# Renewable Energy Transition: A Study on the impact of ODA, Public Investment, and FDI in Africa

By

**MUSE, Abshir Yonis**

**THESIS**

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

**MASTER OF DEVELOPMENT POLICY**

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Committee in charge:

Professor Tabakis, Chrysostomos, Supervisor ______________________

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Professor Lee, Dongil ______________________

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## ABSTRACT

**RENEWABLE ENERGY TRANSITION IN AFRICA: STUDY ON THE IMPACT OF ODA, PUBLIC INVESTMENT, AND FDI**

By

MUSE, Abshir Yonis

This thesis investigates the influence of Official Development Assistance (ODA), public investment, and foreign direct investment (FDI) on Africa's transition to renewable energy. The study employs a natural logarithmic transformation and utilizes both simple linear regression and multiple panel ARDL models to examine the causal effects. The analysis reveals a positive and statistically significant association between ODA and the transition to renewable energy, with a 1% increase in ODA corresponding to a 0.07% increase in the share of renewable energy in total consumption. Control variables, such as GDP growth rates, also indicate a positive impact on the transition. The findings align with previous research on economic growth and electricity consumption. However, public investment and FDI do not show significant impacts on renewable energy consumption.

Based on the results, policy recommendations are provided. It is crucial to address disparities in investment outcomes to maximize the effectiveness of ODA in facilitating the transition to renewable energy sources in Africa. Cross-regional policy targets should be prioritized. Additionally, the study highlights the need to reassess investments made by African economies in renewable energy sources, which have yielded insignificant effects so far.

**JEL Codes:**

**Keywords:** Korea. Access to clean energy, renewable energy transition, Renewable Energy, public investment, financial subordination, trade openness

*Dedicated to my beloved parents*

**Yonis Muse Osman & Maryan Mohamed Abdi**

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Globally, energy is an essential catalyst in facilitating socio-economic progress, poverty alleviation, and quality of life (Salite et al., 2021). Its impact extends to various aspects of life, including improved manufacturing capabilities, enhanced telecommunications and business opportunities, and access to domestic lighting and refrigeration. These factors contribute to better employment prospects, higher income levels, improved social connections, access to healthcare, and opportunities for night-time education. However, mounting concerns about climate change and environmental degradation, coupled with the surge in oil prices, have posed significant challenges to conventional energy sources. In fact, the global economy is forecasted to undergo a substantial contraction of more than eighteen percent in its Gross Domestic Product (GDP) as a consequence of the repercussions arising from climate change (Sweerts et al., 2019). Geopolitical tensions, such as the conflict in Ukraine and subsequent sanctions on Russia's oil exports, have further exacerbated this trend. It has become paramount to consider the pace of the energy transition in order to address historical contingencies and the influence of past choices. (Oyewo et al., 2022). Scholars like Sarkodie and Adams (2020) and Karekezi et al. (2021) renewable energy has been acknowledged as a pivotal and universally recognized energy alternative for carbon dioxide emissions mitigation and attenuation of volatility in fossil fuel prices. Renewable energy is generated from natural resources such as sunlight, wind, water, and the earth. It has demonstrated its effectiveness in achieving carbon peak and carbon neutrality. Although RE investments increased from US$ 200 billion to US$ 315 billion between 2005 and 2018, there is a need to further increase global RE investments to US$ 600 billion by 2030 to expand energy access and meet climate change targets. The low investment in renewable energy projects in developing countries can be attributed to factors such as capital intensity, unattractive risk-return profiles, limited financing channels, and inadequate adaptability of policies to changing markets. To reduce investment risk exposure, it is crucial to understand risks and their dynamic interactions (Abba et al., 2022)The lack of electricity access in Africa is a critical issue, with around 70% of the global population without reliable electricity, affecting approximately 789 million individuals (Salite et al., 2021). Fossil fuels, such as oil, coal, and fossil methane, currently dominate the energy landscape in Africa, accounting for approximately 80% (over 600 TWh) of the total energy generation, and this percentage is projected to be between 47% and 61% by 2030 (Oyewo et al., 2022). To address this challenge, the greatest potential for renewable energy lies in providing energy access to marginalized populations in major urban centers.

In Sub-Saharan Africa, the cost of providing electricity services poses significant developmental obstacles due to infrastructure investments, maintenance expenses, technology upgrades, and high electricity tariffs. These tariffs are among the highest in the world, limiting socioeconomic development and negatively impacting the quality of life. Furthermore, around 57% of households and businesses in Africa face electricity reliability issues, experiencing frequent and unpredictable power interruptions that last for extended periods, further exacerbating the region's challenges (Salite et al., 2021). Recognizing the interconnectedness of poverty, inequality, unemployment, and energy poverty, the African Agenda 2063 emphasizes the need for pragmatic and implementable strategies that contribute to Africa's transition toward an inclusive and environmentally sustainable energy supply system (Momodu et al., 2022).

Investing in new coal-based infrastructure in Africa could lead to increased emissions and perpetuate dependence on fossil fuels, potentially making these nations significant global emitters. On the other hand, prioritizing renewable energy sources offers Africa the opportunity to develop new industries, create employment, and drive significant socio-economic progress to meet its rapidly growing energy demand while avoiding carbon-intensive development pathways and the associated risks of being locked into such trajectories (Alova et al., 2021; Ram et al., 2020; Steckel et al., 2020;Oyewo et al., 2022). The transition to renewable energy is crucial for achieving sustainable development goals and addressing the impacts of climate change.

In recent years, investments in renewable energy in Africa have reached approximately 34 billion USD (Africa Land and Business, 2021). However, as energy demand is projected to increase, higher levels of investment will be needed (IEA, 2019). Yet, African countries face significant challenges in adopting and scaling up these technologies, particularly in Sub-Saharan Africa. These challenges include institutional fragility, mismanagement of limited public investment and external financial support, and inconsistent energy policies. Extensive research has been conducted on the potential of renewable energies, specifically independent off-grid systems, to promote sustainable development in developing countries (Zhu et al., 2022). However, there is a notable lack of research on energy pathways for sustainable development in Africa, particularly regarding carbon-neutral investments and complex contingencies. Existing studies primarily focus on renewable energy transitions in the Global North, resulting in a significant research gap regarding energy transitions and supportive policies in the Global South, specifically Africa (Hansen et al., 2019; Müller et al., 2020; Oyewo et al., 2021).

This study aims to address this research gap by investigating the role of different investment schemes in Africa's transition to renewable energy. Specifically, it examines disparities across regions and how the income category of some 52 countries influences this transition using a logit model. By exploring this topic, the study aims to provide valuable insights to policymakers, enabling them to assess the impact of previous investments when formulating future renewable energy policy frameworks in Africa.

