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Macroeconomic Determinants of Renewable Electricity Technology Adoption in Nigeria

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Abstract: Renewable electricity technology adoption is an essential part of the measures to mitigate climate change and promote sustainable development. This paper investigates the drivers of and barriers to renewable electricity technology adoption in Nigeria. Specifically, the factors that influence the share of renewable electricity in total electricity consumption in Nigeria is investigated using data from 1981 to 2011 and employing the Johansen cointegration technique and vector error correction method. The results show that there is a long run relationship between renewable electricity consumption and GDP, trade openness, financial development and share of fossil fuel in energy consumption. Trade openness promotes renewable electricity consumption while obsession with economic growth and the lobby of conventional energy sources undermine it in Nigeria. Financial development does not have significant impact on renewable electricity technology adoption in Nigeria. It is recommended that the Nigerian government should pursue policies that not only increase the amount of renewable electricity, but also increase the share of renewables in total electricity consumption.

Keywords: Renewable technology, electricity consumption, economic development, Nigeria

JEL codes: Q43 Q56 O55 P48

1. Introduction

Nigeria's economic growth in the past decades has been accompanied by increase in energy consumption. According to the EIA, Nigeria's primary energy consumption doubled from 0.42 Quad BTU in 1980 to 0.84 Quad BTU in 2011. Similarly, her electricity net consumption

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increased form 4.69 billion kilowatthours in 1980 to 23.11 billion kilowatthours in 2011. With the increase in total primary energy and electricity consumption, energy-related carbon emission is also expected to increase significantly. As at 2012, Nigeria's fossil fuel-related co2 emission stands at 86.40 million metric tons compared to 69.14 million metric tons in 1980. The current emission level makes Nigeria the second co2 emitting countries in sub-Sahara Africa, behind South Africa. With her current status as the largest economy in Africa, increase in economic activities and investment is expected to result in significant rise in energy consumption and co2 emisison in the near future (Gertler et al, 2013, p 15).

One of the key measures aimed at addresing energy-related co2 emission and achieveing deep decarbonisation and sustainable development is increasing the share of renewable energy in the total energy mix. While this has been achieved considerably in developed countries like the US, EU and some emerging eonomies, the level of renewable energy adoption in developing countries including Nigeria is relatively low. Net renewable electricity consumption in the United States and Germany stand at 507.788 billion kwh and 140.092 billion kwh respectively in 2012, compared with Nigeria's 5.60 billion kwh in 2011 (EIA Database). Given the large disparity between renewable energy adoption in developed and developing countries, there is need for comprehensive studies to analyse the barriers to renewable energy adoption in developing countries. Against this background, this paper examines the determinants of renewable energy consumption in Nigeria.

A number of studies have been conducted on renewable energy. Peterson (2007) surveys the empirical evidence technology transfer with respect to greenhouse gas mitigation and finds little evidence of the impact of trade, foreign direct investment, official development assistance and other funding sources on greenhouse gas mitigation technology. Popp et al (2011) examine the influencing factors of renewable energy technology deployment in 26 OECD countries from 1991-2004. Brunnschweiler (2010) analyses the impact of financial sector development on renewable energy technology deployment in non-OECD countries. Similar to Brunnschweiler's study, Pfeiffer and Mulder (2013) analyse the diffusion of renewable energy technology in 108 developing countries. Salim and Shuddhasattwa (2012) analyses the influencing factors of renewable energy consumption in 6 emerging economies of Brazil, China, India, Turkey, Philippines and Indonesia. Omri and Nguyen (2014) examines the determinants of renewable energy consumption in a panel of 64 countries using data from 1990 to 2011.

