sizes, its capacity to handle time series of different orders, and its ability to deal with endogeneity problems by appropriately choosing the lags for the dependent variable and regressors[47] [48]. Panel ARDL model's equation is written as:

$$\Delta END_{it} = \alpha_i(END_{i,t-1} - \theta_i' X_{i,t}) + \sum_{m=1}^{a=1} \Psi_{im} \Delta_i END_{i,t-m} + \sum_{m=0}^{b-1} \beta_{im}^{1} \Delta X_{i,t-m} + \omega_i + e_{it} \ldots (2)$$

where $\alpha_i = (1 - \delta_i)$, is the coefficient of the group-specific speed of adjustment $(\alpha_i < 0)$, θ_i' is the vector of long-run relationship, $ECM = (END_{i,t-1} - \theta_i' X_{i,t})$ represents error correction term, ξ_{im}, β_{im}^{1} represents coefficients of the short-run dynamic. PARDL model is stated as:

$$\Delta END_{it} = \alpha_0 + \theta_1 X_{it-1} + \sum_{m=0}^{a} \beta_{1im} \Delta END_{it-1} + \sum_{m=0}^{a} \beta_{2im} \Delta FDI_{it-1} + \sum_{m=0}^{a} \beta_{3im} \Delta ODA_{it-1} + \sum_{m=0}^{a} \beta_{4im} \Delta PPI_{it-1} + \varepsilon_{it} \ldots\ldots\ldots (3)$$

where $X_{it-1} = (END_{it-1} - \theta_1 FDI_{it} - \theta_2 ODA_{it} - \theta_3 PPI_{it})$, methods used in this study include the mean group - MG, dynamic fixed effect - DFE, and pooled mean group - PMG variants of Panel ARDL. While long-term homogeneity is presumed, country-specific variability is anticipated in the short term due to local rules. For this analysis, the PMG estimator is therefore considered to be more effective than the MG and DFE estimators[49]. The Hausman test is also employed to ascertain the most suitable technique. The PMG estimator is chosen as the most effective if the null hypothesis, which states "that there is no systematic difference between the DFE and PMG estimators", is accepted. Conversely, other estimators are taken into consideration if the null hypothesis is rejected.

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47 Pesaran, M. H., Shin, Y. & Smith, R. (2001). Bound testing approaches to the analysis of level relationships, Journal of Applied Econometrics 16, 289-326, http://doi.org /10.1002/jae.616

48 Adebayo Augustine Kutu and Harold Ngalawa 'Dynamics of Industrial Pro duction in BRICS Countries' (2016) 8(1), 1-25, International Journal of Economics and Finance Studies, https://dergipark.org.tr/en/download/article-file/256523 accessed 15 July 2023.

49 Blackburne Edward and Frank Mark 'Estimation of nonstationary heterogeneous panels' (2007) 7(2), 197-208, The Stata Journal, <https://journals.sagepub. com/doi/pdf/10.1177/1536867X0700700204> accessed 3 August 2023.

3.3 Sources of Data, Location, and Scope of the Study

Data for 43 SSA countries from 1990 to 2021 were obtained from reliable international organizations. This period is justified by the numerous liberations in the energy sector that have taken place, the increased inflow of external financing to SSA countries within the timeframe, and the expansion of the time frame that has been addressed in earlier research on the topic. The International Monetary Fund - IMF, the World Bank's World Development Indicator - WDI, and the International Energy Agency - IEA are the data's primary sources.

4. PRESENTATION EMPIRICAL RESULTS

4.1 Descriptive and Correlation Analyses

Table 1 displays the panel series variables' summary statistics. The first column displays the statistic's values, and the following columns show energy development (END), FDI, ODA, and PPI, in that order: second, third, fourth, and fifth. The results from Table 1 reveal that the mean energy development in SSA is 666.58 with a median of 444.02, a maximum of 6389.61, and the country with the lowest development of 8.92. While the mean and median of FDI are 0.19 and 0.11 per cent, and the values of the maximum and minimum are 6.94 and 0.01 per cent. The mean percentage of official development assistance is 8.74 per cent, with a median percentage of 0.11 percent, a maximum percentage of 9.10 per cent, and a minimum percentage of 0.05 per cent.

