

RENEWABLE ENERGY FINANCING AND RENEWABLE ENERGY MARKET PENETRATION IN SUB-SAHARAN AFRICA

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DOI: <https://doi.org/10.5281/zenodo.13745094>

Abstract: The study examined the role of the public and financial sectors in financing for renewable energy market penetration in Sub-Saharan Africa for the period 2000 to 2022. The study mainly investigated how government financing of renewable energy interacts with financial sector credit to boost renewable energy consumption in Sub-Saharan Africa. The study used a panel data from fourty six countries in Sub-Saharn Africa and two step system Generalized Method of Moments for the analysis. The study revealed that renewable energy public sector financing has a negative significant effect on renewable energy market penetration, while financial sector private sector credit has a positive significant effect on renewable energy market penetration in SSA. It also found that the interaction between renewable energy financing and financial sector development significantly influence renewable energy market penetration in SSA. Consequently, the study concludes that the potential for renewable energy increase consumption in Sub-Saharan Africa exists given adequate financial support from public and private sectors as well as the financial sector. Hence, the study recommends that to enhance the effectiveness of financial sector investment in promoting renewable energy adoption, policies should focus on streamlining the investment climate for financial institutions and private enterprises, particularly concerning asset financing, stocks, and bonds tailored for the renewable energy sector.

Keywords: public sector financing, renewable energy consumption, financial sector credit, system GMM.

1. INTRODUCTION

Lack of access to clean energy, especially electricity has perpetually posed serious problems to social and economic prosperity in Sub-Saharan Africa. Energy stands as a crucial driving force behind economic activities, playing an essential role in economic prosperity. Lack of access to energy has immensely contributed to poor performance of the productive sectors of the SSA economies, despite boasting abundant clean energy resources, (Energy Commission of Nigeria, 2008). Conversely, heightened reliance on fossil fuels escalates the risk of adverse climatic conditions, posing a threat to natural resources. Therefore, an increase in the consumption of

clean energy not only fosters the exploration of natural resources but also serves as a catalyst for productive activities and economic prosperity in Sub-Saharan Africa, (Oyedepo, 2013).

Among the Sustainable Development Goals (SDGs) adopted by the United Nations General Assembly in 2015, goal 7 aims at ensuring access to affordable, reliable, sustainable and modern energy for all, (United Nations, 2015). This goal holds particular significance for Sub-Saharan Africa, given its profound impact on agricultural production, economic endeavors, and overall human development. Nonetheless, a significant challenge persists; as of 2022, 600 million Africans lack access to electricity, constituting 75% of the global population without such access. Furthermore, per capita electricity consumption in Sub-Saharan Africa remains significantly lower than in other regions worldwide, underscoring the pressing need for improvement, (International Renewable Energy Agency and African Development Bank, 2022). The widespread consumption of renewable energy signifies its market penetration, typically measured by the percentage of electricity generated or consumed through renewable sources, (AFDB, 2022). However, discussions on market penetration of renewable energy is often viewed from the amount of electricity consumed, because most new sources of renewable generation are close to where the electricity is consumed, (AFDB, 2022).

In Sub-Saharan Africa, renewable energy sources like solar, wind, and hydropower abound, driven by factors such as environmental consciousness, urbanization, population growth, infrastructural development, and improved electricity accessibility. Additionally, advancements in technology across various sectors contribute to the burgeoning demand for renewable energy sources (United Nations Environment Program, 2019). In countries like Nigeria, renewable energy assumes a pivotal role in bridging energy gaps, particularly in off-grid areas, thereby enhancing energy stability, (ECN, 2008). Despite Sub-Saharan Africa boasting the highest level of hydropower consumption globally, other renewable sources struggle with low generation and consumption rates, primarily due to inadequate financial support hindering their market penetration, (AFDB, 2023; World Bank, 2023). As such, increased penetration of renewable energy sources into the energy mix in SSA is key to achieving adequate and stable power supply.

