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Energy Pricing Policy and Environmental Quality in Nigeria: A Dynamic Computable General Equilibrium Approach

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ABSTRACT

The fuel subsidy policy as a policy had been argued to hamper efforts at environmental sustainability. Thus, this study investigates the extent to which the removal of fuel subsidy influences the level of carbon emissions in Nigeria over a 5 year period. It adopts the recursive dynamic version of the partnership for economic policy computable general equilibrium model based on the 2006 Nigerian social accounting matrix. Simulating a partial, gradual and complete removal of import tariff on imported petrol indicates reduction of emissions only when subsidy removal was partial. Findings from the results showed carbon emissions marginally increased under the gradual and one shot removal. This suggests that removing petrol subsidy was not sufficient to reduce carbon emissions level, but should be accompanied with necessary supporting policies. Fuel blending can be a useful alternative to fossil fuel along with renewable energy and green growth practices to ensure a low-carbon growth strategy.

Keywords: Energy Policy, Environmental Quality, Dynamic Computable General Equilibrium
JEL Classifications: C68, Q43, Q56

1. INTRODUCTION

Environmental problems being witnessed globally continues to raise concerns for experts and policy makers globally in ensuring/meeting sustainable development targets. These problems vary from either the emission of damaging pollutants to the overuse of natural resources (United Nations Environment Programme, UNEP, 2004). Different strategies are been employed in addressing these challenges. One of the sectors identified to have contributed to this problem, especially climate change, is the energy sector. The energy sector's contribution had been through the production and consumption of fossil fuel which results in increased emission of carbon dioxide (a greenhouse gas [GHGs]). The important role that the energy sector plays in enhancing the prosperity and by extension growth of an economy had exacerbated further degradation of the environment. As an essential component in the development process of an economy needed for economic and social growth, energy serves as an important source of revenue for government, especially for oil-producing countries like Nigeria. This crucial role of energy in supporting growth makes government usually seek to ensure adequate access to energy resources by exercising control on pricing of these energy products. This is often done through the use of energy subsidies. Energy subsidy is one of the policy tools government employ to actualise the objective of enhanced energy access as a means of promoting growth. This policy is aimed at achieving certain economic and welfare objectives such as the strengthening of industrial growth, expanding domestic consumption and expansion of energy access for poor households. Government place energy price below equilibrium market price and pay the difference so as to protect households from volatile oil price shocks of the international market. However, despite these positive contributions of this policy, it has been argued to exert pressure on budgetary balance of countries, divert resources from priority sectors (education, health, infrastructure) and contributes to carbon emissions thereby resulting to environmental degradation. Thus, the high price of energy coupled with strained government budget and concerns over GHGs emissions have resulted in a renewed focus of the dynamics of environmentally harmful fossil fuel subsidies.

Different empirical studies have analysed different forms through which the energy sector affects the environment, one of which is how lower energy prices lead to increased emission and concentration of GHGs through higher levels of energy consumption. This is the channel of transmission through which fuel subsidy affects environmental quality. This negative influence of the energy sector on the environment has necessitated the need for the transformation of the sector. This has become crucial especially in the face of the threats to human health and environmental quality that continues to grow globally (UNEP, 2004). This transformation has the ability to deliver a greener growth and cleaner environment. Many reports from international organizations such as the International Energy Agency (IEA), Organization for Economic Co-operation and Development (OECD), United Nations, European Union, G-20, World Bank, African Development Bank, among others, have shown that rising energy demand coupled with increased emission of GHGs (e.g., CO_2) calls for urgent need to reassess the interaction of the energy sector and the environment. Thus, driving a green growth agenda will require a low carbon industrial strategy which had been the emphasis in many sustainable growth/development literatures.