Currently, renewable energy policies in Africa primarily prioritize meeting the increasing energy demands, without thoroughly considering the outcomes of previous or ongoing energy transition investments. This lack of reflection inhibits comparable progress and restricts policymakers' ability to make informed decisions. Additionally, comparative studies on renewable energy technologies often yield generalized conclusions, disregarding variations in key driving factors due to their relatively recent development. Moreover, these studies often focus solely on the direct relationship between investment schemes and power consumption, overlooking the complex indirect effects.

To comprehensively understand the relationship between investment schemes and renewable energy transitions, it is necessary to consider multiple moderating factors, particularly national characteristics. Therefore, this research aims to explore how the income level of countries and regional classifications influence the performance of public investment, international financing, and foreign direct investment in relation to changes in the share of renewable energy in energy consumption. By considering these moderating factors, a more comprehensive understanding of the relationship between investment schemes and renewable energy transitions can be achieved.

### 1.2 Problem Statement:

The transition to renewable energy in Africa is crucial for achieving sustainable development, poverty alleviation, and mitigating the impacts of climate change. However, there is a significant research gap regarding the role of different investment schemes, particularly Official Development Assistance (ODA) for promoting renewable energy (RE) and public investment, in facilitating

Africa's transition to renewable energy sources. This gap hinders policymakers' ability to assess the impact of previous investments and develop effective policy frameworks to promote renewable energy.

Previous research has predominantly concentrated on determinants of carbon dioxide emissions at the macro level, with insufficient emphasis on investment variables pertaining to renewable energy, despite the substantial magnitude of these investments (Yang et al., 2022). Furthermore, the majority of research on energy transitions and supportive policies has concentrated on the Global North, resulting in a lack of comparative research on these issues specifically in the Global South, particularly Africa. Additionally, comparative studies on renewable energy technologies often overlook complex indirect effects and variations in driving factors.

To comprehensively understand the relationship between investment schemes, regional disparities, the income category of the 52 countries, and the performance of public investment and international financing in relation to renewable energy consumption in Africa, further research is needed. By addressing these gaps, this research aims to provide policymakers and stakeholders with relevant insights and guidance, thereby assisting in accelerating Africa's renewable energy transition in a sustainable and inclusive manner.

### 1.3 Significance of the Study

The significance of this academic research lies in addressing the critical dilemma faced by rapidly growing economies in Africa. Despite being a promising market with a young population and higher fertility rate, the continent struggles to reconcile its objective of sustaining economic growth with the increasing energy demand while mitigating the impacts of climate change. Many studies highlight the unique position of Africa to benefit from renewable resources and meet its energy demands in a sustainable (Sweerts et al., 2019). However, the outcomes of various investment schemes, particularly through Official Development Assistance (ODA) and public investment, have been disproportionately distributed across regions. Some nations have made significant progress in augmenting the proportion of sustainable energy sources (RE) in their energy consumption while driving economic growth through clean energy, while others lag behind.

This research argues that the disparities in outcomes can be attributed to national characteristics and geographical location. By recognizing the role of country-specific attributes in RE investment schemes for transitioning to clean energy, this study aims to provoke a rethinking of Africa's energy policy framework. The findings of this research will contribute to shaping a paradigm shift in energy policy, enabling more effective and targeted approaches to promote renewable energy adoption in Africa. Ultimately, this research seeks to support sustainable and inclusive economic growth while addressing the challenges of climate change in the continent.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Africa: Overview

The sub-Saharan African region exhibits significant geographic, demographic, and economic heterogeneity. The provision of electricity plays a crucial role in enabling the modernization of production methods, leading to substantial gains in productivity, particularly in the agricultural sector. This sector has experienced stagnation in per capita productivity over an extended period (Chapel, 2022). Access to electricity is essential for the development of industries and services in rural areas. As it is shown in table 1.1, African countries enjoyed a positive economic economic growth in the past three years with some countries, like Niger, in 2021 and 2023, realized double digits in its annual growth rates. However, challenges arise due to the absence of electrical infrastructure and inadequate service quality, impeding sustainable development throughout the continent. Multiple factors, both on the supply and demand sides, contribute to the region's situation, where it accommodates 17% of the global population but accounts for merely 3% of global electricity demand. To ensure unrestricted electricity demand, it is imperative to address the barriers on the supply side as well.

The African continent exhibits the most limited electrification rates among global regions, characterized by a pronounced dichotomy between North Africa and Sub-Saharan Africa. Consequently, a substantial majority of the global population lacking access to electricity, approximately three-fourths, resides within the confines of sub-Saharan Africa(Tete et al., 2023).