Government financing of renewable energy projects has witnessed an increase globally in recent years. However, public sector energy investment in SSA has been falling in recent years, especially spending on fossil fuels which has accounted for about two-thirds of investment and spending on clean energy has remained flat, (IRENA and AFDB, 2022). Generally, annual renewable energy funding which includes renewable power, grids, storage, efficiency improvements and end-use renewable and electrification in 2022 was \$231 billion in Asia, \$154 billion in Europe, \$97 billion in USA, while the whole of Africa spent \$10 billion, Brazil in Latin America spent \$7 billion and \$5 billion was spent in Middle East (International Energy Agency, 2023). These reports imply that even though Sub-Saharan Africa accounts for around 20% of the world's population, she attracts less than 2% of its spending on clean and renewable energy. As a result, access to alternative electricity sources and socio-economic activities suffer due to low power generation and consumption, leading to rise in poverty.

However, studies such as (Azhgaliyeva, Beirne, & Mishra, 2023) have pointed out multiple factors that have hindered the increase in funding for renewable energy opportunities in SSA. Part of these factors include, the debt crisis in many parts of Africa which has led to limited public capital available for such financing and also caused higher payment risks from government own energy companies, and non-robust financial infrastructure. The financial sector especially banks and stock market are supposed to bridge the gap between capital requirements and available funds, allowing renewable energy projects to progress and contribute to Sub-Saharan Africa's renewable energy transformation, by offering wide range of financial products such as loans, project finance, and guarantees to support renewable-energy companies, (Prempeh, 2023). However, lack of robust financial sector infrastructure and investments in SSA has obstructed the scaling up of renewable energy financing and investment by the private sector in SSA, (Ali, Hook & Bin, 2015; United Nations Environment Programme, 2019).

Due to this poor nature of the innovative financial products and poor development of the financial infrastructure in SSA, many private investors are reluctant to enter the Sub-Saharan African markets because of high perceived financial risks, thereby affecting market penetration of renewable energy, (Bloomberg New Energy Finance, 2022). Thus, the study examines the role of the public sector and the financial sector in facilitating renewable energy market penetration in SSA. This study contributes to empirical literature on renewable energy financing and its market penetration by examining the interaction role of financial sector credit on the nexus between renewable energy financing and renewable energy consumption in SSA. Following the introduction, the literature review is taken up in Section 2. The methodology is presented in Section 3. While section 4 covers the results and associated discussions, the study is concluded in section 5.

2. LITERATURE REVIEW

2.1 Conceptual Clarifications

2.1.1 The Concept of Renewable energy

Renewable energy comprises energy derived from sources that are perpetually replenished, such as solar, wind, and hydropower. These primary renewable energy sources encompass hydroelectric energy, solar energy, wind power, and geothermal energy. They are called renewable due to their continual replenishment, in contrast to conventional energy sources, which are both finite and environmentally harmful, (IRENA, 2022). These renewable sources find utility in electricity generation, water heating, and various industrial and commercial applications. Renewable energy penetration denotes the proportion of electricity produced from a specific resource, (IRENA and AFDB, 2022). This penetration can be expressed as a percentage relative to the total electricity generated or consumed. Typically, the penetration of renewable energy is gauged based on electricity consumption since most new renewable generation sources are located in close proximity to where electricity is consumed, (IRENA and AFDB, 2022).

2.1.2 Renewable Energy Financing

Renewable energy finance is the process of raising capital to sponsor investments in renewable energy. It encompasses financing options for renewable or clean energy projects, drawing from various funding sources and

investment mechanisms. These financing options include banks, private investors, venture capitalists, government agencies, and international organizations, (Drezek, 2023; Donovan, 2015). However, in this study emphasis on renewable energy financing concentrates on public sector financing of renewable energy.

2.2 Theoretical Framework

The energy consumption theory, as posited by (Medlock, 2009; Vosooghzadeh, 2020), serves as the conceptual framework that elucidates the interplay between renewable energy financing and its penetration into the market. According to this theory, the financial demands associated with utilizing energy resources in various production and service activities can be offset by the overall positive economic impact generated by these endeavors. Additionally, the theory suggests that energy resources encompass not only the acquisition and material purchases related to energy consumption but also drive positive economic advancements through residual and incremental innovations within operations.

