Final Report

Assessing the macroeconomic impacts of the financing options for renewable energy policy in Nigeria: Insights from a CGE model

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Abstract

Measures to mitigate global climate change require the decarbonisation of the entire energy system in line with the Paris Climate Agreement and the Sustainable Development Goals. The Nigerian government formulated the Nigeria Renewable Energy and Energy Efficiency Policy (NREEEP) in 2015 to promote the development of renewable energy. The policy instituted a number of instruments and incentives aimed at achieving the renewable energy target. This study examines the macroeconomic impacts of these policy incentive using computable general equilibrium model. The policy incentive examined is a 20% production subsidy for the renewable electricity sector. The results show that the policy incentive is effective with respect to increasing the demand for renewable electricity input relative to fossil fuel electricity input across the sectors of the economy. The policy, however, have mixed impacts on labour demand in different sectors. Household income and consumption budget also reduce signifying a negative impact on household welfare. Lastly, the policy leads to a decrease in economic growth, but the decrease in real GDP is negligible.

JEL: Q42; Q43; L94; C68

Keywords: Renewable Energy; Energy Policy and the Macroeconomy; CGE models, Nigeria.

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List of abbreviations

CBN	Central bank of Nigeria
CES	Constant Elasticity of Substitution
CET	Constant Elasticity of Transformation
CGE	Computable General Equilibrium
CHEER	China Hybrid Energy and Economic Research
CO_2	Carbon Dioxide
ECN	Energy Commission of Nigeria
EE	Energy Efficiency
EU	European Union
FIT	Feed-in tariff
GAMS	General Algebraic Modelling System
GDP	Gross Domestic Product
GEM-E3	General Equilibrium Model for Economy-Energy-Environment
IFPRI	International Food Policy Research Institute
IMPLAN	Impact Analysis for Planning
IRENA	International Renewable Energy Agency
PEP	Partnership for Economic Policy
PV	Photovoltaic
MAED	Model for Analysis of Energy Demand
MESSAGE	Model for Energy Supply Strategy Alternatives and their General Environmental Impact
NEEAP	National Energy Efficiency Action Plan
NGOs	Non-Governmental Organizations
NREAP	National Renewable Energy Action Plan
NREEEP	Nigeria Renewable Energy and Energy Efficiency Policy
OECD	Organization for Economic Co-operation and Development
RE	Renewable energy
RES	Renewable energy sources
R&D	Research and Development
SAM	Social Accounting Matrix
SDGs	Sustainable Development Goals
UNDP	United Nations Development Program

Executive summary

This study investigates the impacts of the fiscal incentives proposed to enhance renewable energy development in Nigeria. The Nigerian government as part of the actions taken following the approval of the Sustainable Development Goals (SDGs) and Paris Climate Agreement launched the National Renewable Energy and Energy Efficiency Policy (NREEEP) in 2015 as a framework to develop the renewable energy sector in the country. The development of renewable energy is seen as a means of improving energy access to the population and also meeting the obligations of the Nigerian government under the Paris Climate Agreement and Sustainable Development Goals.

The NREEP sets ambitious targets for different types of renewable energy sources, including hydro, solar, wind and biomass. However, to achieve this, the government outlined a number of incentives and action plans. These include providing fiscal incentives to producers and consumers of renewable energy, enacting legal frameworks and regulations to support the development of the sector, research and development, capital grant to the sector, financial support from local banks and international organisation, preferred pricing in the form of a feed-in-tariff, etc. As the experiences of other countries have shown, the fiscal incentives are commonly used tools, and if properly designed, are critical to enhancing renewable energy development.

While these incentives are broadly to enhance the development of renewable energy, they may also have unexpected macroeconomic impacts. This is the main objective of this study. This study broadly examines the macroeconomic impacts of the NREEEP in Nigeria. Specifically, it investigates the effectiveness of the fiscal incentives proposed in the NREEEP in achieving higher renewable energy penetration and the impacts on macroeconomic outcomes such as income, savings, employment, GDP and foreign trade.

The study adopts a computable general equilibrium (CGE) model to achieve the objective of the study. CGE model is an appropriate method for evaluating the economy-wide effects of public policies, and has been used extensively in energy and environmental policy research. The specific CGE model used in the study is the PEP-1-1 model, adjusted to fit the objective of the study. The baseline data for the study is the social accounting matrix (SAM) of Nigeria. The original 2006 SAM has been updated to 2013 using the SAMBAL implementation in GAMS, and the updated SAM has

been disaggregated accordingly for the purpose of the study. The PEP-1-1 model is used to calibrate the SAM and the model is implemented with the GAMS software.

The results show that the 20% production subsidy for the renewable energy sector increase the demand for renewable electricity factor vis-à-vis fossil fuel electricity factor, indicating the effectiveness of the policy to achieve its primary goal. However, the policy has mixed effects on other macroeconomic indicators. The policy incentive has a negative effect on income, savings, investment, gross fixed capital formation and GDP. The impacts on labour demand, imports and exports vary across sectors of the economy.

In terms of policy, production subsidy incentive for the renewable energy sector is effective in promoting renewable energy inputs vis-à-vis fossil fuel energy across all sectors of the economy, but the policy has a negative impacts on other key macroeconomic indicators such as labour demand, income, savings, investment, gross fixed capital formation and GDP. The government needs to consider the economic implications of fiscal incentives for renewable energy development with a view to ensuring the policy does not promote renewable energy development at the expense of macroeconomic development.

1. Introduction

1.1 Context of the study

Climate change is one of the major challenges facing the world today, and is largely caused by CO_2 emissions from the combustion of fossil fuel energy resources (Stern, 2008; IPCC, 2011). The SDGs and the 2015 Paris Climate Agreement encouraged countries to develop policies towards ensuring access to affordable, reliable, sustainable and modern energy for all as well as energy-related CO_2 emission reduction. Nigeria, like other signatories to these agendas, formulated the National Renewable Energy and Energy Efficiency Policy (NREEEP) in 2015 to drive the development of renewable energy and support the attainment of the SDG and her commitments to the Paris Climate Agreement. The policy sets specific targets for different renewable energy sources, such as hydro, wind, solar, and biomass, as well as the measures to be taken to achieve these targets.

The government seeks to enhance electricity access by developing renewable energy capacity and generation to complement existing generation from conventional sources. Although renewable energy policies are aimed at addressing environmental problems, there are increasing interests in how they affect the macroeconomy. Moreover, several incentives and policy instruments were proposed to achieve the NREEEP, and this is the main focus of this study. Therefore, this study aims to examine the effectiveness of the fiscal incentives for the NREEEP and their macroeconomic impacts. We apply a computable general equilibrium (CGE) model to assess the economy-wide impacts of the NREEEP.

1.1.1 Overview of the National Renewable Energy and Energy Efficiency Policy

The National Renewable Energy and Energy Efficiency Policy (NREEEP) was endorsed as a policy document by the Federal Executive Council in 2015. It is the first and only comprehensive tool to push for the development of renewable energy (RE) and enhance energy efficiency (EE) in Nigeria. NREEEP presents the thrust of the measures and policies for fostering RE and EE in Nigeria. It mandates the development of the National Energy Efficiency Action Plan (NEEAP) and National Renewable Energy Action Plan (NREAP).