The mean private participation in infrastructure in the region is 0.56 with a median of 0.11 percent. Its maximum and minimum values are 9.46 and 0.01 per cent respectively. The values of the standard deviation for the variables are moderate except for the very large energy development. This suggests that there is a broad spectrum of value associated with energy development. The variables exhibit high kurtosis and positive skewness, indicating that the distributions are peaked and strongly skewed. The variables' very significant Jarque-Bera test results further imply that the variables are not often distributed.

Correlation results in the lower part of Table 1 further show that energy development is positively correlated with FDI and private participation in infrastructure, but has a negative correlation with official development assistance. With their correlation coefficients being less than 0.8, this indicates

that none of the explanatory variables are correlated. The likelihood of the absence of severe multicollinearity in the model indicates that the model estimated with the variables utilised in this study is consequently free of a substantial multicollinearity issue[50].

Table 1: Descriptive and Correlation Analyses

Variables	END	FDI	ODA	PPI
Mean	666.58	0.19	8.74	0.56
Median	444.02	0.11	6.52	0.11
Maximum	6389.61	6.94	9.14	9.46
Minimum	8.92	0.01	0.05	0.01
Std. Dev.	772.59	0.32	1.09	1.12
Skewness	2.97	11.85	3.39	3.65
Kurtosis	13.98	218.06	24.74	19.34
Jarque-Bera	6602.78	1983563.01	21992.17	13568.62
Probability	0.00	0.00	0.00	0.00
Observations	1017	1017	1017	1017
Correlation Matrix				
END	1.00 -----			
FDI	0.19 (0.00)	1.00 -----		
ODA	-0.10 (0.00)	-0.03 (0.32)	1.00 -----	
PPI	0.22 (0.00)	0.05 (0.09)	0.13 (0.00)	1.00 -----

Source: Authors' Computations (2023)

4.2 Unit Root and Cointegration Tests

To prevent the consequences of spurious regression findings coming from the ordinary least squares (OLS) approach with non-stationary series, Table 2 presents the results of the unit root test, which is used to ascertain whether or not each of the model's variables is stationary. Unit root test results indicate that only FDI is stationary in the first difference and the level form, whereas PPI, ODA, and END are stationary in the first difference form only.

[50] Asteriou, Dimitrios & Hall Stephen, Applied Econometrics (Third Edition, Macmillan Education, Palgrave 2011).

Table 2: Unit roots test

Series	Stationary	PP- Fisher	ADF- Fisher	LLC	Breitung	IPS
FDI	Level	143.06*** (0.00)	118.96*** (0.00)	-3.81*** (0.00)	-1.34* (0.09)	-4.16*** (0.00)
	First Diff.	218.63*** (0.00)	58.63*** (0.00)	-17.29*** (0.00)	-14.82*** (0.00)	-20.26*** (0.00)
END	Level	35.76 (0.99)	35.40 (0.99)	1.15 (0.88)	3.10 (0.99)	3.57 (0.99)
	First Diff.	910.08*** (0.00)	241.73*** (0.00)	-1.60* (0.06)	-7.10*** (0.00)	-10.67*** (0.00)
ODA	Level	157.90*** (0.00)	79.90* (0.09)	-1.54* (0.06)	1.88 (0.97)	-1.22 (0.11)
	First Diff.	3221.73*** (0.00)	381.27*** (0.00)	-8.18*** (0.00)	-1.45* (0.07)	-16.93*** (0.00)
PPI	Level	49.13 (0.92)	45.22 (0.96)	-0.44 (0.33)	4.84 (1.00)	6.40 (1.00)
	First Diff.	948.99*** (0.00)	200.88*** (0.00)	-4.74*** (0.00)	-5.77*** (0.00)	-8.15*** (0.00)

Source: Authors' Computations (2023). Notes: Breitung and Im-Pesaran-Shin (IPS), Levin-Lin-Chu (LLC), PP-Fisher, ADF-Fisher, (Null: Panels include unit roots). The p-values of the test statistic are represented in parenthesis ( ); ***, **, and * imply rejection of the null hypothesis at the 1, 5, and 10% significance levels, respectively.