**Table 2.1 Economie forecasts : Sub-Saharan Africa (Real GDP growth ; percent)**

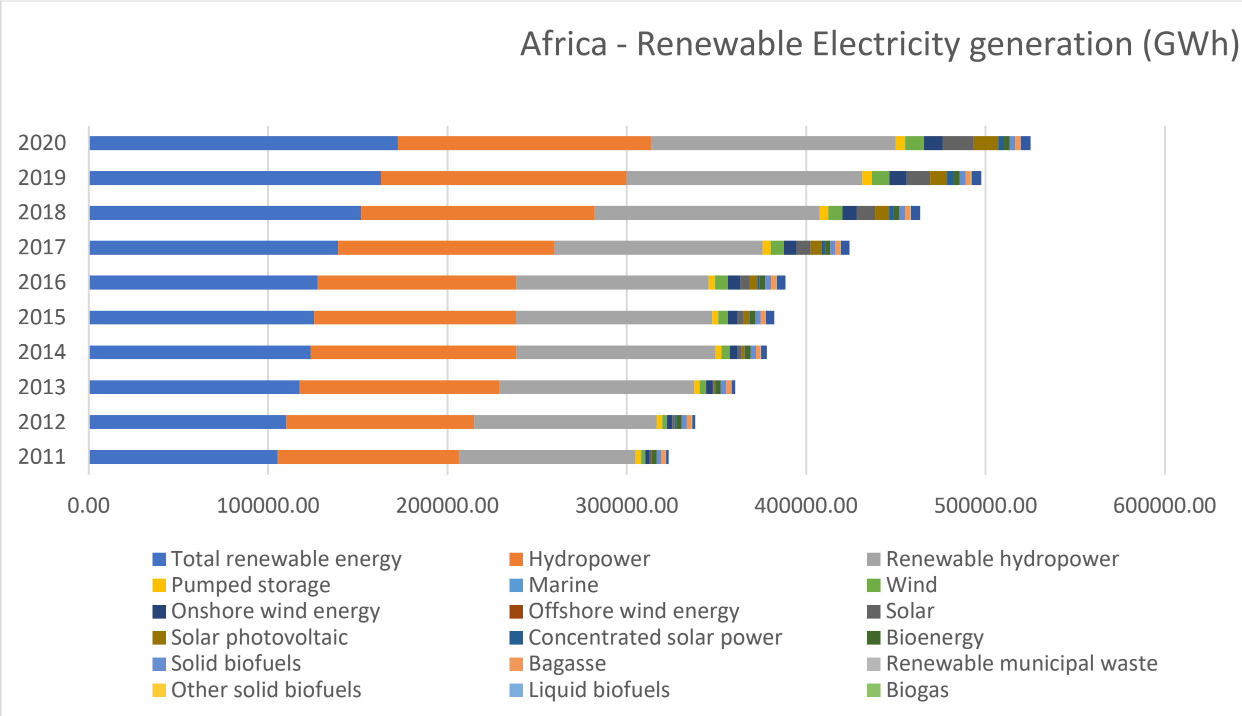
| | 2022 | 2023 | 2024 |
|---|---|---|---|
| **Sub-Saharan Africa** | **3.9** | **3.6** | **4.2** |
| Angola | 2.8 | 3.5 | 3.7 |
| Benin | 6.0 | 6.0 | 5.9 |
| Botswana | 6.4 | 3.7 | 4.3 |
| Burkina Faso | 2.5 | 4.9 | 5.9 |
| Burundi | 1.8 | 3.3 | 6.0 |
| Cabo Verde | 10.5 | 4.4 | 5.4 |
| Cameroon | 3.4 | 4.3 | 4.4 |
| Central African Republic | 0.4 | 2.5 | 3.8 |
| Chad | 2.5 | 3.5 | 3.7 |
| Comoros | 2.4 | 3.0 | 3.6 |
| Congo, Democratic Republic of the | 6.6 | 6.3 | 6.5 |
| Congo, Republic of | 2.8 | 4.1 | 4.6 |
| Côte d'Ivoire | 6.7 | 6.2 | 6.6 |
| Equatorial Guinea | 1.6 | -1.8 | -8.2 |
| Eritrea | 2.6 | 2.8 | 2.9 |
| Eswatini | 0.5 | 2.8 | 2.5 |
| Ethiopia | 6.4 | 6.1 | 6.4 |
| Gabon | 2.8 | 3.0 | 3.1 |
| The Gambia | 4.4 | 5.6 | 6.3 |
| Ghana | 3.2 | 1.6 | 2.9 |
| Guinea | 4.3 | 5.6 | 5.7 |
| Guinea-Bissau | 3.5 | 4.5 | 5.0 |
| Kenya | 5.4 | 5.3 | 5.4 |
| Lesotho | 2.1 | 2.2 | 2.3 |
| Liberia | 4.8 | 4.3 | 5.5 |
| Madagascar | 4.2 | 4.2 | 4.8 |
| Malawi | 0.8 | 2.4 | 3.2 |
| Mali | 3.7 | 5.0 | 5.1 |
| Mauritius | 8.3 | 4.6 | 4.1 |
| Mozambique | 4.1 | 5.0 | 8.2 |
| Namibia | 3.8 | 2.8 | 2.6 |
| Niger | 11.1 | 6.1 | 13.0 |
| Nigeria | 3.3 | 3.2 | 3.0 |
| Rwanda | 6.8 | 6.2 | 7.5 |
| Sao Tomé & Príncipe | 0.9 | 2.0 | 2.5 |
| Senegal | 4.7 | 8.3 | 10.6 |
| Seychelles | 8.8 | 3.9 | 3.9 |
| Sierra Leone | 2.8 | 3.1 | 4.8 |
| South Africa | 2.0 | 0.1 | 1.8 |
| South Sudan | 6.6 | 5.6 | 4.6 |
| Tanzania | 4.7 | 5.2 | 6.2 |
| Togo | 5.4 | 5.5 | 5.5 |
| Uganda | 4.9 | 5.7 | 5.7 |
| Zambia | 3.4 | 4.0 | 4.1 |
| Zimbabwe | 3.0 | 2.5 | 2.6 |

Source: IMF World Economic Outlook Database, April 2023.

African nations have reevaluated their developmental aspirations to attain universal electrification, with the aim of mitigating sociopolitical and economic deprivation, underdevelopment, unemployment, elevated illiteracy rates, and heightened migratory patterns(Tete et al., 2023b). The existing barriers extend from insufficient electricity generation, inadequate storage and distribution infrastructure, and unreliable service quality. The prevailing obstacles encompass inadequacies in electricity generation, suboptimal storage and distribution infrastructure, and unreliable service quality. To tackle these challenges, numerous initiatives and strategic endeavors have been set in motion, such as Sustainable Energy for All and Power Africa. According to a model for universal electricity access devised by KTH and UNDESA, an annual investment of $70 billion is imperative until the year 2030 (Chapel, 2022). Green finance endeavors to furnish financial capital for environmentally sustainable endeavors, driven by the paramount objective of ecological integrity. Its purview encompasses the amelioration of environmental harm and strives to exert influence across diverse domains, encompassing but not limited to energy, public health, and socioeconomic prosperity(Mngumi et al., 2022)

The African continent has experienced a multifaceted progression of renewable energy (RE) characterized by economic, legal, and political dimensions (De Angelis et al., 2021). Similar to other emerging economies, African nations heavily rely on fossil fuel resources for energy production. Gas and coal contribute less than 2% to the region's total technical reserve potential, while the biomass resource potential remains unquantified (Musonye et al., 2020). The region houses the 13th largest oil-producing country globally, with a daily output of 2.35 million barrels. As shown in figure 1.1, Hydropower is the primary renewable energy source, while wind and solar sources are underutilized (Musonye et al., 2020). However, the region faces challenges of energy underdevelopment, including insufficient supply, limited access, high costs, and financial difficulties for utility providers. Despite potential, the electricity market remains underdeveloped.

**Figure 2.1 Renewable electricity production in Africa**




Source: Renewable Energy Agency (IRENA) in their report titled "Renewable Energy Statistics 2022" published in 2022

The technical energy resource potential of African continent is estimated over 11 TW (Musonye et al., 2020). However, the advancement of technology necessitates the allocation of financial resources for the endeavors, which assume a pivotal role in the exploration and progression of innovative technologies aimed at stimulating the generation of renewable electricity. While global economies remain committed to adopting appropriate policies for socio-economic and environmental development to attain the Sustainable Development Goals (SDGs), the effective implementation of these policies often encounters hindrances due to financial constraints. A conspicuous hindrance in the execution of renewable energy technologies in Africa resides in the formidable undertaking of attracting adequate and economically efficient financial resources. Therefore, African nations are not exempt from the challenges facing the renewable energy sector and often rely on international aid and donor organizations for financial support (Tete et al., 2023b).

## 2.2 ODA Support on the Adoption of Renewable Energy in Africa

According to the international Energy Agency (IEA), projections indicate that by 2050, could account for approximately 10-15% of the overall electricity generation, even in the absence of explicit climate policies. However, renewable energy technologies are known for their higher capital intensity compared to conventional energy sources. The initial capital expenditures associated with renewable energy projects encompass a wide range of factors, including the acquisition of technology, procurement of land, construction activities, project development, and financial considerations. Financing costs, specifically, are contingent upon a myriad of variables, such as debt expenses, returns on equity, debt-to-equity ratios, commitment periods, and capital acquisition fees. In contrast to traditional energy sources, which derive their costs mainly from fuel expenses, renewable energy technologies exhibit a greater reliance on capital investments, characterized by substantial initial capital outlay.