The main contribution of this paper to the literature is threefold. First, although there have been enormous studies on renewable energy in the field of energy and environmental economics, majority of these studies focus on developed and industrialised countries such as United States, EU and generally, OECD countries (Marques et al. 2010; Popp et al., 2011). In contrast, this paper models and analyses the determinants of renewable energy adoption in a developing country. Second, most of the empirical studies analysing the drivers of and barriers to renewable energy employ panel data techniques, and do not adequately incorporate country specific factors (Aguirre and Ibikunle, 2014; Omri and Nguyen, 2014; Pfeiffer and Mulder, 2013). Following the SDSN and IDDRI (2014), deep decarbonisation of energy system requires both globally coordinated decarbonisation strategy and individual country-level decarbonisation pathways. Also, according to Vachon and Menz (2006), individual country characteristics such as culture, wealth and renewable energy endowment are important drivers of renewable energy. The individual country characteristics and pathways are necessary given the significant differences in income level, resource endowment, energy consumption level and structure, technology advancement, amount of co2 emission, energy market structure, mitigation and adaptation capabilities, and development policy goals across countries. Thus, this study takes these factors into consideration, and focuses the analysis on an individual country. Third, most of the previous studies on renewable energy use the amount of renewable energy produced or consumed as dependent variables. However, based on Aguirre and Ibikunle (2014), it is the share of renewable energy in total energy consumption and not the amount or size of renewable energy consumed that is important for deep decarbonisation of energy systems and climate change mitigation. Therefore, this study uses the share of renewable electricity in total electricity consumption as the dependent variable - proxy for renewable electricity technology adoption. In effect, the major objective of this paper is to determine the drivers of and barriers to renewable electricity technology adoption in Nigeria using data from 1981 to 2011.

2. Lierature Review

There has been substantial research attention on renewable energy in recent years. Renewable energy is recognised as a viable option to enhance energy access and at the same time mitigate climate change (Moomaw et al., 2011). Research on the determinants of renewable energy can be classified into panel and time series analysis, developed and developing countries, investigation of individual variables, and various types of renewable energy.

Marques et al. (2010) analyse the drivers of renewable energy in the European Union (EU) using fixed effect vector decomposition (FEVD) technique on data spanning 1990 to 2006. The study focuses on political, socioeconomic and country-specific factors affecting renewable energy. The result shows that the influence of traditional energy sources and co_2 emission undermine renewables commitment while the goal of reducing energy dependency stimulates renewable energy consumption. Rafiq and Alam (2010) study the determinants of renewable energy consumption in leading renewable investor emerging countries. The study uses data from six emerging economies (Brazil, China, India, Indonesia, Philippines and Turkey) and employ panel methods (FMOLS and DOLS) and autoregressive distributed lag (ARDL). The result of the study shows that income and pollutant emission are the major driver of renewables in Brazil, China, India and Indonesia while income seems to be the only driver of renewable energy in Turkey and Philippines. Omri and Nguyen (2014) determine the influencing factors of renewable energy consumption in a panel of 64 countries over the period 1990-2011 using dynamic GMM panel model. They also developed subpanels of high, middle and low-income countries. They find that trade openness and increase in carbon emissions are the major influencers of renewable energy. Oil price has a negative but small impact of renewable energy development in the middle-income and global panels.

According to Marques et al. (2010), some studies have investigated the role of individual factors, policies and variables in promoting renewable energy adoption in different countries (Vachon and Menz, 2006; Van Rooijen and Van Wees, 2006; Wang, 2006; and Wustenhagen and Bilharz, 2006). Johnstone et al. (2010) provides the prospects and challenges of public policies in promoting renewable energy. Carley (2009) and Menz and Vachon (2006) point out the importance of state policies and financial incentives in promoting renewable energy use. Empirical evidences from Gan et al. (2007) and Chien and Hu (2008) show that energy security is a major promoter of renewable energy development. Chang et al. (2009) investigates the link between renewable energy, GDP and energy prices, and find that countries with higher GDP have the capacity to adopt renewables regardless of their high price. Sardosky (2009a) hypothesized that high environmental concerns are significant incentives for renewable energy development and deployment. Sovacool (2009) argue that the share of conventional energy sources (fossil fuels) in the total energy consumption has potential influences on the deployment of renewable energy. The impact of income, measured by the level of GDP, on renewable energy adoption has been comprehensively discussed in the literature, with most of the studies finding a strong positive impact of income on renewables (Huang et al., 2007; Narayan and Smyth, 2008; Sardozy, 2009b). From an empirical survey conducted by Peterson (2007), there is little evidence that factors and financial mechanism like trade, foreign direct investment (FDI), overseas development assiatnce (ODA), Global Environmental Facility (GEF) and Clean Development Mechanism (CDM) significantly enhance greenhouse gas mitigation-related technology. Popp et al. (2011) investigates the impact of patenting activity on renewable energy technology in 26 OECD countries from 1991-2004. They find that knowledge has a small but robust effect on renewables. Similarly, Brunnschweiler (2010) analyses the impact of financial sector development on renewables in non-OECD countries.