One of the key policies identified for transforming the energy sector for efficiency and environmental quality is the reform of environmentally harmful subsidies such as fossil fuel subsidies. This is given that current energy systems in many economies are fossil fuel dependent. Thus, the clamour for the need to lower the carbon intensity of the energy sector can be achieved through the reform of this class of subsidies even for developing African economies like Nigeria that may not be contributing much to global emissions. The June 2009 declaration on green growth by the OECD further support the importance of reforming policies that encourage fossil fuel use. According to Oosterhuis (2013), 34 countries vowed to encourage domestic policy reform geared towards eliminating environmentally harmful policies capable of thwarting green growth efforts. Also, in the same year, the G-20 leaders while at the Pittsburgh Summit, committed to the phasing out of inefficient fossil fuel subsidies over the medium term, while calling on the rest of the world (ROW) to do same (Oosterhuis, 2013). This reform process had been high on the agenda on many heads of government (Umar and Umar, 2013) and international institutions such as the IEA, OECD, G-20, EU, Global Subsidies Initiative, AfDB, IMF and World Bank which is evident from their various reports. Nigeria as one of the leading oil-producers in the world is one of the countries implementing the fuel subsidy policy reform (Umar and Umar, 2013). One of the needs for this implementation is to overcome some of its fiscal constraints and show support for its environmental commitment (e.g., the Kyoto protocol and United Nations Convention on Climate Change [UNFCC]).

Subsidizing fuel price has a long history in Nigeria as an energy pricing policy and had been plagued with different arguments and debates. The policy was introduced in the mid-1980s with the value moving from 1 billion in the 1980s to an expected 6 billion in 2011. The growth strategy in Nigeria has been based on delivering maximum economic benefits with minimal consideration for the environmental implications of the chosen growth strategy (Adenikinju et al., 2012). This makes environmental implications of different policy strategies especially as it relates to environmental management essential. Thus, this paper thus attempt to investigate the extent to which energy pricing policy such as the reform of fuel subsidy can be a useful tool in driving environmental quality in Nigeria, particularly in the face of the controversy marking any attempt by government to remove fuel subsidy using an economy-wide model such as computable general equilibrium (CGE) model. The Nigerian government intends to place the economy at the top 20 by the year 2020 through its Vision 20:2020 blueprint. An important aspect of this economic plan is enhancing a paradigm shift to a low-carbon industrial growth strategy. This raises a number of questions. For example, what if subsidy on refined oil is reduced or completely removed through increase in import tariff on refined oil? How does this change the level of carbon emissions? To what extent can the reform of fossil fuel subsidy be used to drive the green growth (low carbon strategy) agenda in order to enhance environmental quality, particularly in the face of the threat of climate change experienced globally? In other words, can the reform of fuel subsidy significantly reduce carbon emission level for environmental sustainability? In view of these questions, the paper analyses the different CO_2 emission scenarios that will occur from the imposition of shocks on import tariff on refined oil for the Nigerian economy. The remainder of the paper is given as follows. The introductory section is followed by a brief overview of the literature on fuel subsidy and carbon emissions, this is followed by the methodology which presents the analytical framework, model of the study, simulation design and expected results. The final section focuses on likely policy implications and concluding remarks.

2. OVERVIEW OF THE LITERATURE

Subsidies are disbursed for various purposes which range from the promotion of industrial development, facilitation of innovation to ensuring redistribution of income and natural resources (Mukherjee and Chakraborty, 2014). Energy subsidies are prevalent in both developed and developing countries. They are designed to encourage the production of goods and services through lowering the cost of production and other times, lighten the burden of rising prices on consumers (Umar and Umar, 2013). These subsidies are said to be capable of encouraging economic activities that can result to some environmental concerns such as climate change related when conducted beyond sustainable level (Mukherjee and Chakraborty, 2014). This cheap energy pricing has aided inefficient energy consumption trends among economic agents which have contributed to prevalence of inefficient energy capital stock in the residential, industrial and transport sectors of the economy (Adenikinju et al., 2012). The negative consequences of these harmful subsidies have led to the call for their adequate reform. This reform centers around the elimination of these categories of subsidies while also putting in place appropriate safety net measures that will alleviate any short term hardship the removal may cause. Growing international pressure to curb GHGs emission has enhanced focused attention on existing policies that may, either by design or by effect, subsidize consumption and production of fossil fuel (Koplow and Dernbach, 2001).