Public financing sources, despite their inherent risk tolerance, are insufficient in magnitude to meet the investment requirements necessary for the successful transition to a fully sustainable energy system. This predicament holds particular significance in the context of developing nations, wherein a myriad of impediments collectively contributes to an elevated perception of risk. These barriers encompass information asymmetries, technical limitations, intricate regulatory frameworks, administrative complexities, political instabilities, and financial limitations. Achieving these ambitious expansion scenarios necessitates significant investments globally, amounting to approximately $60 to $120 trillion between 2015 and 2050, particularly in developing countries facing unfavorable financial conditions. Especially within the African context, the arduousness of garnering adequate and cost-effective financial resources persisted as a pivotal impediment hampering the widespread adoption of renewable energy technologies in the region.

Nevertheless, numerous nations have implemented policy frameworks aimed at expediting capital outlays in the domain of renewable energy throughout the preceding two decades. To address the investment barrier, international financial initiatives have been established with the aim of mitigating financial risks, thereby fostering the potential expansion of renewable energy technologies and its prevalence in to the most demanded areas. Among these, is the ODA by DAC countries donate to the developing with the aim of promoting transition to renewable energies. The efficacy of official development assistance (ODA) on diverse facets of development has been subject to extensive scrutiny at the macroeconomic scale, yet a consensus regarding the heterogeneity of ODA's effects across African nations remains elusive. For example, our analysis reveals that targeted development assistance initiatives pertaining to renewable energy exhibit a favorable and statistically significant influence on the process of electrification within communities situated in the sub-Saharan African region (Chapel, 2022). Nevertheless, it is important to acknowledge that these investigations possess certain constraints, primarily concerning their external generalizability. Additionally, the scope of micro-level inquiries focused on the energy domain remains notably restricted. The present study endeavors to surmount this constraint by conducting a microeconomic examination of diverse official development assistance (ODA) financing strategies for renewable energy (RE) initiatives across various African nations.

### 2.3 Transition to Renewable Energy and its impact on Access to Energy in Africa

The global trajectory of energy consumption is exhibiting an accelerated growth rate, thereby engendering apprehensions regarding the adequacy of supply, the depletion of energy resources, and the consequential deleterious environmental ramifications. However, the facilitation of dependable, resilient, cost-effective, and ecologically sound energy provisions is indispensable to tackle the multifaceted predicaments entailed in global sustainable development endeavors.

Diverse nations within Sub-Saharan Africa (SSA) depend on a range of energy sources to fulfill their energy consumption requirements, encompassing solar photovoltaics, geothermal potential, hydroelectric power, coal combustion, petroleum and natural gas resources, and wind energy. (Musonye et al., 2020). Only a few Nexus frameworks consider localized electricity accessibility and its implications for financing energy and water supply. Many points of convergence among these areas lack scrutiny, analysis, modeling, and effective translation into technology, economics, and business model implications (Falchetta et al., 2022).

Best, (Falchetta et al., 2022) argues that energy needs in smallholder agriculture are mainly related to transport, while (Shirley et al., 2021) employ geospatial analysis to delineate priority regions for addressing electricity demand near agricultural areas, focusing on the specific instances of maize and coffee cultivation in Uganda as a case study. The low electrification rate in agriculture and rural areas is now attributed to inadequate financial allocations rather than unverified technological solutions. This necessitates the deployment of Distributed Renewable Energy (DRE) technologies accompanied by suitable business models that take into account the hyper-local factors influencing demand within the agricultural or rural community (Falchetta et al., 2022).

Financial development and globalization have the potential to expand markets, provide resources, foster global environmental sustainability, and influence innovation and greenhouse gas emissions (Abbas et al., 2023). The absence of energy infrastructure in rural regions of Africa has been perpetuating a chronic state of impoverishment, precipitating recurring periods of food shortages and compromising the prospects for local socio-economic advancement (Falchetta et al., 2022). The agricultural sector at the regional level faces heightened vulnerability in response to climate change, escalating occurrences of hydrological extremes with heightened frequency and intensity, and the rapid expansion of the regional population alongside growing demands for sustenance (Falchetta et al., 2022) In this context, most households and businesses lack reliable electricity access, while some irrigated areas heavily rely on small and medium-sized diesel water pumps. This strains domestic energy utilities financially, perpetuating indebtedness and a dependence on fossil fuels, thus contributing to localized pollution concerns (Falchetta et al., 2022).

### 2.4 Public Investment

Green investments heavily rely on renewable financing, with public financial institutions playing a crucial role in optimizing these financing options. While developing countries benefit from foreign financing, developed nations, which are more likely to be self-sufficient in funding low-carbon initiatives aligned with Sustainable Development Goals (SDGs), should primarily focus on domestic funds. Ideally, these funds should be allocated to the energy sector (Siddik et al., 2023). Government support serves as a vital mechanism for promoting renewable energy, particularly in relatively developed yet environmentally polluted countries. Government subsidies have the potential to facilitate the growth of renewable energy and drive low-carbon economic development (Siddik et al., 2023). Also, that government can approach to the energy sector needs by investing and collaboration with the private sector and setting policies attractive to more official development assistance (Chapel, 2022).

Examining table 2.2, it is evident that Africa has experienced an increase in investment towards renewables, rising from USD 26 billion to USD 36 billion, while investment in non-renewable sources declined from USD 104 billion to USD 40 billion between 2015 and 2023. However, certain countries have encountered challenges in efficiently integrating wind and solar energy. Each renewable energy sector exhibits varying effects in terms of reducing carbon dioxide emissions. This raises the question of how governments can effectively prioritize policy choices, particularly in Africa where there is a high demand for electricity consumption (Tenaw & Beyene, 2021).