Hence, the series are integrated of various orders, i.e. combining of I(0) and I(1). To determine if cointegration between energy development and external financing exists, the Pedroni cointegration test is used. In light of this, the Pedroni cointegration test was carried out using the model specification's cointegration tests for long-run equilibrium. The null hypothesis of no cointegration is refuted by the empirical results shown in Table 3. Strong evidence that every panel in the data is cointegrated is provided by the five test statistics shown in the table. This shows that energy development and external financing have a long-term connection in SSA.

Table 4: Panel Cointegration Test

Tests Statistics	t-statistic	p-value
Modified Phillips-Perron	7.30***	0.00
Phillips-Perron	3.49***	0.00
Augmented Dickey-Fuller	4.68***	0.00

Source: Authors' Computations (2023). Notes: Null: No Cointegration. At a 1% significance level, *** denotes the null hypothesis' rejection.

4.3 Presentation Panel ARDL Results

In keeping with the aims of this study, which include estimating the influence of external funding on SSA's sustainable energy development. The panel ARDL variants (MG, PMG, and DFE) are found to be the most suitable method for the estimate and analysis of the model after investigating the various tests. Consequently, the MG, PMG, and DFE long- and short-term estimates are shown in Table 5. Alongside the estimating findings, Hausman specification results were also presented to determine the most appropriate among these three estimators, the result of which is then interpreted and discussed.

The effects of external financing policies on Sub-Saharan Africa's energy development are seen in Table 5. The choice between the MG and PMG variations yields a statistic value of 0.141 with a p-value of 1.000 from the Hausman test results. The value of the Husman test for deciding between the DFE and PMG estimates is 0.094 with a probability value of 1.000. "The PMG is preferable to MG" and "the PMG is preferable to DFE" are the null hypotheses of choice between the MG and PMG and the DFE and PMG, respectively. Since the Hausman test's statistic is not significant in the two hypotheses, the null hypothesis could not be refuted, thus, the PMG approach is more appropriate than the MG and DFE. The outcome of the PMG approach is therefore the most appropriate one.

Table 5: Sustainable Energy Development Model

Variable	PMG			MG			DFE		
	Coef.	z-stat.	p-value	Coef.	z-stat.	p-value	Coef.	z-stat.	p-value
				0.812					
FDI	86.993***	8.341	0.000	-50.913	-1.13	0.258	66.016	0.24	
ODA	-0.102***	-5.978	0.000	2.694	1.07	0.285	-60.189***	-3.34	0.001
PPI	17.519***	6.126	0.000	93.241	1.04	0.298	23.265***	3.43	0.001
Short Run Estimates									
ECT	-0.085***	2.890	0.004	-0.204***	-7.01	0.000	-0.074***	-7.77	0.000
ΔFDI	19.068	0.073	0.942	101.401	0.25	0.806	-0.099	-0.00	0.996
ΔODA	0.117	1.328	0.185	-0.256	-1.16	0.244	3.705	0.22	0.824
ΔPPI	-29.367	-1.142	0.254	14.049	1.02	0.306	-1.984	-0.37	0.713
Constant	58.092***	2.720	0.007	94.338**	2.28	0.022	182.033***	4.62	0.000
Observations	985			985			985		
Number of Groups	32			32			32		
Hausman test				0.141		1.000		0.094	1.000

Source: Authors' computation and analysis of data (2023). Note: ΔFDI, ΔODA, and ΔPPI are short-run values for FDI, ODA, and PPI respectively, At 10, 5, and 1% significance levels, the null hypothesis is rejected, as indicated by the symbols *, **, and ***.