Studies by the Energy Commission of Nigeria using Model for Analysis of Energy Demand (MAED) and Model for Energy Supply Strategy Alternatives and their General Environmental

Impact (MESSAGE) energy planning model show the expected energy use needed to meet economic growth targets. RE contribution towards attaining these targets are based on 7% growth scenario and presented in the table below.

Table 1: Summary of RE targets under the NREEEP

S/N	Renewable energy type	2015 (Short term)	2020 (Medium term)	2030 (Long term)
1	Large Hydro	2121.00	4549.00	4626.96
2	Small Hydro	140.00	1607.22	8173.81
3	Solar	117.00	1343.17	6830.97
4	Biomass	55.00	631.41	3211.14
5	Wind	50.00	57.40	291.92
	Total	2483.00	8188.20	23134.80
	Share of RE in total (projected) electricity generation	10%	18%	20%

Source: NREEEP

1.1.2 Proposed incentives and policy instruments for achieving the NREEEP

The government proposed various incentives and policy instruments to promote RE in Nigeria. These include regulatory and legal frameworks, financial investments, capacity building, technology transfer, fiscal incentives, market and pricing supports, community participation, and research and development.

The main focus of this study are the fiscal incentives aimed at enhancing the development of renewable energy. These includes power production tax credit, tax incentives to manufacturers of RE and EE equipment; tax holiday on dividend incomes from investments on domestic RE sources; excise duty and sales tax exemption on EE appliances and lighting; soft loans and special low interest from the power sector development fund for RE supply and EE projects; grant or land allocation to manufacturers of EE equipment and RE projects; tax credits for users of EE lighting and appliances; tax credits to companies that produces EE appliances, and so on. Of these incentives, the impacts of a production tax incentives will be simulated to examine its effectiveness as well as other impacts it may have on the economy.

1.2 Research questions and objectives

The present study evaluates the impact of the policy incentives for achieving the NREEP on the Nigerian economy. It specifically focuses on tax incentives to the renewable energy sector. Thus, the main research question is: what are the economy-wide impacts of production tax incentives for Nigeria's renewable energy sector? The specific research questions are as follows:

- Is the production tax incentive for renewable energy sector effective in promoting renewable energy development?
- How does this renewable energy fiscal incentive impact macroeconomic variables?

2. Literature review

Rising energy demand around the globe entails that the contribution from renewable energy would be important. Therefore efforts to enhance different policies, upgrade current technologies and develop new generation fuels have been made by different countries. This surge in interest in renewable energy and policies that support its development is driven by the increased awareness of the impact of human activities on the climate and the security concerns posed by over reliance on fossil fuel-based energies (IRENA, 2017).

The economic implications of renewable energy policies are, however, becoming important research priorities, due to the crucial link between energy consumption and the economy. The current studies examining the subject use methods ranging from reviews (Boluk, 2013), econometric analysis (Jaraitė et al., 2015; Silva, et al., 2012; McKitrick, 2013; Hillebrand et al., 2006), primary data analysis (Sastresa et al., 2010), macro-econometric modelling (IRENA, 2016; Ragwitz et al., 2009), meta-analysis (Nkolo et al., 2018) to CGE modelling (Bohringer et al., 2012, 2013; Dai et al, 2016).

While these studies are diverse in methodological approach and case study, the major limitation is that they are narrowly focused on a single economic indicator such as GDP and employment and fail to capture economy-wide effects and sectoral changes that may have occurred as a result of environmental policy. This limitation is explicitly expressed by Tavoni, et al. (2015). According to the study, emission-reduction expenditure costs are borne by the emission-reducing sectors, and they will lead to a reduction in output and international competitiveness of the sector via increase in production costs. On the other hand, the subsequent increase in the demand for emission-reduction goods will boost the output and competitiveness of the sectors producing them. Similarly, Bohringer et al. (2012) posits that renewable energy development are likely to have general equilibrium effects. Therefore, it is important to investigate the net effects of the policies.

To overcome the key limitations mentioned above, CGE models are used to estimate the macroeconomic effects of renewable energy policies due to the economy-wide effects of energy policies. This paper builds on the growing literature using CGE models to investigate the impacts of renewable energy and environmental policies on the economy. Bohringer, et al. (2012) employs a multi-sector and multi-region CGE model to evaluate the employment impacts of Ontario's feed-in-tariff program. In the model, the CES for renewable energy sector is a nested CES of capital, labour, energy and material combined with a fixed factor input to reflect limited renewable energy sites. They also create a domestic manufacturing sector that produces renewable energy equipment like turbine blades, solar panel, inverter, batteries, etc for the renewable generation sector to reflect the minimum domestic content in the program. The study concludes that there is an overall net employment loss, as positive effects on jobs in the renewable energy and manufacturing sectors are offset by job losses in other sectors of the economy.

Dai, et al. (2016) examines the impact of large scale renewable energy development in China using a dynamic CGE model. The study adjust the standard CGE model in three different ways. First, the authors disaggregated the electricity production sector in the original input-output table into different categories (coal, oil, gas, nuclear, hydro, wind, solar PV and biomass). Second, in the production function, all the sectors (except electricity) have combination of only labour and capital. The electricity sector is disaggregated into fossil and non-fossil electricity generation. The non-fossil electricity generation does not use fossil fuel, but is only composed of labour and capital. On the other hand, the fossil fuel generation technology requires capital, labour and energy, but energy is not bundled with capital, but linked directly to the output. This depicts a linear relationship between energy and output. Thirdly, the model also distinguish two types of investment – conventional investment and investment in construction of non-fossil fuel plants. The model considers two scenarios – a reference scenario and an aggressive renewable energy penetration scenario. Under the reference scenario, non-fossil fuel and renewable energy sectors experience increased value added and job creation while fossil fuel and energy intensive sectors experience negative growth and job losses. There is a negative economic impact under the drastic growth scenarios as GDP and household consumption reduce by 0.3-1.5%. The study however has some key limitations, which the present study addresses. First, it fails to incorporate foreign trade of renewable energy technologies. This is particularly important given that China has the largest market and is a global player in the renewable energy technology market.

Huang (2010) also utilizes a CGE model developed by Lofgren et al. (2002) and modified by Holland et al. (2007) to suit the Impact Analysis for Planning (IMPLAN) dataset to examine the effects of bio energy policies in the Southeastern United States of America. In the first stage, intermediate and primary inputs (land, capital and labour) are demanded in fixed proportions in the production of each unit of output. In the second stage, total intermediate input is specified by a Leontief function of disaggregated intermediate inputs while primary inputs constant elasticity of substitution (CES) function is used to capture the value added. General investment, three household income classes, the federal and state government and the rest of world are the major institutions in the model. The study disaggregated bioenergy production sectors from existing sectors directly from the SAM. The policy scenarios involve displacement of 1% conventional electricity generation with forest biomass based electricity; displacement of 1% conventional liquid fuel with cellulosic ethanol; $1.01 per gallon subsidy for production of cellulosic ethanol and reduction of 10% intermediate inputs for forest bio energy sectors owing to technological advancement. The study find gross regional product and social welfare reduce when conventional energy portion was replaced with forest biomass. On the contrary, the study find that enhancing technologies and providing incentives for forest bio energy lead to an increase in total labour demand, gross regional product and welfare.