**Table 2.2 summary of the investment in energy sector in Africa**

| Africa | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|
| **Total (billion $2022)** | 130 | 112 | 114 | 111 | 71 | 59 | 62 | 69 | 76 |
| **of which: clean energy** | 26 | 26 | 26 | 25 | 26 | 23 | 28 | 32 | 36 |
| **Supply (by type)** | 127 | 108 | 107 | 105 | 63 | 54 | 55 | 63 | 70 |
| **Fossil fuels without CCUS** | 104 | 86 | 88 | 87 | 46 | 36 | 34 | 37 | 40 |
| **Renewables** | 11 | 10 | 9 | 9 | 10 | 12 | 14 | 17 | 20 |
| **Electricity networks** | 12 | 12 | 11 | 10 | 8 | 6 | 8 | 9 | 9 |
| **Other supply** | 0 | - | - | - | - | - | - | 0 | 1 |
| **End-use** | 4 | 4 | 6 | 6 | 8 | 6 | 6 | 6 | 6 |
| **Energy efficiency** | 3 | 3 | 5 | 5 | 7 | 4 | 4 | 4 | 4 |
| **Other end-use** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| **Other end-use renewables** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | |
| **Fuels** | 93 | 74 | 76 | 78 | 38 | 32 | 29 | 33 | 37 |
| **Fossil fuels** | 92 | 73 | 76 | 78 | 38 | 32 | 29 | 33 | 37 |
| **Oil** | 68 | 53 | 55 | 55 | 23 | 19 | 17 | 19 | 23 |
| **Gas** | 22 | 18 | 19 | 21 | 13 | 12 | 11 | 11 | 11 |
| **Coal** | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 3 |
| **Clean Fuels** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | |
| **Power** | 34 | 35 | 31 | 27 | 25 | 22 | 26 | 30 | 34 |
| **Generation** | 22 | 23 | 20 | 17 | 17 | 16 | 19 | 21 | 24 |
| **Coal** | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 0 |
| **Oil and natural gas** | 10 | 11 | 10 | 7 | 6 | 3 | 4 | 4 | 3 |
| **Nuclear** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| **Renewables** | 10 | 10 | 8 | 9 | 9 | 11 | 14 | 16 | 20 |
| **Fossil fuels: with CCUS** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Storage** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Electricity networks** | 12 | 12 | 11 | 10 | 8 | 6 | 8 | 9 | 9 |
| | | | | | | | | | |
| **Memo: Oil & gas upstream** | 76 | 58 | 62 | 66 | 26 | 20 | 15 | 17 | 14 |

Source: International Energy Agency (IEA)'s 2023 World Energy Investment report

It is important to acknowledge the phenomenon known as "paradox of plenty," which suggests that nations endowed with abundant reserves of exhaustible resources, such as fossil fuels, often experience adverse economic, social, and environmental outcomes. (Inuwa et al., 2023, Tambari et al., 2023). The theory of the resource curse posits that nations endowed with significant reserves of non-renewable resources develop an overdependence on the revenue derived from such resources. Consequently, they might overlook the significance of investing in other critical economic domains, including renewable energy, and fail to diversify their economy through strategic investments.

**2.5 International Trade and Its role in Renewables in Africa**

Numerous scholarly investigations have illuminated the repercussions of global commerce on renewable energy sources. Several conceptual frameworks exist that strive to elucidate the interrelation between energy trade, specifically petroleum prices, and the progression of sustainable energy alternatives. The theory of resource curse posits that nations relying heavily on non-renewable resources are prone to experiencing economic volatility due to fluctuations in global commodity markets. (Miamo & Achuo, 2022, Tambari et al., 2023). This theoretical proposition bears substantial ramifications for the interaction between commerce and clean energy. Nations with a substantial reliance on exports of non-renewable energy sources may manifest a diminished propensity to allocate resources towards the development of renewable energy, notwithstanding periods of heightened crude oil prices (Inuwa et al., 2023, Miamo & Achuo, 2022, Tambari et al., 2023). Hence, the concept of resource dependence highlights the need for countries to diversify their economies and channel investments into renewable energy to mitigate the detrimental consequences associated with overreliance on non-renewable resources like oil.

The scholarly literature has shown limited empirical investigation into the intricate connection between oil prices and the advancement of renewable energy in both oil-importing and oil-exporting countries, with a particular focus on African nations facing energy insecurity and reliance on fossil fuels.. Despite the abundance of scholarly research on the association between crude oil prices and the utilization of renewable energy, the outcomes have displayed incongruities. Some studies have reported positive associations between oil prices and renewable energy, while others have identified negative relationships (Wang et al., 2020,Mukhtarov et al., 2020,Mukhtarov et al., 2021,Miamo & Achuo, 2022,18, Tambari et al., 2023). However, certain studies [(Guo et al., 2021, Miamo & Achuo, 2022, (Tambari et al., 2023) have demonstrated that the relationship is not always straightforward and can exhibit both positive and negative aspects. These studies have been conducted across different countries and employed diverse methodologies to investigate the effects of oil prices on renewable energy consumption. However, notwithstanding the extensive corpus of scholarship, certain deficiencies endure within the current academic discourse. Specifically, a predominant focus of prevailing investigations centers on the impact of petroleum prices on the utilization of renewable energy, thereby offering constrained perspectives regarding the discrete ramifications of petroleum prices on the progress of renewable energy in nations that both import and export petroleum resources. This knowledge gap is particularly pronounced within African contexts marked by their heavy reliance on fossil fuels and prevailing energy insecurities.

### 2.6 Foreign Direct Investment (FDI) and Transition to Renewable Energy in Africa

Africa serves as a compelling magnet for foreign direct investment (FDI) from economically advanced nations and emerging economies in South Asia, driven by the abundance of its natural resource endowments. In 2021, African nations experienced a noteworthy influx of FDI totaling $83 billion, with a considerable portion of investments targeting key commodity sectors, including energy, precious metals, industrial metals, and agriculture. Remarkable FDI inflows were recorded, such as $42 billion directed towards Mozambique, $14 billion towards Ghana, and $8.2 billion towards the East African region (Balcilar et al., 2023). Nevertheless, the impact of FDI on renewable energy remains a subject of intense scholarly debate. While numerous empirical investigations suggest that foreign direct investment (FDI) inflows are associated with ecological deterioration, particularly in developing countries, alternative perspectives posit that FDI has the potential to foster environmental amelioration through investments in sustainable technologies and the implementation of eco-conscious managerial approaches within host nations (Balcilar et al., 2023). According to (Zakari & Khan, 2022), FDI can exert a significant positive influence on the relationship between energy consumption and economic growth. For instance, FDI plays a role in stimulating the economic growth of the host nation by facilitating the transfer of new technologies and technical expertise. Borensztein, De Gregorio, and Lee (1998) argue that FDI yields a positive effect on the GDP growth rate when ample technological advancements are available to the host countries. Transnational corporations (TNCs) have a tendency to reduce the share of renewable energy in nations characterized by low reliance on natural resources and limited foreign investment, although this correlation displays modest statistical significance. In contrast, elevated dependence on natural resources in countries with substantial foreign investment is positively linked to the shift towards renewable energy, while actual income exhibits a negative correlation with the transition to renewable energy sources. The Gini coefficient, which measures income inequality, displays a negative relationship with renewable energy transition at lower quantiles but shifts to a positive association from the 0.3-th to the 0.9-th quantile (Balcilar et al., 2023).

# CHAPTER 3

# DATA AND METHODOLOGY

## 3.1 Variable Measurement and Source of Data

This research encompasses the panel Pooled data model employed to investigate the effects of Official Development Assistance (ODA), public investment, and foreign direct investment on on the variation in the share of renewables in the total energy consumption. The study leverages a dataset encompassing 52 African countries during the timeframe from 2012 to 2020, with the exception of Eritrea due to data inconsistency. Furthermore, the investigation incorporates data on Gross Domestic Product (GDP) per capita, trade-GDP ratio, and population growth procured from the World Bank's Worldwide Development Indicators (WDI) Database as covariates or control variables. The table below shows the variables measures and the data sources.