4.4 Discussion of Empirical Results

The long-run estimations are displayed in the top section of Table 5 based on the PMG results, which represent the relationship between sustainable energy development and external financing policies (FDI, ODA, and PPI). According to the long-run estimates, the coefficients of FDI and private participation in infrastructure are significant and positive, while the coefficient of ODA is significant and negative. This suggests that foreign direct investment and private participation in infrastructure have positive impacts on energy development in SSA, while the development of energy is negatively impacted by official development assistance. A 1 per cent rise in foreign direct investment and private infrastructure investment are linked to 86.9 and 17.5 per cent rise in energy development in SSA, respectively, as demonstrated by their coefficients. While a 1 per cent decrease in official development assistance is associated with an increase in energy development in SSA by 0.1 per cent. The observed positive effects of FDI and private participation in infrastructure are in support of the theories and with results from a few prior studies like Kwakwa *et al.*[51] and Pan *et al.*[52] among others. The observed negative effects of official development assistance contradict the *a priori* expectation as well as the studies conducted by Amadou and Manama and Chapel [53] [54]. Contrarily, this is consistent with the study Wang *et al.* conducted[55].

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[51] Kwakwa Paul Adjei, Adusah-Poku Frank, and Adjei-Mantey Kwame 'Towards the Attainment of Sustainable Development Goal 7: What Determines Clean Energy Accessibility in Sub-Saharan Africa?' (2021) 3(3), 268-286, AIMS Press < https://www. aimspress.com/article/doi/10.3934/GF.2021014>

[52] Pan Xuanming, Dossou Toyo Amègnonna Marcel, Berhe Mesfin Welderufael and Kambaye Emmanuelle Ndomandji 'Towards Efforts to Promote Renewable Energy Development in Africa: Does Governance Quality Matter?' (2022) 0(0), 1-16, Energy & Environment <DOI: 10.1177/0958305X221120259> accessed 15 July 2023.

[53] Amadou Sy and Mariama Sow 'Does Good Governance Matter more for Energy Investment? Evidence from Sub-Saharan Africa' (2019) 28, AERC Supplement 1, i16 –i40, Journal of African Economies, <DOI: 10.1093/jae/ejy023> accessed 15 July 2023.

[54] Chapel, Capucine 'Impact of Official Development Assistance Projects for Renewable Energy on Electrification in Sub-Saharan Africa' (2021) 152, 105784, World Development, <DOI:10.1016/j.worlddev.2021.105784> accessed 15 August 2023.

[55] Wang Qiang, Guo Jiaqi, and Dong Zequn 'The Positive Impact of Official Development Assistance (ODA) on Renewable Energy Development: Evidence from 34 Sub-Saharan African Countries' (2021) 28, 532–542 Sustainable

The bottom section of the table shows the short-run estimates, which represent the connection between the development of energy and external financing policies over the short run. In addition to the external financing policies used in the long-term estimates, the short-term estimates also include error correction term (ECT), which captures the short-term dynamics of the connection between energy development and external financing factors. According to the short-run estimates, the ECT coefficient is negative and statistically significant at a 1% level, with a probability value of 0.000. This implies that there is a tendency for energy development to return to its long-run equilibrium level in the short run, with a rate of adjustment of 8.5 percent. Also, the coefficients of FDI and ODA are positive but statistically insignificant, while the coefficient of PPI is statistically insignificant and negative. This indicates that external financing policies do not have a significant impact on energy development in the short run in SSA.