Moreover, the theory highlights the random induced demand multiplier effect on financial transactions, (Lestari, Hasid, Busari, and Ananda, 2022). Central to this framework is the nexus between the financing of energy production and energy consumption, which is connected by the involvement of financial institutions in generating revenue from these energy operations for businesses, industries, financial intermediaries, and consumers. This revenue, in turn, triggers consequential financial transactions and a monetary multiplier effect, as articulated by (Vosooghzadeh, 2020).

2.3 Empirical Literature Review

Studies have mainly focused on the impact of financial sector development on renewable energy consumption. Alsagr (2023) investigated whether the relationship between financial efficiency and investments in renewable energy is symmetrical or asymmetrical across 23 advanced and developing nations using data from 1996 to 2020. Using the nonlinear Autoregressive-Pooled Mean Group estimation technique, the study found that improved financial efficiency symmetrically promotes long-term investments in renewable energy. Asymmetrically, the study revealed that while increased financial efficiency supports renewable energy investment, decreased financial efficiency hinders it, with varying impacts in emerging and developed economies. Similarly, Dogan & Afsar (2023) examined the impact of financial development on renewable energy investments in the G-7 nations from 2000 to 2017. The study also considered the effects of economic growth, carbon emissions, inflation, fossil fuel consumption, and policy index on renewable energy investments. Using the panel threshold regression model, they found a positive, nonlinear relationship between financial development and renewable energy investments, identifying a threshold value for financial development. Above this threshold, the marginal positive effect of financial development on renewable energy investments diminished.

Prempeh (2023) explored the long-term effects of financial development on renewable energy consumption in Ghana, considering energy prices and economic growth from 1990 to 2019. Employing methods like ARDL bounds testing, Bayer-Hank, Gregory and Hansen cointegration, Vector Error Correction Model, Fully Modified Ordinary Least Squares, and Dynamic OLS techniques, the study found that financial development boosts

renewable energy use, while high energy costs and economic growth negatively impact renewable energy adoption. Similarly, Guo, Yang, Ji, & Liu (2023) investigated how green finance development drives renewable energy development in China from 2007 to 2019. Using OLS panel data regression, the study identified two paths through which finance development affects renewable energy: the clean biased technical progress path and the financial constraint path. They found significant differences in the driving effects of green finance development and government policies at different stages.

Sun, Zhang, & Gao (2023) studied the impact of financial development on renewable energy consumption across 103 countries, including 28 developed and 75 developing nations, from 1991 to 2014. Using the GMM estimation technique, the study found a positive correlation between financial development and renewable energy consumption, highlighting the crucial role of banking sector development. The study also revealed positive influences of financial institution depth, access, efficiency, and stock and bond market development on renewable energy consumption. Heterogeneity analysis showed that while financial development significantly promoted renewable energy consumption in developed economies, this positive effect was only evident for financial institutions in developing economies. Azhgaliyeva, Beirne, & Mishra (2023) examined the determinants of private investment in renewable energy across 13 Asian countries from 2008 to 2018. Focusing on various financial sources such as asset finance, corporate research and development, public markets, venture capital, and private equity, the study employed a fixed-effect panel model for analysis. The results indicated that government expenditure on research and development positively influenced private investment through asset finance and corporate research and development.

Dimnwobi, Madichie, Ekesiobi, & Asongu (2022) investigated the correlation between financial development and renewable energy consumption in Nigeria from 1981 to 2019. Using a comprehensive financial development index and renewable energy's share in total energy consumption, alongside indicators like GDP growth rate, foreign direct investment, and consumer price index, the study employed the Autoregressive Distributed Lag Model to ascertain the long-run relationship. The findings underscored the critical role of financial development in driving renewable energy consumption in Nigeria. Lahiani, Mefteh-Wali, Shahbaz, & Vu (2021) examined the impact of financial development on renewable energy consumption in the United States from 1975Q1 to 2019Q4, using a nonlinear autoregressive distributed lags (NARDL) model. The study found both positive and negative short-term effects of changes in financial development indicators on renewable energy consumption. In the short term, only negative changes in the overall financial development index and the stock-based financial development indicator significantly affected renewable energy consumption, suggesting that renewable energy consumption does not respond to short-term fluctuations in bank-based financial development.