Studies explaining the deployment of specific types of renewable energy are also copious in the literature. Bird et al. (2005) and Menz and Vachon (2006) investigate the factors promoting wind renewable energy in US states. Beckman et al. (2011) investigates the determinants of on-farm (wind and solar) renewable energy adoption in the US using data from the 2009 on-farm renewable energy survey and adopting a binary-choice model. The result shows that farmers with large farm size, on-farm residence, and those adopting conservation practices are more likely to report renewable energy production while those that specialise in row crop production and use expensive machinery are likely to report less. Adelaja and Hailu (2007) examine the projected impacts of renewable portfolio standards on wind industry development in Michigan, and find that the policy enhances wind energy development in the state. Pfeiffer and Mulder (2013) analyse the drivers of non-hydro renewable energy in 108 developing countries using two-stage estimation methods. The result of the study shows that economic and regulatory instruments, higher per capita income, stable and democratic regimes, higher schooling level improve the possibility of renewable energy adoption. On the other hand, openness, aid, increase electricity consumption, high fossil fuel production and institutional policy support programs undermine adoption of renewables.

The choice of renewable energy policies has also attracted attention in the literature. Stadelmann and Castro (2014) examine the domestic and international determinants of renewable energy policies in 112 developing and emerging countries using data from 1998 to 2009. The study focuses on four types of policies – renewable energy targets, feed-in-tariffs, framework policies, and other financial incentives – and employs logit-linked discrete-time events history model. The result of the study shows that domestic factors such as population and wealth are positively associated with the adoption of renewable energy policies, with endowment only driving renewable policies in some specific cases while hydro power resources undermine the adoption of targets. With respect to international factors, colonial influence and EU membership foster renewable policy adoption while climate finance mechanisms such as Global Environmental Facility (GEF) and Clean Development Mechanism (CDM) only facilitate the adoption of targets and frameworks and are ineffective on tariffs and incentives. According to Martinot (2002), the design of domestic policies such as electricity sector liberalisation could affect renewable energy deployment. Mitchell et al. (2011) shows that domestic factors such as employment generation, pursuit of affordable energy and possibility of developing new industries are very important drivers of renewable energy policies in developing countries. Carley (2009) evaluate the effectiveness of renewable energy electricity policies in US states.

In terms of renewable energy in Nigeria, there is substantial evidence it has considerable potential and could bridge the energy gaps in rural areas of the country (Shaaban and Petirin, 2014). According to Newsom (2012), the potential of concentrated solar thermal power potential in Nigeria stands at over 427,000 MW, as against the current 5,000 MW generated from various sources. Other renewable sources such as biomass, wind and hydro energy also hold huge promise in Nigeria (Mohammed et al., 2013). The Renewable Energy Programme of the Nigeria's Ministry of Environment is established in fulfilment of the country's commitment to the United Nations Framework on Climate Change (UNFCC) and as parts of the strategy to improve energy access and security and mitigate climate change. However, despite this potential and initiatives, the level of renewable energy production and consumption in Nigeria is still very low. More so, most studies on renewable energy in Nigeria largely focus on the potentials and challenges (Emberga et al. 2014; Abur and Duvuna, 2014). There is no known study that has empirically investigated the drivers or barriers of renewable energy in Nigeria.