In another study, Bohringer, et al. (2013) analyses the impact of renewable energy promotion on employment and welfare in Germany using CGE analysis. In their study, they simulated four alternative ways of financing the subsidy to power production from RE sources: an electricity tax, a labour tax, a lump-sum tax and German coal subsidies replacement. In all four financing scenarios, they studied the impact of various subsidy electricity production rates from domestic RE sources (bar hydropower) on the real consumption, real wage, electricity price and unemployment. The subsidy is expressed as a percentage of the consumer electricity price and varies from 0 to 100 percent, approximately reflecting the variety of technology-specific feed-in tariffs paid in Germany to various renewable technologies. They find that any positive effects on employment and welfare are limited and depend on the level of subsidy rates and financing mechanism; and there are negative welfare and employment impacts if renewable energy subsidies are financed by labour taxes. On the contrary, they find a minor positive effect if an electricity tax is imposed to finance renewable, but these positive effects becomes negative after the subsidy rates exceeds some threshold values.

Mu et al. (2018) analyses the employment impacts of China's RE policies using CGE model. They decompose these impacts into direct, indirect and induced impacts and utilize the static version of the China Hybrid Energy and Economic Research (CHEER) model. Capital is modeled on the production factor in the CHEER model to be completely mobile across sectors. Capital supply is calibrated to the base year, while capital demand differs endogenously in order to clear the capital market. They developed a reference scenario and two scenarios for renewable electricity policy. The reference scenario is calibrated to 2012 as a baseline for the analysis without any further policy shocks. In the reference scenario, 103.0 TW h and 0.36 TW h, respectively, are generated from wind and solar sources. Subsequently, policy simulations are carried out to expand wind and solar power generation in policy scenarios through two distinct financial instruments, which contains feed-in tariffs (FITs) funded by (i) an additional electricity consumption fee (ECF) and (ii) a lump-sum tax (LST). Solar PV and wind expansions are each independently modeled. They find that solar PV and wind power expansion per 1 TWh would generate about 45.1 thousand and 15.8 thousand direct and indirect jobs in China.

In a similar study to the present research, Ge and Lei (2017) investigate the policy options for non-grain bioethanol in China using an economy-energy-environment CGE model. In the model, output is decomposed into value added and intermediate consumption. A CES function is further used to disaggregate value added into labour and energy-capital composite, and the latter further into capital and energy. The energy input is further disaggregated into electricity and non-electricity using a CES, with the latter further decomposed into coal and non-coal. The study categorizes the policy incentives into five scenarios and compares the impact on the macroeconomy, energy consumption and CO_2 emissions. The scenarios include subsidy on bioethanol production, subsidies for non-grain feedstocks planting, subsidies on marginal land reclamation, subsidies for more cities to consume bioethanol, and consumption tax on gasoline. The study finds that bioethanol production and consumption subsidies can boost GDP and at the same time reduce crude oil and gasoline consumption and CO_2 emissions. But this will also result in increase in coal and electricity consumption. On the other hand, bioethanol production subsidy can promote GDP and reduce energy consumption and CO2 emissions, but have limited effects on bioethanol development.

Another study that looks at a specific renewable energy source (Wianwiwat and Asafu-Adjaye, 2013) examines the impacts of biofuel policy in Thailand using CGE model. Their model comprises of 51 sectors and 62 commodities. They disaggregated the energy-source industry into 24 energy sectors and 32 energy source goods. They developed three new industries –Molasses-Ethanol (split from sugar refining), Cassava-Ethanol (split from tapioca refining) and biodiesel (split from palm oil) to evaluate the effects of encouraging bio-liquid fuels. Four mixed-bio-liquid fuel industries (Gasohol-91, Gasohol-95, B3, and B5) were also disaggregated and treated as petroleum refinery dummy industries. The disaggregation promotes the imposition of policy shocks such as increase in capital stocks in the biodiesel sectors, cassava-ethanol and molasses-ethanol. Furthermore, the model can simulate different scenarios like adding more bio-liquid fuels to mixed-bio-liquid fuels, for instance raising the biodiesel content in B3 from 3% to 5% (B3 to B5). In addition, they disaggregated the electricity industry into four new sectors (hydro power, main electricity, small power producers and very small power producers) to assess the impacts of purchasing electricity from biomass-fired energy plants according to various technologies. The study analyzed these policy shocks: a 100% decrease in the use of gasoline -91 in all sectors except petroleum refinery sectors; a 100% increase in ethanol content in E10 goods (E10 to E20); and a two-thirds rise in biodiesel content in B3 (B3 to B5) and a 200% rise in biodiesel content in B5 (B5 to B20). They find that promoting biofuel leads to rapid increase in biofuel price and feedstock in the short run, but a slight increase in the long run.

Though there are studies on the economic impacts of renewable energy expansion in Nigeria, those adopting a CGE model or macroeconomic modelling are rare. Ajayi and Ajayi (2013) examine energy policies and legal ethics of renewable energy development in Nigeria. They focus on the country's legal framework of renewable energy development by evaluating the nation's vision 20:2020 and the renewable energy master plan jointly developed by the United Nations Development Programs (UNDP) and Energy Commission of Nigeria (ECN). Similarly, Lin and Ankrah (2019) adopt ridge regression technique to assess the economic impacts of renewable energy in Nigeria and also examine the substitution and output elasticity of both renewable and non-renewable energy sources. Using dataset from 1980 to 2015 within the framework of the translog production function model, the results show that both energy sources do not exert significant impacts on economic output. Okoro, Schickhoff and Schneider (2018) use a novel Forest and Agricultural Sector Optimization Model to assess the environmental and societal impacts of bioenergy policies under diverse global climate and societal development scenarios. Their findings show that bioenergy subsidy have an insignificant impact on social welfare in Nigeria. Nigeria is also one of the reference countries in IRENA (2016).The study finds that the deployment of renewable energy has a negative effect on the GDP of Nigeria as a result of reduction in fossil fuel export. However, the deployment of renewable energy leads to increase in welfare by 0.5-1.1% depending on the scenario, coupled with a $50 billion worth of fossil fuel import reduction. But this study estimates the welfare impact through changes in GDP. GDP is an inaccurate and inappropriate measure of welfare. Thus, in addition to estimating the impact of renewable energy policy on GDP, employment, trade, fiscal position and other macroeconomic indicators, the present study measures welfare changes from the effects on household income and consumption.

As seen in the literature, several studies have investigated the economic impacts of renewable energy and environmental policies. But there are still some gaps in the literature. First, studies on the aggregate macroeconomic impacts of environmental and renewable energy policies in developing countries in general and Nigeria in particular are very rare. Since the formulation of renewable energy policies in Nigeria in 2003 up to the current National Renewable Energy and Energy Efficiency Policy initiated in 2015, there is no single study that has empirically investigated its economy-wide impacts. Most of the existing empirical studies in the literature focus considerably on developed countries such as OECD and EU countries, and their conclusions may not correspond to Nigeria or other developing countries. Nigeria depends on fossil fuel production and export for foreign exchange, government revenue and electricity generation; hence the macroeconomic and sectoral impacts of renewable energy policies will differ significantly from non-fossil fuel producing and exporting countries. Second, in the case of Nigeria, there is high level of self-generated electricity from diesel and petrol-based generators. This accounts for a significant proportion of electricity supply in Nigeria. But this is usually not considered by previous studies. Our study model energy in a CGE framework following the study of Ge and Lei (2017) and Wianwiwat and Asafu-Adjaye (2013).