Evaluation of the dynamics of fossil fuel involves assessment of the scope and magnitude of the subsidy and the impact they exert on key economic parameters (e.g., trade, GDP, budget, investment). Fuel subsidy affects the economy economically, socially, politically and environmentally. They are designed to expand domestic consumption and energy access for poor households to drive growth and alleviate poverty, among other things. However, despite the advantages used to justify the introduction of fuel subsidies, they are marked with a number of negative consequences. These large payments impose fiscal pressure on government finances while also creating environmental concerns that can alter growth and development process. As stated earlier, impact analysis as it relates to effect on the economy covers economic, social (welfare), political and environmental impact assessment. While the economic impact assesses the extent to which fuel subsidy or its reform affects economic aggregates, the social impact examines how it influences the welfare level of the citizenry. The political aspect focuses on analysing the political dimension, dynamics and power play that surrounds the reform of the subsidy. Environmental impact is concerned with the analysis of reducing emission through the reform of fuel subsidy. These various impact assessments had been carried out for different countries and even for panel studies where a number of country comparisons are done. Thus, the economic, social and political impact of fuel subsidies have received substantial attention in empirical literature, however, analysis on how the persistence of fuel subsidy in many developing oil-producing countries such as Nigeria tends to be under-researched.

The relationship between energy subsidy and environmental quality is rooted in the idea that lowering prices for energy products that are environmentally harmful will further increase the already high levels of carbon emissions. This tends to hinder current efforts at addressing different environmental problems experienced globally (e.g., drought, flooding, ocean rise, and so on). Thus, energy subsidy is viewed as a policy that counters the drive to achieve lower concentration and emission of dangerous GHGs. The works of Askolani (2010), Oil Change International (2012), Abraham (2013) and Whitley (2013) are examples of studies that examined how reform of fuel subsidy can be useful in fighting climate change. According to Oil Change International (2012), there are two important medium through which fossil fuel subsidy phase out benefits the environment (climate). Firstly, eliminating this type of subsidies which brings about a reduction in the production and consumption of fossil fuels, can help close the gap between current mitigation pledges and the level of emission reduction needed to stay below 2 degrees centigrade. Secondly, the removal of fossil fuel subsidies can free up finance needed for urgent mitigation and adaptation to climate change (Oil Change International, 2012). A number of studies have already established the fact that energy and environmental tax-related policies are effective support in the reduction of overall energy demand and the accompanied CO_2 emissions (Hong et al., 2012). These studies using different techniques for different countries and under varying scenarios, asserted that with the removal of subsidies, prices move up, energy consumption falls and carbon emissions can then fall thus helping to addressing climate change impacts (Koplow and Dernbach, 2001; Guiyang, 2007; Morgan, 2007; Allaine and Brown, 2012; Ballali, 2012; Holton, 2012; Hong et al., 2012: Whitley, 2013; Mukherjee and Chakraborty, 2014; Merrill et al., 2015). These studies show that the achievement of these win-win scenarios may not come easy, cheap and straightforward. Yusuf and Ramayandi (2008) compared the two instruments of reducing fuel subsidy and taxing carbon noting that the two have the tendency in reducing energy consumption and carbon emissions, though their impacts may differ on the economy and the environment.