3. Methods and Materials

3.1 Model Specification and Data

To investigate the dynamic relationship between renewable electricity technology adoption and its drivers and barriers in Nigeria, this study specifies the following model:

$$RES_t = \alpha_0 + \alpha_1 GDPt + \alpha_2 OPEN_t + \alpha_3 FINDEV_t + \alpha_4 FUEL_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where RES_t = share of renewables in total electricity consumption; $OPEN_t$ is trade openness, $FINDEV_t$ is financial development, $FUEL_t$ is lobby effect of the fossil fuel industry and ε_t is the error terms. In order to avoid heteroscedasticity in the model, we take the natural logarithm of the independent variable. Thus, equation 1 becomes:

$$RES_t = \alpha_0 + \alpha_1 logGDPt + \alpha_2 logOPEN_t + \alpha_3 logFINDEV_t + \alpha_4 logFUEL_t + \varepsilon_t \ldots\ldots(2)$$

3.2 Method of Analysis

To capture the dynamic relationship between the variables in equation (2) above, the vector error correction method (VECM) technique is employed. The VECM framework allows us to determine the direction of causation between observed variables while providing estimates on both the long run and the short run. The co-integration analysis which is a property of long run equilibrium provides information about the long run relationship among the variables while the granger causality test which is a short run phenomenon provides information on the short run dynamics among the variables (Saibu et al, 2012). Therefore, equation (2) can be expressed in VAR model as follows:

$$X_t = A_0 + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \beta_3 X_{t-3} + \ldots\ldots + \beta_q X_{t-k} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

where: $X_t = [RES^I \quad GDP \quad OPEN \quad FINDEV \quad FUEL]^1$

equation (3) can be written more compactly as:

$$X_t = \alpha_0 + \beta_1 \sum_{j=1}^{k} X_{t=j} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

equation (4) can be written in a VECM form as:

$$\Delta X_t = A_0 + \Pi X_{t-1} + \sum_{j=1}^{k} \Gamma_j \Delta X_{t-j} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Where Δ is the difference operator, $X_t$is a 5*x1* – dimensional vector of non stationary I(1) endogenous variables of the model, α_0 is a 5*x1* - dimensional vector of constant and ε_t is *k*-dimensional vector of the stochastic error term normally distributed with white noise properties

N(0,σ^2). ΠX_{t-1} is called the error correction term.'and Π ' is the long run matrix that determines the number of co-integrating vectors that consist of α and β' representing speed of adjustment towards long run equilibrium and long run parameter respectively. Γ is the vector of parameters that represents the short term relationship.

3.3 Data Description and Sources

Renewable electricity technology adoption (RES) is represented by the share of renewables in total electricity consumption. Data on renewables and total electricity consumption are obtained from the online database of the United States Energy Information Administration (EIA). Economic growth is measured by gross domestic output (GDP) and is obtained from the World Development Indicator of the World Bank. Trade openness (OPEN) is measured by the ratio of trade to GDP. In other words, it is total trade (import plus export) as a percentage of GDP. The data is also obtained from the World Development Indicator of the World Bank. Financial development (FINDEV) is measured by the ratio of credit to the private sector to gross domestic product, and is obtained from the World Development Indicator of the World Bank. Fossil fuel industry lobby (FUEL) is proxied by the share of fossil fuel in total energy consumption. The data is obtained from the World Development Indicator of the World Bank.

4. Presentation and discussion of results

This section presents the results of the analysis and their interpretation. The results are further discussed in relation with the situation in Nigeria.

4.1 Unit root test

Before analysing the driver and barriers to renewable electricity technology adoption in Nigeria, we check the stationarity properties of the time series data used in this study. The Augmented Dickey Fuller (ADF) test is used to examine the existence of unit root and the result is presented in table 1 below. From the table, it is observed that all the variables are non-stationary at levels, but their first difference forms are stationary. Thus, we can go ahead to conduct Johansen cointegration test.

Table 1: Summary result of ADF unit root test.