**Table 3.1 Variable Measurement and data sources**

| Variable | Measurement | Data source |
|---|---|---|
| Transition to Renewable energy | Percentage share of renewable energy in total energy consumption | IEA (2021), World Energy Balances |
| Official Development Assistance (ODA) | Aggregate of ODA grants, loans, equity investment, and other official flows towards energy generation from renewable sources donated by DAC Countries to African | OECD database (2023) |
| Public Investment | Aggregate of yearly investment by government in the renewables | International Renewable Energy Agency (IRENA) (2022), Renewable Energy Statistics 2022 |
| Energy Supply | Aggregate annual energy generation | World Energy Outlook 2022 |
| Regional Category | The classification of African countries based on their geographical locations (Eastern Africa, northern Africa, western Africa, Southern Africa, and Central Africa) | African Development Bank (ADB) |
| Income category | The classification of African countries by income group (Low-income, low-middle income, upper-middle income, and high-income countries) | World Bank (2023) |

### 3.2 Econometric method

The panel Autoregressive Distributed Lag (ARDL) model is an advanced econometric approach that enables robust analysis in the presence of exogeneity or endogeneity concerns, as well as different orders of integration for the variables (either order zero or one, 2_2). This framework employs a single equation setup, which enhances interpretability and yields unbiased and efficient estimations by effectively addressing issues like serial correlation and endogeneity. By incorporating lagged values of the variables, the ARDL model effectively mitigates the problem of endogeneity. Moreover, it accommodates both homogeneous and heterogeneous slope coefficients across the panel units, allowing for flexibility in the analysis. Notably, the panel ARDL model can be integrated with the vector error correction model to examine short-run and long-run effects.

In general, according to Pearson (Pesaran et al., 1999 Tenaw & Beyene, 2021), the ARDL (p, q) model can be specified as:

$$\Sigma it\ Yit = \beta 0 + \Sigma it\ \beta 1X1it + \Sigma it\ \beta 2X2it + \Sigma it\ \beta kXkit + \alpha i + \varepsilon it \qquad (1)$$

In the model, Yit represents the dependent variables, namely EDIit and EFPit, for a specific country i at a particular time t. $Xi,t-j$ is the vector comprising all the independent variables. The term $\mu i$ signifies the fixed effect or the unobservable effects specific to individual cross-sectional units. The variables p and q correspond to the lags of the dependent and independent variables, respectively. Consequently, the application of the Pearson (Tenaw & Beyene, 2021) estimation procedure, as suggested by Pesaran, 2006, can address the challenge posed by balanced pooled panel data. In this scenario, the proposed approach involves augmenting the Panel ARDL model with logistic regression to address the research inquiries more comprehensively. To facilitate the interpretation of effects in percentage terms, the initial step involves transforming the variables into natural logarithmic terms.

$$lnREcon_{it} = \alpha_i + \delta_t + \beta_1 \, lnODA_{it} + \beta_2 \, lnPubInv_{it} + \beta_3 lnFDI_{it} + \varepsilon_i \qquad (2)$$

Where, $lnREcon_{it}$ signifies the logarithmic transformation of the dependent variable, reflecting the percentage changes in the proportion of renewable energy within the aggregate energy consumption. It serves as the response variable for observation i at time t. $\beta_0$ represents the constant term or intercept. $\beta_1$ $lnODA_{it}$ represents the independent variable, denoting the logarithmic transformation of Official Development Aid (ODA) for observation i at time t. $\beta_2$ $lnPubInv_{it}$ signifies the logarithmic transformation of the independent variable, representing the percentage changes in public investment for observation i at time t. $\beta_3$ $lnPubInv_{it}$ symbolizes the logarithmic transformation of the independent variable, signifying the percentage changes in ODA for observation i at time t. $\alpha_i$ denotes the individual-specific fixed effects or time-invariant characteristics pertaining to each entity or individual i. $\varepsilon_{it}$ represents the error term, encapsulating the unobservable factors and stochastic error. Given the inherent trade-off between the properties of consistency and efficiency in the estimators, the application of the Hausman test facilitated the identification of estimators that are most suitable and relevant for this examination. If the P-value surpasses the 5% threshold in the Hausman test, it can be deduced that the fixed-effect estimators manifest superior consistency and efficiency.

# DATA ANALYSIS AND RESULTS

## 4.1 Descriptive Statistics

Table 4.1 presents the statistical characteristics of the primary variables examined in our research. The dataset consists of 468 observations encompassing 52 African nations. The mean population growth rate across the 52 countries in our sample is approximately 2.4%. The average yearly GDP growth rate for the entire set of countries surpasses 3.6%, signifying overall expansion within the African countries during the 9-year period under study. A more detailed analysis reveals an average annual electricity supply of 10329 exajoules, while the share of renewables in energy consumption averages around 46%. In total, the 52 countries received an annual support of USD 10.586 million to facilitate the transition to renewable energy sources. Additionally, the average annual government investment by these African countries in renewable initiatives is estimated to be USD 110.712 million. The inward Foreign Direct Investment (FDI) received by the 52 countries amounts to approximately USD 31 million per year. Lastly, trade accounts for more than 60% of the total GDP, with an average annual import value of over USD 8147 million and an average annual export value of over USD 9570 million.

**Table 4.1 summary of means and standard deviations**

| Variable | Total no. of observations | Mean | Std. Dev. |
|---|---|---|---|
| Population growth rate | 467 | 2.371 | 1.009 |
| Average GDP growth rate | 466 | 3.634 | 6.837 |
| Total electricity supply | 408 | 10328.719 | 25356.486 |
| Share of renewable in overall energy consumption (%) | 468 | 45.999 | 35.167 |
| ODA | 468 | 10.586 | 35.513 |
| Public investment | 468 | 110.712 | 429.158 |
| FDI | 451 | 31.012 | 22.686 |
| Trade to GDP rate | 451 | 60.202 | 47.55 |
| Export | 451 | 8147.231 | 16948.783 |
| Import | 451 | 9570.479 | 18484.178 |

*Note: This table presents averages and the standard deviations across all the years for the 52 countries included in this analysis.*

### 4.2 Multicollinearity Test

Multicollinearity has the potential to disrupt the distinct impacts of the correlated variables and complicate the determination of their singular contributions to the dependent variable. It can further yield unstable estimations of coefficients, substantial standard errors, and complexities in ascertaining the significance of individual predictors. The detection and resolution of multicollinearity plays a crucial role in upholding the dependability and precision of regression analyses. In order to test the existence of a high degree of linear association among the independent variables, thus which results multicollinearity, we used the Eigenvalues correlation matrix. The five proposed variables all showed lower correlation coefficients, degree of multicollinearity between independent variables in a regression model. The summarization of reliability of the factors is displayed in Table 4.3.