3. Data

This study investigates the economy-wide effects of Nigeria's renewable energy policy using a computable general equilibrium (CGE) model. The baseline data for the modelling is the Social Accounting Matrix (SAM) of Nigeria. The SAM describes the interrelations among all economic agents, sectors and factors of production. It shows the circular flow of inflow (income) and outflow (expenses) of economic agents (Breisinger et al., 2009), and describes how factors of production are allocated to sectors and how sectoral outputs are distributed among the economic agents. In effect, it shows the overall picture of the allocation of economic resources and activities among all these agents in an economy. The main economic agents in a SAM are households, firms, government and the rest of the world.

3.1 Overview and modification of the SAM

The latest SAM for Nigeria was published in 2010 based on 2006 national accounts data. According to Nwafor et al. (2010), the data for constructing the SAM were obtained from various publications of key government agencies such as the Central Bank of Nigeria, National Bureau of Statistics and Ministry of Agriculture and Water Resources. The main modules of the SAM include activities/sectors, commodities, factors of production, transaction costs, agents (households, firms, government, and rest of the world), taxes, stock variation, savings and investment. The rest of the world and some taxes cover the international trade aspect of Nigeria's economic activities.

Three production factors are reported in the SAM, and they include land, labour and capital. The households are sub-divided based on the six geo-political zones and rural/urban divides. In all, there are twelve categories of households (South-South rural, South South urban, South East rural, South East urban, South West rural, South West urban, North Central rural, North Central urban, North East rural, North East urban, North West rural, and North West urban). But for this study, the 12 households have been merged into only one household. There are also four categories of taxes – direct/income tax paid by household and firms to the government, indirect/sales taxes paid on commodities, activity tax paid by firms to the government, and import tax.

A total of sixty-one (61) economic activities/sectors and sixty-two (62) commodities are in the original SAM, covering such activities as rice, potatoes, beans, maize, beef, goat meat, poultry meat, transport, finance, health, NGOs, etc. However, we aggregate all the agriculture-related activities and commodities into four major sectors/activities, consisting of crop production, fisheries, livestock and forestry. Other sectors/activities are as they are in the original matrix except "beverages and tobacco products" and "processed foods" which are merged and "transportation and other equipment" absorbed into "other manufactured product". The reason for the aggregation of the agriculture-related commodities and sectors is that there are no economic or theoretical reasons to believe that renewable energy policies will affect different crops like rice, potatoes, beans, etc in different ways. Also, the Nigerian national accounts published by the Central Bank of Nigeria categorise the agriculture sector into this four main categories. After adjusting the original SAM, there remains twenty-five (25) sectors/activities and twenty-six (26) commodities.

The Nigerian economy has changed significantly in size and structure between 2006 – whose national accounts data was used to build the SAM- and now, and the original SAM may not reflect the current state of the economy. Given the absence of a recent input-output table to build a new SAM, this study follows the SAMBAL implementation (in GAMS) developed by Lemelin, Fofana and Cockburn (2013) to update the SAM. According to Lemelin, Fofana and Cockburn (2013), the approach is more appropriate to balance a SAM in the final stage of construction over the RAS-equivalent approach and IFPRI method. In addition, it does not require knowledge of the row or column total. Implementing the SAMBAL in GAMS, the Nigerian 2006 SAM was updated to 2013 national accounts data. 2013 is selected because it was the latest year before the global oil price plunge adversely affected the Nigerian economy and resulting in a recession. The updated (2013) SAM is the baseline data used in this study.

Because renewable electricity policy is the main focus in this study, the “utility” sector/activity and commodity in the updated SAM is disaggregated into water and electricity sectors and commodities, based on their proportions in the national account data published by the Central Bank of Nigeria (CBN, 2017). The electricity sector is further disaggregated to determine the respective shares of conventional fossil-fuel (FELE) and renewable electricity (RELE) sectors and commodities based on Nigeria’s electricity generation data obtained from the online database of the United States Energy Information Administration (EIA). Also, a new self-generation electricity factor (SELE) is created to capture the electricity produced from petroleum and diesel generators. According to the World Bank’s enterprise surveys (World Bank, 2015), a significant proportion of electricity use in Nigeria is self-generated. Hence, we assume that half of intermediate consumption of refined oil is used for self-generation of electricity. After all the modifications, the updated and revised SAM contains twenty-six (26) sectors/activities and twenty-seven (27) commodities.

3.2 Description of the Nigerian economy based on the updated 2013 SAM

From the SAM, it can be seen that the output of most sectors are largely made up of value added (Table 2). On average, value added accounts for 73.20% of total output. In terms of the factor intensity in each sector, all sectors of the economy, except other manufacturing, crude oil and gas, refined oil, other solid minerals and construction, are labour intensive. The most labour intensive sectors include real estate, wholesale and retail trade, other services, hotel and restaurants, public service, education and banking and financial sector. Livestock, fishing and forestry sectors also have high labour intensity. Land is only used in the crop production sector and accounts for 42% of value added in the crop production while labour accounts for 58%. Expectedly, the proportion of labour in the value added of the crude oil and gas sector and refined oil sector is very low at only 0.27% and 0.91%. The sectors are highly capital-intensive. The contribution of electricity factor to value added is low, which reflects the challenge of limited electricity supply in Nigeria vis-à-vis other production factors.

Table 2: Value added coefficients, intermediate consumption and factor intensity (%)

	Value added coefficients and intermediate consumption			Sectoral factor intensity					
	Value added	Intermediate Consumption	Activity Tax	LABOUR	CAPITAL	LAND	SELE	FELE	RELE
CROP	91.41	8.60	-0.02	57.60	0.36	41.84	0.01	0.17	0.02
LIVE	61.27	38.21	0.51	72.02	27.29		0.69		
FISH	91.73	8.20	0.07	69.41	30.54		0.06		
FORE	78.53	20.71	0.76	71.68	25.96		0.14	1.97	0.26
BEVG	40.15	59.34	0.51	70.94	28.75		0.00	0.28	0.04
TEXT	56.55	42.97	0.48	62.35	37.40		0.07	0.15	0.02
WOOD	76.36	23.13	0.51	63.07	36.62		0.00	0.27	0.04
OMFC	57.43	43.69	-1.13	18.79	77.20		3.08	0.83	0.11
COIL	92.21	7.76	0.03	0.27	99.15		0.58		
ROIL	28.92	70.88	0.20	0.87	72.21		4.46	19.87	2.59
OMIN	81.41	18.59	0.00	7.22	83.97		2.16	5.88	0.77
CONS	80.83	18.72	0.45	2.11	97.47		0.21	0.19	0.02
WATER	81.11	18.30	0.59	54.71	40.98		3.41	0.79	0.10
FELECT	81.11	18.30	0.59	54.71	40.98		3.41	0.79	0.10
RELECT	81.11	18.30	0.59	54.71	40.98		3.41	0.79	0.10
RTRA	59.98	39.72	0.30	53.42	34.05		11.91	0.55	0.07
OTRA	49.43	48.00	2.57	54.85	26.01		16.85	2.02	0.26
TRAD	78.06	21.93	0.01	93.49	5.41		1.10		
HOTL	65.55	34.32	0.13	80.88	7.94		1.25	8.79	1.15
COMM	62.84	33.86	3.30	66.57	30.57		0.59	2.01	0.26
BSER	62.69	35.80	1.51	83.57	9.40		2.86	3.69	0.48
REST	88.71	10.89	0.39	98.16	1.55		0.30		
EDUC	61.09	38.91	0.00	82.68	0.12		2.71	12.81	1.67
HEAL	66.96	33.04	0.00	60.83	0.09		4.23	30.84	4.02
PSER	34.72	65.28	0.00	81.82	0.09		3.45	12.95	1.69
OSER	92.45	7.60	-0.05	92.96	0.59		0.87	4.94	0.64

Source: Authors' computation from updated 2013 SAM

The SAM also shows the sectoral export intensity and import penetration by products in Table 3. Expectedly, the crude oil sector accounts for the largest proportion of export at 71.46%. This is followed by banking service and financial institutions at 11.60%. Other sectors with modest export intensity include road transport sector and other manufacturing. With respect to import penetration, other manufacturing accounts for 43.25% of imports, followed by road transport and refined oil at 11.64% and 11.08% respectively. The large import penetration of other manufacturing/transportation and other equipment corroborates the fact that local manufacturing of heavy equipment are almost non-existent and Nigeria depends on the importation of these products. Other sectors with high import penetration include crop production and banking service and financial institutions.