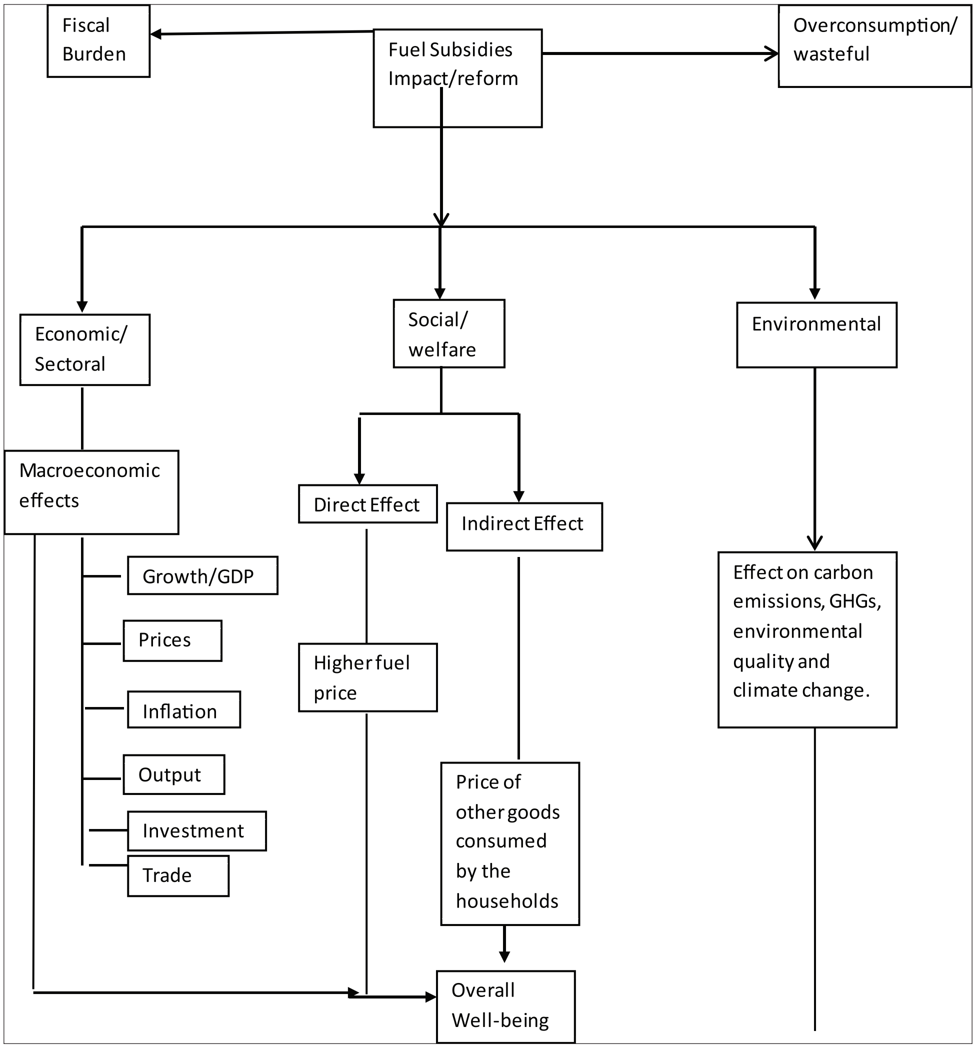
According to Koplow and Dernbach (2001), the presence of baseline subsidies makes achieving GHGs reductions under the UNFCC and Kyoto protocol more expensive. Hong et al. (2012) asserted that China is able to obtain both economic and environmental gains from the reform of energy subsidies. The study found that fossil fuel subsidies reform could result in a money saving 582.00 billion RMB, an energy saving of 50.67 million tce including 77.60 million tons in reduction of CO_2 emission. UNDP (2012) found significant reduction in emissions using an emissions modelling of Vietam's energy sector when cuts in fuel subsidies and imposition of tax on fossil fuels were introduced. While the IEA (2011) asserted that lower fossil fuel demand would in turn cut CO_2 emissions by 4.7% by year 2020 and 5.8% by 2035; the OECD estimated a 10% reduction by year 2050 (IEA, OECD, OPEC and World Bank, 2010; Global Subsidies Initiative, 2012). However, Ballali (2012) noted that the substantial CO_2 emission from fossil fuel subsidy removal would depend on own price and cross-price elasticities of demand. Morgan (2007) in describing the magnitude of energy subsidies, how they affect energy investment and GHGs emissions; stated that removing such subsidies yields a win-win policy as it could bring about major economic, social and environmental gains.