Variables	DF statistics @ levels	DF statistics @ 1st diff.	Order of integration
res	-0.537	-5.617*	I(1)
loggdp	1.050	-5.034*	I(1)
logopen	-2.065	-7.330*	I(1)
logfindev	-2.369	-4.873*	I(1)
logfuel	-2.740	-6.018*	I(1)

*=1% significance level.

Source: Authors computations

4.2 Optimal lag selection

The model in equation 2 is used to analyse the relationship between renewable electricity technology adoption (res) and GDP (loggdg), trade openness (logopen), financial development (logfindev) and conventional fuel sources (logfuel). The Akaike Information Criterion (AIC) and Schwarz Bayesian Information Criterion (SBIC) are mostly used in lag selection. From table 2, all the lag selection criteria except the SBIC criterion selects lag 4. The SBIC chooses lag 1. However, according to Hong (2010), when n > 7, the SBIC impose a higher penalty for model complexity than AIC, which is measured by the number of estimated parameters relative to the sample size n. As a result, the SBIC criterion is more consistent and will choose a more parsimonious model than the AIC criterion. Thus, we follow the SBIC criterion and select lag interval 1.

Table 2: Lag selection criteria

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-108.527				.003089	8.40944	8.4808	8.64941
1	-23.9272	169.2	25	0.000	.000039	3.99461	4.42274	5.43443*
2	-.588928	46.677	25	0.005	.000054	4.1177	4.90261	6.75737
3	31.7678	64.713	25	0.000	.00006	3.57276	4.71445	7.41227
4	91.1743	118.81*	25	0.000	.000026*	1.02412*	2.52259*	6.06349

*=1% significance level.

Source: Authors computations

4.3 Cointegration rank test

The result of the Johansen test for cointegration rank is presented in the table 3 below. As the trace statistics (75.3366) > the 5% critical value (68.52), we reject the null hypothesis of the cointegration rank is zero (0). However, the null hypothesis of cointegration rank is 1 cannot be rejected because the trace statistics (45.0795) < the 5% critical value (47.21). So based on the trace statistic, there is one cointegration equation among the variables. In other words, there is a long run relationship between renewable electricity technology adoption and the independent variables in Nigeria.

Table 3: Johansen cointegration rank test

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	30	-44.380469		75.3366	68.52
1	39	-29.251903	0.64773	45.0795*	47.21
2	49	-18.573423	0.52119	23.7225	29.68
3	51	-10.444773	0.42913	7.4652	15.41
4	54	-6.7434488	0.22529	0.0625	3.76
5	55	-6.712176	0.00215		

Trace test indicates 1 cointegrating eq. at 5% significance level
Source: Authors computations

4.4 Normalised cointegration coefficient

The coefficient of the long run relationship between renewable electricity technology adoption, GDP, trade openness, financial development and conventional energy sources in Nigeria is shown in table 4 below.

Table 4: Normalised cointegration coefficient

res	loggdp	logopen	logfindev	logfuel	constant
1	15.80398	-25.43859	9.142020	45.9144	-498.5857
Std. error	2.061922	4.097778	4.789685	14.7784	
z or t-value	7.66*	-6.21*	1.91	3.11*	
p-value	0.000	0.000	0.056	0.002	
log of coefficient	2.760262	- 3.236267	2.212881	3.826779	- 6.211775

Note. coefficients are in the second row; *=1% significance level
Source: Authors computations

The cointegration equation from table 4 is expressed as:

$$\mathbf{res_t + 15.80398gdp_t - 25.43859open_t + 9.142020findev_t + 45.9144fuel_t - 498.5857 = 0}$$