Table 3: Export intensity and import penetration (%)

	Sectoral export intensity	Import Penetration
CROP	1.45	10.91
LIVE		0.72
FISH	0.02	1.62
FORE	0.02	
BEVG	0.34	2.59
TEXT	0.85	1.15
WOOD	0.05	0.12
OMFC	5.02	43.25
FERT		2.43
COIL	71.46	0.18
ROIL		11.08
OMIN	1.19	2.26
RTRA	6.72	11.64
OTRA	1.29	2.17
BSER	11.60	9.90

Source: Authors' computation from updated 2013 SAM

4. The methodology

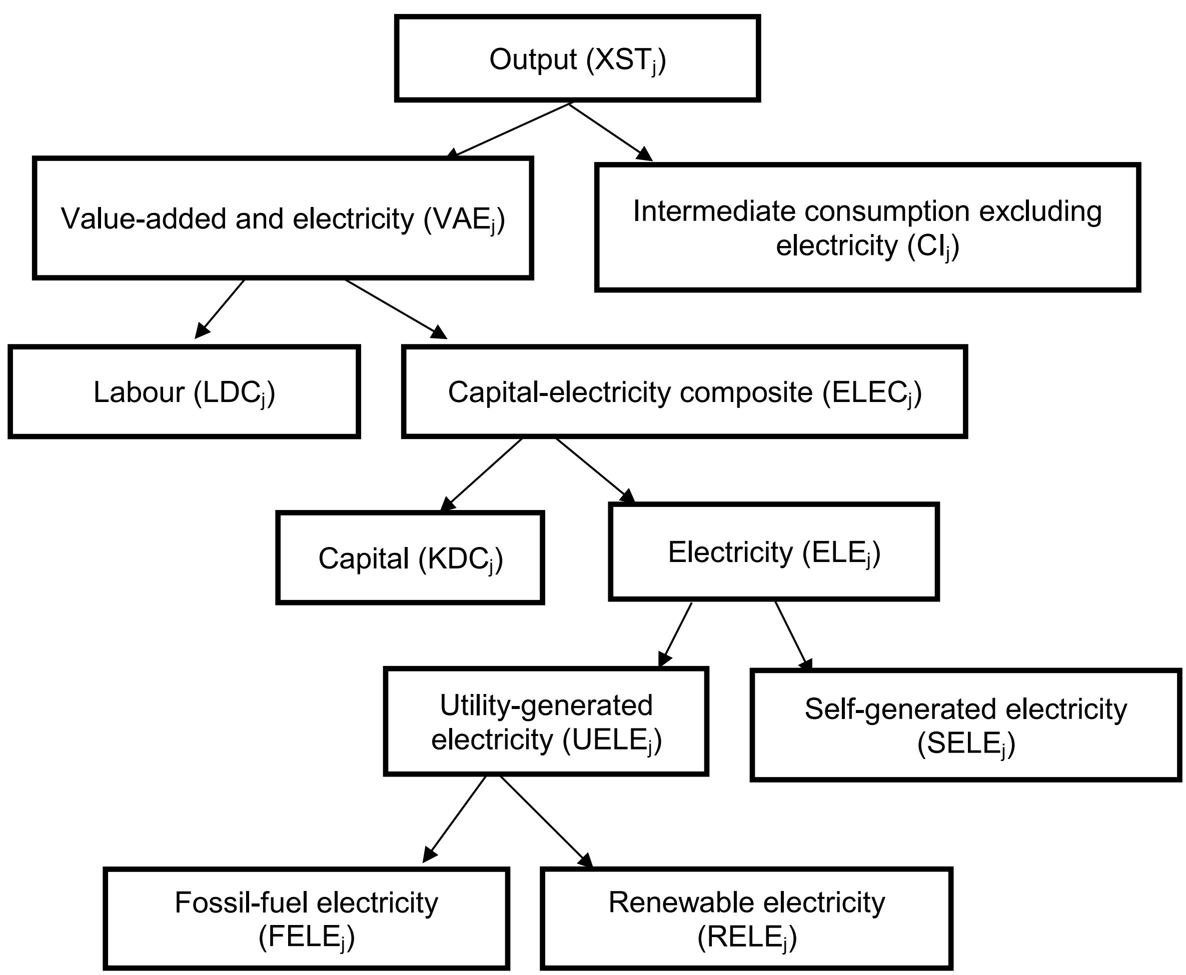
CGE modelling is used to evaluate the macroeconomic impacts of Nigeria's renewable energy policy. It uses a system of equations to model the economic behaviour of economic agents, and has been increasingly employed to assess the macroeconomic, distributional and welfare impacts of energy policies (Kretschmer and Peterson, 2010). It is most appropriate because it is best for understanding the comprehensive economy-wide and distributional impacts of public policy (Nwafor et al., 2010). In addition to understanding the impacts of the policy shocks, CGE model also shows the direction and magnitude of the effects across sectors, commodities, factors and agents. The equations in the CGE model follow the neo-classical economic theory, and assumes that consumers and producers are rational, and seek to maximise utility given a budget constraints and minimise production costs respectively.

For this study, the standard PEP 1-1 model developed by Decaluwe et al. (2013) is used as the reference CGE model. The PEP 1-1 model is a single-country static model. It separates capital and labour into several categories, and takes into account a broader set of tax instruments (Decaluwe et al, 2013). In the model, output is composed of intermediate consumption and value added in fixed proportion. Production is either utilised in the domestic market or exported, and this relationship is depicted by a constant elasticity of transformation (CET) function. Similarly, consumption comprises of both imported and domestically produced commodities, which are assumed to be imperfect substitutes (Sisso, Sawadogo and Natama, 2016). This is introduced using the Armington assumption with a CES function between imported and domestic commodities (Armington, 1969).

One of the main contributions to the standard PEP-1-1 model in this study is the inclusion of electricity as a factor of production. In the standard model, only labour and capital are recognised as the main factors of production, and only these factors constitute value added. But according to Lin and Atsagli (2017) in their study of factor substitution in Nigeria, there is evidence of substitutability between electricity and capital and electricity and labour in Nigeria. Similarly, other studies on renewable energy policy incorporated energy as a factor of production (Ge and Lei, 2017; Wianwiwat and Asafu-Adjaye, 2013). Therefore, based on the conclusions of Lin and Atsagli (2017) and the existing CGE models of Ge and Lei (2017) and Wianwiwat and Asafu-Adjaye (2013), this study extends the PEP-1-1 model to incorporate electricity as a factor of production, as shown in Figure 1 below.