Studies have also focused on the effects of renewable energy consumption on economic growth. Zhe, Yüksel, Dinçer, Mukhtarov, & Azizov (2021) investigated the benefits of renewable energy utilization for economic growth and financial development from 1990 to 2015, employing the VAR model. The findings indicate that while renewable energy utilization and financial development do not notably impact economic growth, renewable

energy adoption positively influences economic growth. Similarly, Alege, Jolaade, & Adu (2018) examined the relationship between renewable energy adoption and economic growth in Sub-Saharan African nations. Using a panel co-integration approach, the results unveiled a long-term relationship between renewable energy utilization and economic growth in the selected Sub-Saharan African countries.

The empirical literature have mainly focused on financial development and renewable energy consumption, there is scanty empirical studies examining the nexus between public sector financing of renewable energy and its market penetration and the role of the financial sector. This study contributes to empirical literature on renewable energy financing and market penetration of renewable energy by examining the interaction role of financial sector credit on the nexus between public sector financing of renewable energy and renewable energy consumption in SSA. The study also extends analytical data on public sector financing of renewable energy and renewable energy consumption using panel data for the period 2000 to 2022.

3. METHODOLOGY

3.1 Model Specification

A functional relationship depicting renewable energy market penetration is one that treats renewable energy consumption as a function of renewable energy finance options and the role of the financial sector. However, studies such as (Ali, Hook, & Bin, 2015) expressed energy consumption as a function of financial development variables, energy cost and economic growth, while scholars such as (Prempeh, 2023) renewable energy consumption as a function of financial development, real GDP per capita and consumer price index. Modifying the model of (Prempeh, 2023), the model for this study is expressed mathematically as follows;

$$REC = f(FD, REF, GCF, GDPPC, INT) \tag{1}$$

Thus, the adopted and modified form of equation (1) is stated in a dynamic form as follows:

$$REC_{it} = \alpha_i + \delta_t + \beta_0 REC_{it-1} + \beta_1 FD_{it} + \beta_2 REF_{it} + \beta_3 GCF_{it} + \beta_4 GDPPC_{it} + \varepsilon_{it} \tag{2}$$

Eliminating the individual effects and gets a consistent estimate of δ as $N \rightarrow \infty$ with T fixed equation (2) us transformed into.

$$REC_{it} - REC_{it-1} = \alpha_i + \delta_t + \beta_0 \Delta REC_{it-1} + \beta_1 \Delta FD_{it} + \beta_2 \Delta RENF_{it} + \beta_3 \Delta GCF_{it} + \beta_4 \Delta GDPC_{it} + \beta_5 \Delta (INT) + \Delta \varepsilon_{it} \dots \dots \dots \tag{3}$$

for $i=1, \dots, 46$ and $t=1, \dots, 22$.

Thus, equation (3) is expressed as system Generalized Method of Moments (system GMM), (Arellano & Bover 1995; Blundell & Bond, 1998), specified as follows:

$$REC_{it} = \alpha_i + \delta_t + \beta_0 REC_{it-1} + \beta_{1i} FD_{it-j} + \beta_{2i} RENF_{it-j} + \beta_{3i} GCF_{it-j} + \beta_{4i} GDPPC_{it-j} + \beta_{6i} (FD * RENF)_{it-j} + v_{it} \tag{3}$$

$$E(\delta_{it} \Delta rec_{it} = 0); \quad E(\delta_{it} \Delta x_{it} = 0)$$

The two step system GMM estimator is meant for studies with small time period and large cross-sections and the independent variables are assumed not strictly exogenous. Thus, the major reason for the two step system GMM

is due to the fact that the number of SSA countries used is 46 with the study covering 22 years time period. The choice of the time and number of countries were influenced by availability and completeness of data.