Based on the fact that equation 2 is a linear-log model (i.e we take the log of all the independent variables but not the dependent variable), we take the natural log of the constant and the coefficients of the independent variables to get their elasticities (last row in table 4). Thus, the estimated cointegration model in equation 2 is as follows:

$$\mathbf{res_t = -2.76gdp_t + 3.24open_t - 2.21findev_t - 3.83fuel_t + 6.21}$$

The result of the cointegration model in table 4 shows that all the variables except financial development (findev) are significant at 1% significance level. Based on the result, a 1% increase in income leads to a 2.76% reduction in renewable electricity technology adoption in Nigeria. The negative impact of income on renewable energy in this result supports the findings of Marques et al. (2010) for non-EU member countries. As the economy grows, the capacity to adopt renewable electricity technology is expected to increase, but this is not the case in Nigeria. The case of Nigeria could be explained by the following reasons. First, as the economy grows, electricity consumption increases but renewable electricity may not increase in the same proportion as total electricity consumption. In other words, the amount of renewable electricity consumption may increase with economic growth, but its contribution to total electricity consumption may not increase or may even decrease. Second, on the understanding that Nigeria's economy largely relies on fossil fuel, the government may be reluctant to change the "working" economic development model from cheap fossil fuel to expensive renewable energy. This is the case in China where the decades of impressive economic development and industrialisation is driven by large consumption of fossil fuel and the government is only embracing renewable energy in recent years because of rising environmental concerns (Lin and Xie, 2014). Governments that are obsessed with economic growth and development may increase the consumption of cheap fossil fuel at the expense of investing in renewable technology, which are seen as expensive. This indicates that investing in renewable electricity technology goes far beyond economy growth, and requires deliberate efforts by the government. This argument is based on Perc and Szolnoki (2010), which states that economic growth could produce some benefits to investors and the economy, but at the expense of the environment.

Trade openness has a significant positive impact on renewable electricity technology adoption in Nigeria. This result confirms earlier study by Omri and Nguyen (2014) which find positive impact of trade and foreign direct investment on renewable energy. According to the result, a 1% increase in trade openness leads to 3.24% increase in renewable electricity technology adoption. Over the past decade, Nigeria has attracted significant amount of foreign direct investment, primarily due to its GDP economic growth and large market. Similarly, Nigeria's import and export trade has expanded significantly. Trade openness facilitates the exchange of green goods, services and technologies and engender opportunities for the development of human capital through skills acquisition.

Financial development has an insignificant impact on renewable electricity technology adoption in Nigeria. This is contrary to expectation as financial development is supposed to enhance investment in renewable technology. The result also contradicts Brunnschweiler (2010) and Omojolaibi (2012). The insignificant relationship between financial development and renewable technology adoption in Nigeria could be as a result of two key reasons. First, the financial sector in Nigeria has been criticised for shying away from financing long term development project due to long payback periods and high risks (Ogujiuba and Obiechina, 2011). Renewable technologies are long term projects with high level of risks and uncertainties. The situation is also aggravated by lack of explicit long term renewable technology policies by the government in Nigeria. The challenge and risks of financing renewable technology and a private sector-led electricity sector in Nigeria has been rasied by Olowojaiye (2013). This factor partly explains why the financial sector often looks away from clean energy projects. Second, uncertainties about future energy and global climate policies often discourage the financial sector from financing climate mitigation projects, as future policies could affect the viability of renewable energy projects. This argument is based on the assertion by IEA (2005) which posit that financial institutions often shy away from providing credits to finance clean energy technology projects because of uncertainties in future climate policies and long payback periods.

The share of fossil fuel in total energy consumption has a negative significant impact on renewable electricity technology adoption in Nigeria. This is known as the lobby effect. A 1% increase in the share of fossil fuel in energy consumption leads to a 3.83% reduction in renewable energy technology adoption in Nigeria. This supports the result of Pfiffer and Mulder (2013) and Sovacool (2009). Sovacool (2009) find that the lobby effect of traditional energy sources impede renewable energy. Similarly, Pfiffer and Mulder (2013) argue that high fossil fuel production appear to delay renewable energy. This result indicates that the fossil fuel industry has significant influence by impeding renewable technology adoption in Nigeria. This is understandable given that Nigeria is one of the largest producers of fossil fuel in the world, and the fossil fuel industry provides substantial revenue and foreign exchange for the government. As a result of this situation, players in the fossil fuel industry would make efforts to undermine measures to promote renewable energy technology.