As shown in Figure 1 below, a Leontief function is used to decompose the output of each sector into intermediate consumption (excluding electricity), and value added and electricity. A constant elasticity of substitution (CES) function is then used to disaggregate the value-added and electricity composite into labour and capital-electricity composite. Similarly, a CES function is employed to decompose the electricity-capital composite into electricity and capital. Furthermore, total electricity is made up of utility-generated electricity and self-generated electricity. It is assumed that half of intermediate consumption of refined oil is used in self generation of electricity. Electricity supply from the utility could be from fossil-fuel electricity producer or renewable electricity producer, and this is modelled through a CES function. This is consistent with the goal of climate change mitigation which requires the substitution of fossil-fuel energy sources with clean and renewable energy sources (Lin and Omoju, 2017).

Figure 1: Schematic representation of expanded model



Source: Ge and Lei (2017) and Authors' computation

Unlike the standard PEP-1-1 model, the value added equation in this study is expressed in eq. 1, where LDC is composite labour while ELEC is capital-electricity composite.

$$VAE_j = B_j^{VAE}[\beta_j^{VAE} LDC_j^{-\rho_j^{VAE}} + (1-\beta_j^{VAE})ELEC_j^{-\rho_j^{VAE}}]^{\frac{1}{\rho_j^{VAE}}} \dots\dots\dots\dots\dots\dots\dots.1$$

The capital-electricity composite is further disaggregated into capital (KDC) and composite electricity (ELE) using the CES function in eq. 2.

$$ELEC_j = B_j^{ELEC}[\beta_j^{ELEC} KDC_j^{-\rho_j^{ELEC}} + (1-\beta_j^{ELEC})ELE_j^{-\rho_j^{ELEC}}]^{\frac{1}{\rho_j^{ELEC}}} \dots\dots\dots\dots\dots.2$$

Electricity supply in Nigeria is from the power utility or self-generation. According to the World Bank (2015), a significant proportion of electricity is generated from diesel and petrol-generators by individual households and enterprises due to limited and unreliable supply by the power utilities. This is expressed in eq. 3 below

$$ELE_j = B_j^{ELE}[\beta_j^{ELE} UELE_j^{-\rho_j^{ELE}} + (1-\beta_j^{ELE})SELE_j^{-\rho_j^{ELE}}]^{\frac{1}{\rho_j^{ELE}}} \dots\dots\dots\dots\dots\dots\dots.3$$

Lastly, electricity from the power utility will be from either fossil fuel or renewable energy sources as shown in eq. 4:

$$UELE_j = B_j^{UELE}[\beta_j^{UELE} FELE_j^{-\rho_j^{UELE}} + (1-\beta_j^{UELE})RELE_j^{-\rho_j^{UELE}}]^{\frac{1}{\rho_j^{UELE}}} \dots\dots.4$$

Due to unavailability of data on the emission coefficient in each sector, an emission module is not included in the model. The adjusted PEP 1.1 model is used to calibrate the updated Nigerian SAM, and the model is implemented with the use of the GAMS software. The elasticity parameters are not available for Nigeria. Hence, the study adopts the elasticities from Decaluwe, Martens and Savard (2001). The electricity-related elasticities – sigma_ELEC (0.6), sigma_ELE (0.9) and sigma_UELE (2) – are adapted from the study of Chi, Guo, Zheng and Zhang (2014) for China and authors' judgement.

5. Results

The study simulates the impacts of key policy incentives and financing options for Nigeria's renewable energy policy on macroeconomic and development indicators. The main focus of this study is fiscal incentive through production subsidy for the renewable energy sector. This provides insights into the effectiveness of production subsidies for renewable energy development as well as their macroeconomic impacts. Thus, we create two scenarios to describe the policy actions by the government. The scenarios are summarised in Table 4 below.

Table 4: Financing/fiscal incentive scenarios for renewable energy

Scenario A	20% production subsidy for the renewable energy sector
Scenario B	20% production subsidy for the renewable energy sector financed by a 10% consumption tax of refined oil commodity

Source: Authors' compilation

Expectedly, the immediate impact of a 20% production subsidy for renewable energy sector is a reduction in total government income from production tax. This ultimately leads to a 1.9% reduction in total government income and 2.9% decrease in government savings. Public consumption of health, education and public services increase by 2.6%, 2% and 1.7% respectively. The impacts of these fiscal incentive on government income and savings are, however, lower when a consumption tax on refined oil commodity is used to finance the subsidies. In other words, taxing the consumption of refined oil to finance renewable energy subsidies can mitigate the negative impacts on renewable energy production subsidies on government finances to some extent.

Table 5: Impact of government revenue, public consumption and savings (% change)

Variable	Scenario A	Scenario B
TIPT	-20.54	-21.88
YG	-1.89	-1.47
SG	-2.86	-2.10
CG		
Health	2.64	3.00
Education	1.96	2.71
Public Services	1.73	2.53

Source: Authors' compilation

Fiscal incentives for renewable energy development have impacts on the demand for production factors. Providing production subsidy for renewable energy sector will lead to a reduction in the relative price of renewable energy commodity/factor (27.8%). The reduction in the price of renewable energy vis-à-vis other production factors will lead to an appreciable increase in the demand for renewable energy input in all sectors. The average increase in the demand for renewable energy input is about 75%. Due to substitution effect, this results in a decline in the demand for fossil fuel electricity inputs, though the extent of decrease varies across sectors. Similarly, the use of self-generation electricity reduces in all sectors except crude oil, road transport, other transports, public services and other services sectors.

Lower demand for fossil fuel and self-generated electricity pulls their prices down by 2.3% and 0.5% respectively. Financing the production subsidy through a consumption tax on refined oil expands the increase in the demand of renewable energy input from 72% to 76%, implying that a kind of environmental tax on conventional energy sources could also enhance renewable energy development.

Table 6: Demand for production factors (% change)

Variable	Scenario A	Scenario B
RELE (average)	72.0	76.0
FELE (average)	-4.4	-4.1
W	-1.63	-2.83
LD		
Crop	1.47	0.58
Live	0.35	-0.41
Fish	0.65	-0.32
Fore	-0.03	-1.17
Bevg	1.51	0.40
Text	1.58	0.13
Wood	-0.46	-0.85
Omfc	1.61	3.30
Coil	2.62	4.40
Roil	-0.62	-0.40
Omin	1.91	3.56
Cons	-5.76	-5.42
Water	0.58	0.47
Felect	-3.25	-3.62
Relect	-27.87	-28.63
Rtra	2.97	3.53
Otra	2.96	5.41
Trad	-0.97	-1.16
Hotl	-0.51	-1.26
comm.	0.45	-0.26
Bser	1.93	3.06
Rest	0.09	-0.86
Educ	-1.34	-1.17
Heal	-3.68	-2.59
Pser	0.75	2.21
Oser	-0.60	-1.31

Source: Author's compilation

Labour demand also responds to price change in electricity factor. The significant reduction in the price of renewable electricity leads to an increase in the use of renewable electricity factor across all sectors. This further lead to decrease in the demand for labour in some sectors despite the reduction in wages. In other words, the increase in the demand for renewable electricity is so significant that electricity use substitute labour in the production process in some sectors. The impact on labour demand also differs when the production subsidy for the renewable energy sector is financed by a consumption tax on refined oil.