3. METHODOLOGY AND DATA

3.1. Analytical Framework

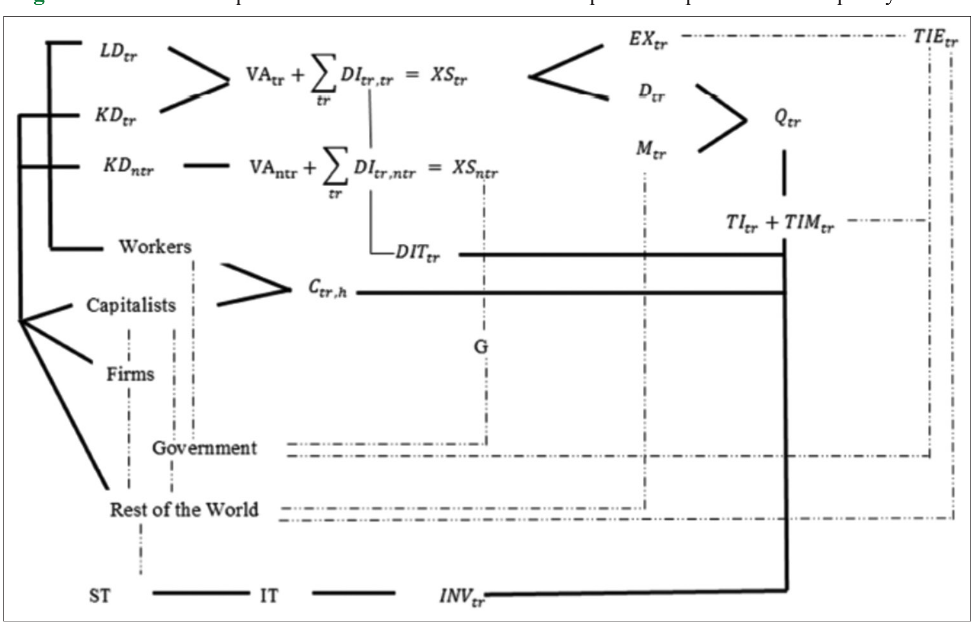
Figure 1 shows the conceptual framework of the mechanics of the impact that fuel subsidy has on the economy through various parameters. From the diagram, policy change such as the reform of fossil fuel subsidy influences the economy economically, socially (welfare), and environmentally. Also, there is the political dimension. The economic impact will be in terms of effect on macroeconomic aggregates such as prices, output, trade, investment, inflation, growth, among others. Social or welfare effects would be in terms of direct effects of increases in fuel prices and indirectly on the prices of other commodities. On the environmental aspect which is the focus of this study, the impact can be traceable from production and consumption. For production, producers will use energy inputs optimally and in an efficient manner due to the rise in fuel price as a result of subsidy reform depending on the nature and level of substitutability. They can even switch to other energy alternatives that are less carbon intensive, thereby gradually cutting down the levels of carbon emission. At the household level, fuel consumption from fossil fuel sources such as petrol can reduce with the increase in price. If the reform targeted the diversion of subsidy funds into the development and commercialisation of renewables, then there can be substantial reduction in carbon emissions. As demand falls, CO_2 emissions are expected to fall as well.