To test for interaction in equation (3), the study is interested in β_6 which provide details on the effect of financial sector credit depth to the private sector and its interaction with renewable energy financing. The coefficient is vital to ascertain if the role of financial sector boost renewable energy financing in influencing the consumption of renewable energy in SSA. A positive significant effect of the interaction term ($\beta_6 > 0$) would mean that financial depth improve the effect of renewable energy financing when ($\beta_2 > 0$). On the other hand, when the interaction is negative ($\beta_6 < 0$), it means financial depth serve as a substitute in influencing renewable energy consumption when there is poor renewable energy financing.

The *a priori* expectation presupposes that FD, RENF, GCF, GDPPC will have positive effect on renewable energy consumption.

3.2 Description of Variables

- a) Renewable energy market penetration (REC): The amount of renewable energy consumption as a percentage of total energy consumption in SSA is represented by this variable.
- b) Renewable energy financing (RENF): This is represented by amount of public sector investment in energy, since hydroelectricity energy constitutes major energy investments in SSA, (IRENA, 2023).
- c) The financial sector depth (FD): This is represented by the financial sector to credit private sector expressed as a ratio of GDP.
- d) Sustainable Growth: The level of overall sustainable growth in African nations is represented by this variable, measured using GDP per capita.
- e) Capital formation (GCF): This represents the gross fixed capital formation, measuring the level of capital stock for investment.
- f) Interaction variable (INT): This measures the interaction between financial depth and renewable energy finance.

3.3 Technique of Data Analysis

The preliminary analyses encompass descriptive statistics, correlation assessments, and tests for cross-sectional dependency. Descriptive statistics is important to allow for the understanding of the data structures and composition. The inclusion of correlation analyses becomes imperative to prevent the utilization of highly correlated pairs of independent variables in the models, thus mitigating issues like multicollinearity. In estimating the two step system GMM, the estimation was first carried out without the introduction of the interaction variable, followed by its inclusion in subsequent estimation.

Additionally, the study incorporates years as genuinely exogenous variables and employs lagged explanatory variables as instruments to address simultaneity concerns. Post-estimation tests, such as the Hansen Test for assessing the validity of exclusion restrictions concerning exogenous instruments, the Sargan J test to evaluate instrument validity, and the Arellano-Bond (AR) test to detect autocorrelation in the error term, were also conducted.

3.4 Sources of Data

The sample period for the study is from 2000 to 2022, with data from 46 SSA countries based on the World Bank classification of countries. The period is based on the availability of data for some of the variables in SSA countries. Data on renewable energy consumption is sourced from the International Energy Agency (IEA), 2023 database, International Renewable Energy Agency 2023 database and the World Bank, 2023 WDI. Data on financial sector depth (PSC/GDP), GDP per capita, and gross capital formation were sourced from World Bank, 2023 WDI.

4. RESULTS AND DISCUSSION

The descriptive statistics of the variables is presented in table 1, from the table, proxy for renewable market penetration (renewable energy consumption) has 989 observations, renewable financing has 1031 observations, financial depth has 998 observations while GDP per capita and gross capital formation have 1032 and 860 observations.

Table 1: Descriptive Statistics

	Observation	Mean	Maximum	Minimum
<i>REC</i>	989	65.6459	98.34	0.71
<i>RENF</i>	1031	4.5014	103.3374	-17.292
<i>GDPPC</i>	1032	4.0796	63.3799	-36.392
<i>FD</i>	998	496.506	995	1
<i>GCF</i>	860	428.5035	858	1

Source: Authors computation using stata

Renewable energy consumption which is the proxy for renewable energy market penetration has a mean of 65.65 per cent between 2000 and 2022, renewable energy financing has a mean of 103.33, and financial depth has a mean of 995, GDP per capita 63.37 while gross capital formation has a mean of 858.

The correlation matrix of the variables is presented in table 2. The results indicate that the regressors used in this study are not highly correlated as none has a correlation coefficient 0.8. Consequently, there is no incidence of multicollinearity among the regressors in the estimated models, as the highest coefficient is 0.32.