Fiscal subsidies to promote renewable energy in Nigeria will lead to a decrease in household income and welfare (Table 7). A 20% production subsidy for renewable energy sector will reduce household income, savings and consumption budget by the same proportion of 1.5%. The negative effect on household income is through the reduction effects on household capital income (0.7%), labour income (1.7%) and transfer income (1.5%). As a result of reduction in wage, post-tax rental rate of capital, government income (which reduces government transfer to households), household income falls. As a result of the fall in household income, household consumption budget and savings fall, indicating a reduction in household welfare.

Furthermore, the negative effects on household income, savings and welfare will be higher if the production subsidy for renewable energy development is financed by a consumption tax on refined oil (as shown in scenario B). The combination of reduction in household and government savings as well as firm's disposable income leads to a 4.7% and 2.7% reduction in total investment and real gross fixed capital formation respectively. This then leads to reduction in aggregate output in some sectors. The decrease in government savings also implies higher future debt stock in the economy.

Table 7: Household income, consumption budget and savings (% change)

Variables	Scenario A	Scenario B
YH	-1.54	-2.92
CTH	-1.54	-2.92
SH	-1.54	-2.92

Source: Author's compilation

This policy incentives also have impacts on foreign trade (Table 8). Nigerian commodity exports become competitive as the price received for exported commodities is lower than the world price of exported products. Only the export price of crude oil commodity is marginally higher than the world price. This consequently leads to an increase in the export of all commodities except crude oil. Also, the reduction in the price of local products relative to the reduction in the price of imported commodities makes import to reduce, except for few commodities. The increase or decrease in the importation of commodities depends on the relative price changes between imported and locally produced commodities and the import penetration of the commodities.

Table 8: Foreign trade (imports and exports)

Exports	Scenario A	Scenario B	Imports	Scenario A	Scenario B
crop	1.66	2.84	crop	-1.51	-4.65
fish	1.71	2.75	live	-2.69	-5.47
fore	1.68	2.61	fish	-2.27	-5.35
bevg	1.80	2.73	bevg	-1.36	-4.64
text	1.73	2.71	text	-1.46	-5.28
wood	1.55	2.69	wood	-3.44	-5.96
omfc	0.97	1.18	omfc	-1.33	-1.48
coil	-0.03	-0.04	coil	1.28	0.56
omin	0.88	0.94	roil	-1.12	-2.17
rtra	1.63	0.94	omin	-1.31	-1.42
otra	1.81	0.80	rtra	0.31	0.83
bser	2.40	3.53	otra	0.10	3.30
			bser	-2.02	-3.39
			fert	0.85	0.34

Source: Author's compilation

The impact of the policy on GDP is shown in Table 9. With a renewable energy production subsidy, nominal and real GDP decreased by 1.6% and 0.04% respectively. The results to some extent support the hypothesis which doubts the compatibility of growth and environmental protection (Jacobs, 2012). But the negative impact of production subsidy for renewable energy on the Nigerian economy is not very strong. The negative impact of the fiscal incentives on GDP will, however, be higher if the subsidies are financed by refined oil consumption tax. From the results, the negative effects on nominal and real GDP will be 2.6% and 0.2% respectively.

Table 9: Impact on GDP (% change)

Variable	Scenario A	Scenario B
GDP_MP	-1.61	-2.61
GDP_MP_REAL	-0.04	-0.16

Source: Authors' compilation

6. Conclusions and policy implications

This study analyses the macroeconomic impacts of Nigeria renewable energy policy instruments using a CGE model. The policy was initiated as an action plan following the ratification of the Paris Climate Agreement and the Sustainable Development Goals. It aims to promote the development of renewable energy to enhance energy access for sustainable development while also minimising environmental damages. The fiscal incentives proposed to facilitate the development of the renewable energy sector in Nigeria are examined in the study as to their effectiveness in promoting renewable energy and their macroeconomic impacts. This research question is investigated with an extended PEP-1-1 CGE model which is used to calibrate the updated 2013 Nigerian SAM.

The main conclusion of the study is that the 20% production subsidy for the renewable energy sector leads to the substitution of renewable energy inputs for fossil fuel energy and labour across sectors. In other words, the fiscal incentive increases the demand for renewable electricity factor vis-à-vis fossil fuel electricity factor. The impact on the demand for labour also varies across sectors. Expectedly, the policy leads to a reduction in government income and savings. Household income, welfare and savings also reduce. The reduction in agents' savings results in a reduction in total investment in the economy and the gross fixed capital formation. Nominal GDP falls by 1.6% as a result of the policy while real GDP only reduce by 0.04%, and the impacts on GDP will be higher if the subsidy is financed by a refined oil consumption tax.

The results of this simulation have implications for Nigeria's renewable energy policy and broadly for sustainable economic development. Government fiscal incentive, particularly production subsidy, for renewable energy sector will be effective in promoting the use of renewable energy inputs vis-à-vis fossil fuel energy input across sectors. Though the policy incentive has a negative impact on household welfare, the negative impact on GDP is very minute. Thus, the common assertion that renewable energy policy undermines economy growth is not very strong in this case. However, the government should review the policy instrument to adapt environmental and economy goals such that there is an effective compromise between renewable energy, sustainable development policy and economic growth.

The study has some limitations. First, the disaggregation of the SAM into water and electricity and further into fossil fuel electricity and renewable electricity are parallel. Data to disaggregate the SAM into this categories are not available for each sector, thus we use the same proportion across all sectors. Availability of data on the proportion of different types of energy in different sectors would enrich the analysis and provide a more accurate analysis. Second, this study only simulates the impacts of fiscal incentives proposed for the NREEEP. There are other non-fiscal instruments in the policy and future studies could investigate the impact of these non-fiscal policy instruments and incentives in order to determine the most effective and optimal policy options. Lastly, due to non-availability of CO_2 emission coefficients across the sectors in Nigeria, this study did not include an emission module in the paper. With available data on emissions, future version of the paper would incorporate this module.

References

AJAYI, O. O. and AJAYI, O.O. (2013):"Nigeria's Energy Policy: Inferences, Analysis and Legal Ethics toward RE Development". *Energy Policy*, 60, 61–67.

ARMINGTON, P. (1969). "A Theory of Demand for Products Distinguished by Place of Production", IMF Staff Papers No. 16, 159-178, International Monetary Fund, Washington, DC.

BOHRINGER, C., KELLER, A., and E. VAN DER WERF (2013): "Are Green Hopes Too Rosy? Employment and Welfare Impacts of Renewable Energy Promotion," *Energy Economics*, 36, 277-285.

BOHRINGER, C., RIVERS, N. J., RUTHERFORD, T. F., and R. EIGLE (2012): "Green Jobs and Renewable Electricity Policies: Employment Impacts of Ontario's Feed-In Tariff," *The B.E. Journal of Economic Analysis and Policy*, 12(1).

BOLUK, G. (2013): "Renewable Energy Policy Issues and Economic Implications in Turkey," *International Journal of Energy Economics and Policy*, 3(2), 153-167.

BREISINGER, C., THOMAS, M., and J. THURLOW (2009): "Social Accounting Matrices and Multiplier Analysis: An Introduction with Exercises. Food Security in Practice Technical Guide 5," International Food Policy Research Institute, Washington, D.C. Available at http://www.ifpri.org/publication/social-accounting-matrices-and-multiplier-analysis.