**Table 4.3: Summary Statistics of Covariates**

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| Population Growth | | | | | | | | | |
| Av. GDP Growth Rate | -0.167 | | | | | | | | |
| Total electricity supply | -0.040 | -0.048 | | | | | | | |
| RE share in energy consumption | 0.378 | 0.038 | -0.083 | | | | | | |
| ODA | -0.103 | -0.061 | 0.196 | -0.130 | | | | | |
| Public Investment | 0.072 | 0.020 | -0.034 | 0.027 | 0.061 | | | | |
| FDI | -0.085 | -0.002 | -0.149 | -0.102 | 0.008 | -0.002 | | | |
| Trade/GDP | -0.057 | -0.013 | -0.104 | -0.056 | 0.027 | 0.067 | 0.690[a] | | |
| Export | -0.134 | 0.070 | 0.173 | -0.188 | 0.165 | -0.006 | -0.087 | -0.090 | |
| Import | -0.081 | 0.012 | 0.238 | -0.095 | 0.168 | -0.033 | -0.050 | -0.033 | 0.352 |

Note: a is control variable

### 4.3 Linear Regression Models

A multivariate linear regression analysis was conducted to explore the influence on the ratio of renewable energy in aggregate energy consumption. An analysis of variance (ANOVA) revealed that a 1% increase in the ODA will result a positive change of 0.07% in the share of renewable in total energy consumption. This result was found to be statistically significant, with $p > .05$. The overall R2 statistic indicated that this linear regression model explained 1% of the observed variability.

A multiple linear regression analysis was conducted to examine the effect on the share of renewable energy in total energy consumption. An analysis of variance (ANOVA) revealed that a 1% increase in the ODA will result a positive change of 0.07% in the share of renewable in total energy consumption. This result was found to be statistically significant, with $p > .05$. The overall R2 statistic indicated that this linear regression model explained 1% of the observed variability.

**Table 4.4: Regression results on the impact of ODA on the share of RE in total energy consumption in Africa**

| %share of RE in In total energy consumption | Coef. | p-value | Sig |
|---|---|---|---|
| lnODA | .07<br>(.034) | .038 | ** |
| Constant | 3.392<br>(.183) | 0 | *** |
| Overall R-squared | 0.010 | | |
| Chi-square | 4.313 | | |
| R-squared within | 0.022 | | |

*** *p<.01, *** *p<.05, ** *p<.1*

Table 4.5 and 4.6 presented below display the outcomes obtained from the regression analysis exploring the alteration in the logarithm of public investment and the logarithm of foreign direct investment (FDI). Employing a Fixed Effect (FE) approach, the results indicate an indirect influence of the fluctuations in public investment and FDI on the variations in the proportion of renewable energy in total energy consumption. However, it is noteworthy that this estimate lacks statistical significance, with a p-value less than 0.05.

**Table 4.5: Regression results on the effect of public investment on the RE's share in total energy consumption in Africa**

| %share of RE in In total energy consumption | Coef. | p-value | Sig |
|---|---|---|---|
| ln public investment | -.012 | .408 | |
| | (.015) | | |
| Constant | 3.421 | 0 | *** |
| | (.181) | | |
| Overall R-squared | 0.010 | | |
| Chi-square | 0.684 | | |
| R-squared within | 0.001 | | |

**** p<.01, ** p<.05, * p<.1*

**Table 4.6: Regression results on the effect of FDI on the RE's share in total energy consumption in Africa.**

| lnShREcon | Coef. | t-value | p-value | Sig |
|---|---|---|---|---|
| lnFDI | -.005 | -0.23 | .817 | |
| | (.021) | | | |
| Constant | 3.459 | 20.54 | 0 | *** |
| | (.168) | | | |
| R-squared | 0.000 | | | |
| F-test | 0.054 | | | |
| Akaike crit. (AIC) | 737.767 | | | |

**** p<.01, ** p<.05, * p<.1*

### 4.4 Multiple Regression Results

A fixed-effect model was employed to conduct multiple linear regression, utilizing the logarithm of the proportion of renewable energy in total energy consumption as the dependent variable. Table 4.7 presents the estimates derived from the ordinary least squares (OLS) regression within this model. To enhance the robustness of our model, we included individual control variables. Notably, the estimates did not exhibit significant deviations from our previous findings. Of particular interest is the positive influence of the percentage changes in the trade-to-GDP ratio on the fluctuations in the proportion of renewable energy in total energy consumption. Additionally, official development assistance (ODA) demonstrated a significant impact on the percentage changes in the proportion of renewable energy in total energy consumption. Specifically, a 1% variation in the trade-to-GDP ratio corresponded to a 9.8% change in the share of renewables in total energy consumption. Moreover, ODA was found to have a noticeable effect on the proportion of renewable energy in total energy consumption at a significant level of $p > 0.10$. Although not statistically significant, it can be observed that public investment in renewables and foreign direct investment (FDI) were indirectly associated with the percentage changes in renewables' contribution to overall energy consumption. However, given the lack of statistical significance in the estimates, we can conclude that public investment and FDI did not have a significant impact on the share of renewables in total energy consumption.

**Table 4.7: Regression results for Overall Model**

| lnShREcon | Coef. | t-value | p-value | Sig |
|---|---|---|---|---|
| %Trade in GDP | .098 | 1.72 | .087 | * |
| | (0.057) | | | |
| Population Growth Rate | .062 | 0.25 | .803 | |
| | (0.249) | | | |
| Average GDP growth rate | .065 | 0.70 | .482 | |
| | (0.092) | | | |
| ODA | .088 | 1.94 | .053 | * |
| | (.045) | | | |
| Public Investment | -.009 | -0.49 | .627 | |
| | (.019) | | | |
| FDI | .012 | 0.35 | .723 | |
| | (.035) | | | |
| Constant | 2.71 | 6.29 | 0 | *** |
| | (.431) | | | |

| | | | |
|---|---|---|---|
| Mean dependent var | 3.378 | SD dependent var | 1.536 |
| R-squared | 0.041 | Number of obs | 240 |
| F-test | 1.330 | Prob > F | 0.086 |
| Akaike crit. (AIC) | 464.157 | Bayesian crit. (BIC) | 488.521 |

*** *p<.01,* ** *p<.05,* * *p<.1*

### 4.5 Logistic regression

The primary objective of this study is to assess the impact of government investment and external financial support, specifically through Foreign Direct Investment (FDI) and Official Development Assistance (ODA), on the transition towards renewable energy in Africa. However, it is also pertinent to investigate how country-specific characteristics, such as geographical location, contribute to the distribution of ODA receipts and disparities in renewable energy adoption across the continent. To address this, a logistic regression analysis is conducted to examine the likelihood of different countries, categorized by income and geographical location, to exhibit favorable conditions for receiving ODA and FDI, investing in renewable energy, and demonstrating significant progress in transitioning towards renewable energy sources.