Table 2: The Correlation Matrix

	<i>REC</i>	<i>RENF</i>	<i>GDPPC</i>	<i>FD</i>	<i>GCF</i>
<i>REC</i>	1.0000				
<i>RENF</i>	-0.1493	1.0000			
<i>GDPPC</i>	-0.1147	0.1081	1.0000		
<i>FD</i>	0.2184	-0.0247	0.0151	1.0000	
<i>GCF</i>	0.1620	0.3200	0.0675	-0.0744	1.0000

Source: Authors' computation

Table 3 contains the result of the variance inflated factor (VIF) for the model with interaction, from the result, both the VIF and its inverse indicate that the model do not suffer from multicollinearity, given that the mean VIF is 4.14 and the individual variables are not greater than 10 (Kleinbaum, Kupper & Muller, 1988)

Table 3: Variance Inflation Factor

Variable	VIF	1/VIF
REC(-1)	3.83	0.260932
RENF	5.87	0.170351
FD	3.84	0.260576
GCF	3.42	0.292108
GDPPC	1.69	0.590625
interaction	6.21	0.160975
Mean VIF	4.14	

The results of the two step system GMM are presented in Panels A and B in table 4 and show the effect of renewable energy financing on renewable energy market penetration.

Table 4: The Two Step GMM Estimations

Panel A: Model of renewable energy financing and renewable energy consumption without interaction term

Variable	Coefficient	Corrected Std. error	p-value
<i>Constant</i>	2.115654	1.562988	0.176
<i>L.REC</i>	0.9823838***	0.0244146	0.000
<i>RENF</i>	-0.1629987	0.0946225	0.085
<i>FD</i>	0.0019954**	0.0009802	0.042
<i>GDPPC</i>	-0.0441338**	0.0210205	0.036
<i>GCF</i>	0.0003582	0.0006248	0.566

Diagnostics

AR (1)	$z = -3.77$ (Pr > $z = 0.000$)
AR (2)	$z = 1.75$ (Pr > $z = 0.081$)
Sargan test (OIR)	$\chi^2(43) = 46.55$; (Prob > $\chi^2 = 0.329$)
Hansen test (OIR)	$\chi^2(43) = 34.93$; (Prob > $\chi^2 = 0.805$)
Hansen test excluding group	$\chi^2(39) = 32.38$; (Prob > $\chi^2 = 0.764$)
Difference (null H exogenous)	$\chi^2(4) = 2.55$; (Prob > $\chi^2 = 0.636$)
Hansen test excluding group	$\chi^2(38) = 31.48$; (Prob > $\chi^2 = 0.764$)
Difference (null H exogenous)	$\chi^2(5) = 3.45$; (Prob > $\chi^2 = 0.632$)
Observations	758
No of groups	40
No of instruments	35
Wald (F-test)	$F(5) = 274764.09$; Prob > F = 0.000

Panel B: Model in which financial depth is interacted with renewable energy finance

Variable	Coefficient	Corrected Std. error	p-value
<i>Constant</i>	3.145015	1.977848	0.112
<i>L.REC</i>	0.9655903***	0.0284565	0.000
<i>RENF</i>	-0.2766733**	0.1308954	0.035
<i>FD</i>	0.0027145**	0.0011935	0.023
<i>GDPPC</i>	-0.0380256	0.0208775	0.069
<i>GCF</i>	0.0002151	0.0005763	0.709
<i>FD*RENF</i>	0.0006037**	0.0003036	0.047

Diagnostics

AR (1)	$z = -3.75$ Pr > $z = 0.007$
AR (2)	$z = -1.55$ Pr > $z = 0.121$
Sargan test (OIR)	$\chi^2(31) = 20.98$; Prob > $\chi^2 = 0.912$
Hansen test (OIR)	$\chi^2(31) = 33.49$; Prob > $\chi^2 = 0.347$
Hansen test excluding group	$\chi^2(27) = 29.36$; Prob > $\chi^2 = 0.343$
Difference (null H exogenous)	$\chi^2(4) = 4.13$; Prob > $\chi^2 = 0.389$
Hansen test excluding group	$\chi^2(26) = 24.60$; Prob > $\chi^2 = 0.541$
Difference (null H exogenous)	$\chi^2(5) = 8.89$; Prob > $\chi^2 = 0.114$
Observations	758
No of groups	40
No of instruments	38
Wald (F-test)	$F(6, 40) = 191595.84$, Prob > $F = 0.000$

Note: *** and ** significant at 1% and 5% respectively.