4.5 Vector error correction model

The result of the vector error correction model is presented in table 5 below. The result shows that there is a long run causality running from the dependent variables to renewable electricity technology adoption in Nigeria. The error correction term of -.552 is negative and significant at 1% level which confirms the existence of long run causality. The error term indicates that when there is an exogenous shock to the model, the model corrects its disequilibrium by 55.2% speed of adjustment per year in order to return to the equilibrium. The result also shows that there is no short run causality among the variables.

Table 5: Summary result of the vector error correction model.

D_res	Coefficient	Std. Error	z	p>|z|
_ce1				
L1	-.551612	.1161437	-4.75	0.000
D_loggdp				
L1	-.0079151	-.006265	-1.26	0.206
D_logopen				
L1	.0087332	.0058856	1.48	0.138
D_logfindev				
L1	.0070365	.0066627	1.06	0.291
D_logfuel				
L1	-.0019334	.001965	-0.98	0.325

Source: Authors computations

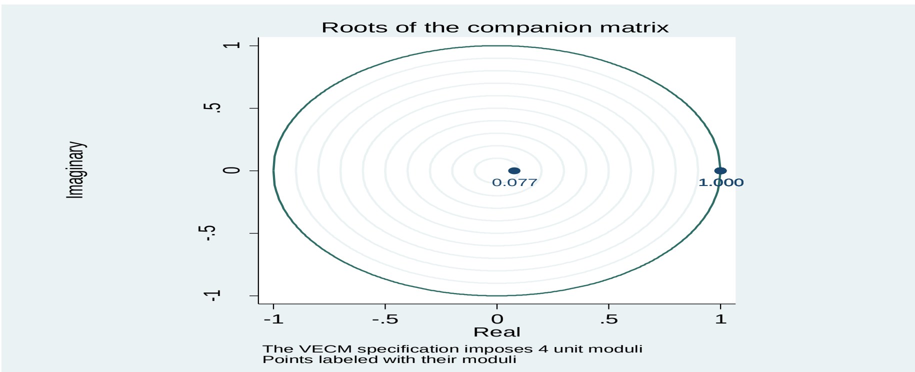
4.6 Diagnostic tests

We perform a number of test to examine the validity and stability of the model. The tests include goodness of fit to check how related is the actual curve and the fitted curve; eigenvalue stability test to verify the stability of the model; Langrange-multiplier test to check for serial correlation; and Jarque-Bera to determine whether the residual are normally distributed.

4.6.2 Eigenvalue stability condition for stability test

The result of the stability test is presented in figure 1. The result shows that except the unit roots assumed by the VECM model itself, the eigenvalue of the adjoint matrix is smaller than 1, and there is no characteristic root outside of the unit circle in the figure. This implies that the model is stable.

Figure 1. Graph of Eigenvalue stability test



The VECM specification imposes 5 unit moduli

Source: Authors computations

4.6.3 Test for serial correlation

We further test for the presence of serial correlation in the model using the Breusch Godfrey test. Table 6 shows the result of the test. Based on the prob > chi^2 values, the null hypothesis of no serial correlation cannot be rejected, indicating that the model is free of serial correlation.

Table 6: Langrange-multiplier test for serial correlation.

Null hypothesis: there is no autocorrelation at lag order			
Lag	chi^2	df	prob > chi^2
1	27.5687	25	0.32809
2	23.4887	25	0.54905

*=1% significance level.

Source: Authors computations

4.6.4 Test for normality of residuals

The result of the Jarque-Bera test in table 7 investigates whether the residuals of the model are normally distributed. Given that the prob > chi^2 is more than 0.05 significance level, the null hypothesis that the residuals are normally distributed cannot be rejected. Thus, we conclude that the residuals are normally distributed.

Table 7: Jarque-Bera normality test

Null hypothesis: Residuals are normally distributed			
Equation	chi^2	df	prob > chi^2
D_res	0.044	2	0.97847
D_loggdp	0.950	2	0.62178
D_logopen	2.091	2	0.35155
D_logfindev	0.768	2	0.68114
D_logfuel	0.249	2	0.88305
ALL	4.101	10	0.94266

*=1% significance level.