**Table 4.7: Logistic Regression based on Regional Group**

| Change by (1%) | Central Africa | Eastern Africa | Northern Africa | Western Africa | Southern Africa |
|---|---|---|---|---|---|
| ODA | -.386** | -.049 | .813*** | .001 | -.066 |
| Public Investment | -.013 | .019 | -.054 | -.104* | .084 |
| FDI | .109 | -.109 | .237 | -.111 | .07 |
| Renewable Energy share in total Energy | .615* | .227** | -1.168*** | .543*** | -.079 |
| Constant | -5.551*** | -.95 | -2.385 | -1.773** | -1.57* |
| No. observations | 266 | 266 | 266 | 266 | 266 |
| Pseudo r-squared | 0.105 | 0.025 | 0.551 | 0.083 | 0.015 |
| Chi-square | 15.452 | 7.760 | 105.440 | 26.874 | 4.361 |
| Prob > chi2 | 0.004 | 0.101 | 0.000 | 0.000 | 0.359 |

Note: The standard errors are displayed in parentheses. The dependent variable is utilized in its standardized dummy variable form. The individual control variables encompass the logarithms of ODA, Public Investment, FDI, and Renewable Energy share in total Energy. Significance levels are denoted as follows: *** p<.01, ** p<.05, * p<.1

The logistic regression analysis, as presented in Table 4.7, yields intriguing findings. Notably, a 1 percent increase in Official Development Assistance (ODA) allocated to support renewable energy initiatives is associated with a decreased likelihood of Central African countries receiving such increments by approximately 0.39. Conversely, the probability of Northern African regions receiving a 1 percent increase in ODA rises by approximately 0.89. These results demonstrate statistical significance, with p-values of 0.05 and 0.001, respectively.

Furthermore, the analysis reveals that a 1 percent increase in the share of renewable energy in total energy consumption is linked to a higher likelihood of it being contributed by economies in the Central African, Eastern African, and Western African regions, with probabilities of 0.615, 0.227, and 0.543, respectively. Conversely, a 1 percent increase in the share of renewable energy consumption makes it 1.168 times less likely to be caused by countries in the Northern African region.

# CHAPTER 5

# CONCLUDING REMARKS AND POLICY RECOMMENDATIONS

## 5.1 Concluding Remarks

This research aimed to examine the influence of Official Development Assistance (ODA), public investment, and foreign direct investment (FDI) on the transition to renewable energy in Africa, as measured by the proportion of renewable energy in total energy consumption. The study employed a natural logarithmic transformation to ascertain the percentage causal effect. Initially, a simple linear regression was utilized to assess the fixed effects of individual explanatory variables on changes in the transition to renewable sources, assuming other explanatory variables were encompassed within the error terms. Subsequently, a multiple panel ARDL model was employed, including all explanatory variables and control variables, to determine potential disparities between the two scenarios, thus ensuring the robustness of the model.

The analysis of variance (ANOVA) conducted in both scenarios revealed a positive and statistically significant association between ODA and Africa's transition to renewable energy. Specifically, a 1% increase in Official Development Assistance (ODA) was found to correspond with a statistically significant positive change of 0.07% in the share of renewable energy in total energy consumption. Notably, the inclusion of control variables also indicated that changes in GDP growth rates have a positive impact on the transition to renewable energy. These findings align with the research conducted by Usama Al-mulalia and Hassan Gholipour (et al., 2013), which demonstrated a positive and reciprocal relationship between economic growth and electricity consumption, including renewable energy. Furthermore, these findings are consistent with other country-level studies conducted in African nations, such as Burkina Faso, China, and South Africa, as documented in a study published in Energy Economics in 2012, entitled "Electricity consumption and economic growth: evidence from former Soviet republics.".

Furthermore, a fixed-effect model was employed in the multiple linear regression analysis, with the logarithm of the proportion of renewable energy in total energy consumption as the dependent variable. Table 4.7 displays the estimates derived from the ordinary least squares (OLS) regression within this model. Additionally, official development assistance (ODA) was found to have a significant impact on the percentage changes in the proportion of renewable energy. Specifically, a 1% variation in the trade-to-GDP ratio corresponded to a 9.8% change in the share of renewables in total energy consumption. Moreover, ODA exhibited a noticeable effect on the proportion of renewable energy in total energy consumption at a significant level of $p > 0.10$. Although not statistically significant, it can be observed that public investment in renewables and foreign direct investment (FDI) were indirectly associated with the percentage changes in renewables' contribution to overall energy consumption. However, due to the lack of statistical significance in these estimates, it can be concluded that public investment and FDI did not have a significant impact on the share of renewables in total energy consumption.

**5.2 Policy Recommendations**

Within our study, two key variables are analyzed: Official Development Assistance (ODA) and average annual growth rates. While ODA has a direct impact on the overall transition to renewable energy sources in Africa, our regional-level analysis reveals that countries receiving ODA contribute minimally to this transition, whereas countries more inclined towards renewable energy as their primary energy source exhibit greater potential for progress. Failing to address disparities in investment outcomes may undermine the substantial impact of ODA in Africa, resulting in increased investment but insignificant advancements. Therefore, policymakers, donors, and stakeholders must prioritize cross-regional policy targets and the resulting outcomes to maximize the effectiveness of ODA in facilitating the transition to renewable energy sources in Africa.

In contrast, the findings highlight an important aspect regarding the investments made by African economies in renewable energy sources, which amount to a total of USD 250 billion since 2015. It is evident that these investments have yielded insignificant effects thus far in achieving the continental goal of alleviating energy poverty and reducing $CO_2$ emissions by 2060. Consequently, decision-makers must carefully reconsider the disconnection between inputs and outputs. Policymakers may need to reassess power tariff levels and evaluate the role of the private sector in the process. Moreover, it is advisable for high-income economies within the region to thoroughly contemplate the implementation of carbon taxes on imports that have a high carbon intensity. This measure would serve to nullify the price advantage associated with such imports. This will help ensure a more effective and impactful utilization of investments towards the desired energy and environmental outcomes.

### 5.3 Limitations of the Study

One of the limitations of this research is the relatively short duration of the panel data, which spans only 9 years from 2012 to 2020. Given that capital-intensive projects often have long-term impacts and extended Engineering, Procurement, and Construction (EPC) periods, the influences of such projects may require a longer observation period. Consequently, the findings of this study are constrained to the timeframe, limiting their applicability to stakeholders with an interest in this specific period.

To address the existing knowledge gaps regarding Africa's transition to renewable energy, it is recommended to conduct similar studies in comparable contexts and within the boundaries of regional groups. This approach would contribute to building a stronger evidence base for the renewable energy sector in Africa. Nevertheless, the findings of this research model can still offer valuable insights to investors interested in the renewable energy market in Africa, as well as domestic and external policymakers seeking to explore pertinent issues within the continent's energy industry.

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