Source: Authors' computation

The coefficient of one year lag of renewable energy consumption in the baseline result without interaction and the result with interaction is above 0.90 and significant at 5% significant level, implying that there is persistence in the poor level of renewable energy market penetration in SSA. The two results revealed that renewable energy financing options have negative relationship with renewable energy market penetration; however, with the introduction of interactive term in the Panel B, renewable energy financing has a significant negative effect on its market penetration. This means that a unit increase in renewable energy financing options led to 0.27 decrease in renewable energy market penetration. This outcome is not in agreement with the findings of (Azhgaliyeva, Beirne, & Mishra, 2023) for Asian countries could be attributed to inadequate renewable energy public sector financing

options in SSA. Since the interaction variable has a positive and significant effect on renewable energy market penetration in SSA and renewable energy financing has a significant negative effect on market penetration, it implies that financial depth complements the renewable energy financing options in improving renewable energy market penetration in SSA. An increase in renewable energy financing combined with active involvement of the financial sector caused a positive infinitesimal increase in renewable energy market penetration in SSA.

In addition, financial depth is positive and significant in both results, implying that an increase in financial depth will increase renewable energy market penetration. This is in agreement with past findings (Alsagr, 2023; Prempeh, 2023). Gross capital formation representing the capital stock needed for investments in renewable market penetration is positive but insignificant in influencing renewable energy market penetration. Moreover, income per capita (GDP per capita) has a negative influence in renewable energy market penetration.

The diagnostic tests indicate that both the first order AR (1) and the second order AR (2) serial correlation are satisfactory. In particular, the AR (2) serial correlation fails to reject the null hypothesis of no autocorrelation. In addition, the Sargan and Hansen tests for over identification restrictions are not significant, implying that the instruments used are valid or not correlated with the error terms. Though the Sargan OIR test is not robust but not weakened by instruments, the Hansen OIR is robust but weakened by instruments. Moreover, in order to validate the Sargan and Hansen OIR tests, Difference in Hansen test for exogeneity of instruments was employed, and the outcomes failed to reject the hypothesis that the entire instruments as a group are exogenous. The probability of the Wald chi-square test for the three results is 0.0000, implying that the joint estimated coefficients are significant.

5. CONCLUSION AND RECOMMENDATIONS

The study examined the role of financial sector in the renewable energy financing and renewable energy market penetration nexus in Sub-Saharan Africa. Panel data on forty six countries in Sub-Saharan Africa were used with data covering the period 2000 to 2022. The study mainly investigated how renewable energy financing interact with financial sector private sector credit to boost renewable energy consumption in Sub-Saharan Africa. The study adopted the two step system Generalized Method of Moments for the analysis. The study revealed that renewable energy financing has a negative significant effect on renewable energy market penetration, while financial sector private sector credit has a positive significant effect on renewable energy market penetration in SSA. It also found that the interaction between renewable energy financing and financial sector development significantly influence renewable energy market penetration in SSA.

Consequently, the study concludes that the potential for renewable energy increase consumption in Sub-Saharan Africa exists given adequate financial support from public and private sectors as well as the financial sector. Hence, the study made the following recommendations based on its results. Initially, to enhance the effectiveness of financial sector investment in promoting renewable energy adoption, policies should focus on streamlining the investment climate for financial institutions and private enterprises, particularly concerning asset financing,

stocks, and bonds tailored for the renewable energy sector. Such measures may involve targeted credit facilities and equity offerings.

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