4.5 Policy Recommendations

Findings from this study contribute to the existing studies on the subject matter and offer valuable insights for policymakers and stakeholders involved in energy development and financing in SSA. The positive long-term association between sustainable energy development and external financing, mainly FDI and PPI, underscores the necessity to attract and hold these types of investments through policies. Governments should work on fostering an optimal investment climate for private and international stakeholders by providing a stable regulatory environment, cutting red tape, and putting incentives for green energy projects. The adverse effect of ODA on energy development suggests a call for a variegated review of current aid strategies and their implementation frameworks. Policymakers should not consider ODA as an instrument for promoting sustainable energy infrastructure and instead channel efforts towards attracting more sustainable and impactful investments.

Theoretically, these empirical results also make a substantial theoretical contribution to our understanding of the interplay between external financing and the growth of sustainable energy in SSA. They offer evidence in favour of the theory that long-term sustainable energy development is greatly aided by external financing, especially FDI and PPI. This is consistent with theories of developmental finance, such as the Two-Gap Theory, which holds

Production and Consumption, <DOI:10.1016/j.spc.2021.06.007> accessed 15 July 2023.

that long-term development, such as energy infrastructure, depends on sustainable investments from private and foreign sources. On the other hand, the detrimental effects of ODA on energy development cast doubt on the efficacy of aid, indicating that depending solely on ODA may not always result in the development of sustainable energy infrastructure. Additionally, the short-term results, which demonstrate a considerable and negative ECT, suggest that short-term strategies have to focus on stabilizing the energy sector in order to facilitate its long-run equilibrium. This can be accomplished by taking short-term fiscal policies that protect the industry from shocks to the global economy, providing short-term funding for emergency infrastructure repairs, and addressing current issues without compromising long-term objectives.

5 CONCLUSION

Sub-Sahara Africa faces a hindrance in energizing its residences and enterprises due to the absence of both the technical expertise and financial capabilities required to tap into these abundant resources. Domestic financing remains the principal avenue for infrastructure funding, but grossly inadequate to address SSA's energy crisis. In search for a comprehensive solution necessitates considering alternative financing sources as supplementary measures, the focus is now increasingly shifting toward the potential role of external funding to support sustainable energy development in SSA. However, despite a substantial influx of external financing into the region over the past two decades, SSA remains confronted with a significant infrastructure shortfall. To contribute to the body of prior research, the present study delved into the link between external financing policies (FDI, ODA, and PPI) and the development of sustainable energy in SSA.

Using annual panel data (1990 – 2021) for the selected African countries. The panel autoregressive distributed lag variants (PMG, MG, and DFE) estimate approach is used to assess the contribution of external financing policies on sustainable energy development. Overall, PMG analysis is chosen over MG and DFE which provides evidence that energy development in SSA is positively influenced by foreign direct investment and private participation in infrastructure in the long term, whereas official development assistance has a negative effect. In the short-run, all the external financing factors have no appreciable effect on energy development in SSA.

From the PMG analysis, generally, it is clear that sustainable energy development and external funding policies have a substantial and favourable

long term relationship, but external financing has no impact on energy development in SSA in the short term. Specifically, both foreign direct investment and private participation in infrastructure have a positive effect on energy development in the long term, whereas official development assistance has an adverse effect on energy development. Additionally, the short-term estimates reveal that the ECT is statistically significant and negative, suggesting a tendency for the energy development to return in the short run to its long-run equilibrium level at 8.5 per cent.

In light of the study's conclusion and empirical results, given the observation that both foreign direct investment and private participation in infrastructure promote energy development in SSA, there is a need for the governments of SSA countries to create an enabling environment that will encourage both the foreign and domestic private investors to partner with state actors in investing more on energy infrastructure. Also, since evidence from the study shows that ODA has an adverse influence on energy development in SSA, it is therefore recommended that authorities involved should desist from using ODA for promoting energy development in SSA but rather exploit the opportunities in other external financing factors and look inward towards encouraging local content for the sustainable energy development. Finally, it is important to recognize the short-run dynamics of sustainable energy development and take measures to ensure that it stays on track toward its long-run equilibrium level. This can be achieved through policies that promote stability and sustainable energy development.

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7. CONFLICTS OF INTEREST

We hereby state that we have no competing interests concerning this research.