Source: Authors computations

5. Conclusion and policy implications

This study examines the drivers of and barriers to renewable electricity technology adoption in Nigeria using data from 1981 to 2011 and employing the Johansen cointegration and vector error correction model (VECM) techniques. This study differs from previous ones by focusing on the share of renewables in total electricity consumption rather than the amount of renewables. The results of the study present the following findings. First, there is a long run relationship between renewable electricity technology adoption and GDP, trade openess, financial development and share of fossil fuel in total energy consumption in Nigeria. Second, obsession with the goals of economic growth and development may undermine renewable electricity technology adoption in Nigeria. This could be either because economic growth may not increase renewable electricity in the same proportion as total electricity consumption or government may be reluctuant to deviate from current economic development model. Third, trade openness significantly promote renewable electricity technology adoption in Nigeria. Trade openness allows the spread and exchange of green goods, services, ideas and technologies. Fourth, financial development does not have significant impact on renewable electricity technology adoption in Nigeria. This could be because the financial sector in Nigeria often shy away from financing long term projects and also the risks and uncertainties about future domestic and global climate change policies. Fifth, conventional fossil fuel have significant negative impact on renewable technology adoption.

Based on the findings of the study, the following policy suggestions are proposed. First, the Nigerian government needs to detach itself of the obsession with economic growth without consideration for environmental concerns. Thus, it should deliberately prioritise renewable technology in order to ensure a low-carbon economic development path. Second, there should be continuous efforts to open-up the economy in order to enhance the importation of green goods, services, ideas and advanced technologies. Third, the financial sector should be strengthened and supported to improve their capability to finance clean energy technology investments. This could be done by providing instruments that guarantees credits allocated towards clean energy projects. Fourth, the Nigerian government should decisively deal with the lobby influence of the fossil fuel industry on renewable technology adoption. Deliberate measures should be taken to significantly reduce fossil fuel consumption. This could be done by eliminating subsidies to the fossil fuel industry and imposing environmental tax in order to make renewable energy competitive. Fifth, the government should not only focus on policies that increase the amount of renewable electricity; rather it should promote policies that would increase the share of renewables in total electricity consumption.

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Makroekonomiczne determinanty adaptacji technologii odnawialnej elektryczności w Nigerii

Streszczenie

Przystosowanie technologia odnawialnej elektryczności stanowi zasadniczą część środków na rzecz zapobiegania zmianom klimatycznym oraz promowania zrównoważonego rozwoju. Niniejszy artykuł podejmuje tematykę czynników przyczyniających się do adaptacji technologii odnawialnej elektryczności w Nigerii, a także barier ją hamujących. Omówiono w szczególności czynniki wpływające na udział odnawialnej energii w całkowitej konsumpcji elektryczności w Nigerii na podstawie danych z lat 1981-2011, a także przy zastosowaniu technik kointegracji Johansena oraz metody korekty błędu wektorowego. Wyniki ukazują, że istnieje długoterminowa korelacja pomiędzy konsumpcją odnawialnej elektryczności oraz PKB, otwartością handlu, rozwojem finansowym oraz udziałem paliw kopalnych w konsumpcji energii. Otwartość handlowa promuje konsumpcję odnawialnej elektryczności, jednak w Nigerii osłabia ją obsesja na punkcie wzrostu gospodarczego oraz lobby wokół konwencjonalnych źródeł energii. Rozwój finansowy nie ma znaczącego wpływu na przystosowanie technologii odnawialnej elektryczności w Nigerii. Rekomenduje się, aby nigeryjski rząd kładł nacisk na technologie, które prowadzą do wzrostu nie tylko ilości odnawialnej elektryczności, ale też udziału źródeł odnawialnych w całkowitej konsumpcji elektryczności.

Słowa kluczowe: odnawialne technologie, produkcja elektryczności, rozwój ekonomiczny, Nigeria