CBN (2017): "2016 Statistical Bulletin: Domestic Production, Consumption and Prices (stabull-2016-004)", Central Bank of Nigeria, Abuja. Available at http://www.cbn.gov.ng/documents/Statbulletin.asp.

CHI, Y., GUO, Z., ZHENG, Y. and ZHANG, X. (2014). “Scenario Analysis of the Energies’ Consumption and Carbon Emissions in China Based on a Dynamic CGE Model”. *Sustainability*, 6, 487-512.

DAI, H., XIE, X., XIE, Y., LIU, J. and T. MASUI (2016): “Green Growth: The Economic Impacts of Large-Scale Renewable Energy Development in China,” *Applied Energy*, 162, 435-449.

DECALUWÉ, B., LEMELIN, A., ROBICHAUD, V., and H. MAISONNAVE (2013): “PEP-1-1: The PEP Standard Computable General Equilibrium Single-Country, Static CGE Model, Version 2.1”. Partnership for Economic Policy (PEP), Nairobi, Kenya.

DECALUWÉ, B., MATERNS, A., and SAVARD, L. (2001). La PolitiqueÉconomique du Développmentet les Modèlesd’équilibreGénéral Calculable. University of Montreal Press, Montreal, Canada.

GE, J. and Y. LEI (2017): “Policy Options for Non-Grain Bio-Ethanol in China: Insights from an Economy-Energy-Environment CGE Model,” *Energy Policy*, 105, 502-511.

HILLEBRAND, B., BUTTERMANN, H. G., BEHRINGER, J. M., and M. BLEUEL (2006): “The Expansion of Renewable Energies and Employment Effects in Germany,” *Energy Policy*, 34(18), 3484-3494.

HOLLAND, D., STODICK, L., and K. PAINTER (2007): “Assessing The Economic Impact of Energy Price Increases on Washington Agriculture and The Washington Economy: A General Equilibrium Approach,” School of Economic Sciences Working Paper No. 2007-14, Washington State University.

HUANG, M. Y. (2010): “Regional Impacts of Bioenergy Policies in the South Eastern United States: A Computable General Equilibrium Analysis,” A Dissertation Presented to The University of Florida, USA. Available at http://etd.fcla.edu/UF/UFE0041091/huang_m.pdf

IPCC (2011): “Summary for Policymakers”. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation, O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IRENA (2016): “Renewable Energy Benefits: Measuring the Economics.” International Renewable Energy Agency, Abu Dhabi, UAE.

IRENA (2017): “Climate Policy drives shift to Renewable Energy”. International Renewable Energy Agency, Abu Dhabi, UAE.

JACOBS, M. (2012): Green Growth: Economic theory and political discourse. Centre for Climate Change Economics and Policy Working Paper No. 108 (University of Leeds) and The Grantham Research Institute on Climate Change and the Environment (London School of Economics), United Kingdom.

JARAITĖ, J., KARIMU, A., KAŽUKAUSKAS, A. and P. KAŽUKAUSKAs (2015): “Renewable Energy Policy, Economic Growth and Employment in EU Countries: Gain Without Pain? CERE Working Paper No. 2015-7, Center for Environmental and Resource Economics, Umea University and the Swedish University of Agricultural Sciences, Sweden.

KRETSCHMER, B. and S. PETERSON (2010): “Integrating Bioenergy into Computable General Equilibrium Models - A survey,” *Energy Economics*, 32, 673-686.

LEMELIN, A., FOFANA, I., and J. COCKBURN (2013): Balancing a Social Accounting Matrix: Theory and Application. Available at https://ssrn.com/abstract=2439868.

LIN, B. and ANKRAH, I. (2019). On Nigeria’s Renewable Energy Program: Examining the Effectiveness, Substitution Potential, and the Impact on National Output. *Energy*, 167, 1181-1193.

LIN, B., and P. ATSAGLI (2017): “Energy Consumption, Inter-Fuel Substitution and Economic Growth in Nigeria,” *Energy*, 120, 675-685.

LIN, B. and O. E. OMOJU (2017): “Focusing on The Right Targets: Economic Factors Driving Non-Hydro Renewable Energy Transition,” *Renewable Energy*, 113, 52-63.

LOFGREN, H., HARRIS, R. L., ROBINSON, S., THOMAS, M., and M. EI-SAID (2002): “A Standard Computable General Equilibrium (CGE) Model in GAMS. Microcomputers in Policy Research 5, International Food Policy Research Institute, Washington, D. C.

MCKITRICK, R. R. (2013): “Environmental and economic consequences of Ontario’s Green Energy Act,” Ontario Prosperity Initiative, Fraser Institute, Vancouver, Canada.

MU, Y., CAI, W., EVANS, S., WANG, C., and D. ROLAND-HOLSTE (2018): “Employment Impacts of Renewable Energy Policies in China: A Decomposition Analysis Based on a CGE Modelling Framework,” *Applied Energy*, 210, 256-267.

NKOLO, J. C., MOTEL, P. C., and DJIMELI, C. G. (2018): “Income-Generating Effects of Biofuel Policies: A meta-analysis of the CGE literature”, *Ecological Economics*, 147, 230-242.

NWAFOR, M., DIAO, X., and V. ALPUERTO (2010): “A 2006 Social Accounting Matric for Nigeria: Methodology and Results. Nigeria Strategy Support Program Report No. NSSP007, International Food Policy Research Institute, Abuja, Nigeria.

OKORO, S.U., SCHICKHOFF, U. and SCHNEIDER, U.A. (2018). “Impacts of Bioenergy Policies on Land-Use Change in Nigeria”. *Energies*, 11(152), 1-18.

RAGWITZ, M., SCHADE, W., BREITSCHOPF, B., WALZ, R., HELFRICH, N., RATHMANN, M., et al. (2009): “The Impact of Renewable Energy Policy on Economic Growth and Employment in the European Union,” Employers Project Report Submitted to the European Commission.

SASTRESA, E.L., USON, A.A., BRIBIAN, I.Z. and S. SCARPELLINI (2010): “Local Impact of Renewables on Employment: Assessment Methodology and Case Study,” *Renewable and Sustainable Energy Reviews*, 14(2), 679-690.

SISSO, D. C., SAWADOGO, B. and NATAMA, H. M. (2016). “Decline in gold prices, tax receipts and employment: Which adaptation strategy for Burkina Faso”. PEP Working Paper No. 2016-28, Partnership for Economic Policy, Nairobi.

SILVA, S., SOARES, I. and C. PINHO (2012): “The Impact of Renewable Energy Sources on Economic Growth and CO_2 Emissions - A SVAR Approach,” *European Research Studies*, 15, 133-144.

STERN, N. (2008): “The Economics of Climate Change”, *The American Economic Reviews: Papers and Proceedings, 98*(2), 1-37.

TAVONI, M., KRIEGLER, E., RIAHI, K., VAN VUUREN, D. P., ABOUMAHBOUB, T., BOWEN, A., et al. (2015): “Post-2020 Climate Agreements in The Major Economies Assessed in The Light of Global Models.” *Nature Climate Change*, 5, 119-126.

WIANWIWAT, A. and J. ASAFU-ADJAYE (2013): “Is There A Role for Biofuel in Promoting Energy Self Sufficiency and Security? A CGE Analysis of Biofuel Policy in Thailand,” *Energy Policy*, 55, 543-555.

WORLD BANK (2015). Enterprise Surveys – Nigeria Country Profile 2014. World Bank Group, Washington, DC.