Figure 1: Transmission mechanism



Source: Authors

Figure 2: Schematic representation of the circular flow in a partnership for economic policy model



Source: Okodua and Alege (2014)

Figure 2 explains further the process of how a policy shock transmits and affect other sectors of the economy in a standard partnership for economic policy (PEP) model. It shows the channel through which a shock in import tariff on refined oil (treated as fuel subsidy) can transmit changes to other sectors of the economy. Energy is used in the production of goods and services, transport and also at the household level, thus if government for example, reduces fuel subsidy (import tariff on refined oil) by 50%, this policy change/shock will flow through the various sectors of the economy. As this simulation is introduced to the model, quantity imported and supplied to the domestic markets changes which can then result to price increases and these changes continues throughout the economy, affecting employment (labour demand), output, value added, intermediate demand, consumption and so on. On the environmental side, there would be changes in the volume of production which directly affects natural resource input requirement and pollutant emissions (UNEP, 2003). Given the proposition that environmental quality is measured as carbon emissions, these CO_2 emissions in turn depend primarily on energy use and their associated energy input intensity and coefficient. Thus, the amount of carbon emissions emitted by each production activity will depend on the type and amount of energy being used as inputs and the carbon emissions associated with each energy input (Adenikinju et al., 2012). These carbon coefficients will then suggest how clean or dirty the production technology is for a particular energy input. The nature of the general equilibrium framework is such that any shock in a sector will affect every other sector especially for policies relating to energy issues given that energy is widely used for varying purposes. The Figure 2 also demonstrates how closely connected the different sectors are within the general equilibrium framework (Okodua and Alege, 2014).

3.2. The Model

This study applies the PEP recursive dynamic CGE model to analyse the environmental consequences of removing fuel subsidy on carbon emission in Nigeria over a 5 year-period. The paper considers the "business-as-usual" scenario when the government continues to provide subsidy for petroleum consumption and an alternative scenario where fuel subsidy is removed as a means of driving a green growth strategy which is consistent with the Nigerian Vision 20:2020 development goal. This is done by adapting an energy-environment (E2) recursive dynamic CGE model of Adenikinju et al. (2012) for the Nigerian economy. This model is a modification of the PEP 1-t (single country-dynamic version) CGE model by Decaluwe et al. (2012). The modelling nature of the CGE model is useful in policy formulation and various policy analysis situations (Chiripanhura and Chifamba, 2015), especially when an economy-wide effects of a policy change is vital. This strength of the CGE model makes it appropriate to apply it to the analysis of the response of the economy to a policy shift such as the fuel subsidy removal. It is rooted in the neoclassical general equilibrium theory which assumes that perfect competition prevails such that consumers and producers can take relative prices as given thereby equalising demand and supply in each market. The assumption is that a typical agent optimises an objective function subject to constraints with producers seeking to maximise profit subject to a given technology and independent price and consumers maximise utility under limited budgets and market prices (Okodua and Alege, 2014). The model reflects the various behavioural interactions between households, firms, government and the ROW (Chiripanhura and Chifamba, 2015). These features are presented in different blocks of simultaneous equations that explain optimising behaivour of these agents. The inclusion of an additional block called the carbon emission block helped to achieve the environmental objective of the study. It contains equations that relate the total carbon emissions in the economy as derived from the energy intensive sectors. The rationale is that carbon emissions depend primarily on energy use and the intensity of each energy input or the CO_2 coefficient (Adenikinju et al., 2012). These carbon coefficients reflects how clean or dirty a particular production technology is for a given energy input use. The sectoral energy intensity and carbon emissions by energy type are calculated from the energy expenditure of each sector from the 2006 re-aggregated Nigerian social accounting matrix (SAM). This is presented in Table1. The carbon emissions in the model are treated as proportional to the energy inputs used as seen in Adenikinju et al. (2012). That is, if a particular sector uses two units of fossil fuel energy, then it emits the same two units of carbon emissions. Detailed description of the PEP 1-t model without the environmental component is contained in Decaluwe et al. (2012), while a brief description is presented in this study.

The model contains features relating to production structure, commodities and behaviour of the different agents. The production structure follows a nested structure where firms maximise profits subject to the constraints of available technology in a perfectly competitive environment. At the top level, sectoral output of each productive activity is produced from the combination of value added and intermediate consumption in fixed shares (Decaluwe et al., 2013). At the lower level, value added is composed of composite labour and capital which follows a constant elasticity of substitution. The industry is responsible for the production of commodities which are either consumed domestically or exported; likewise domestic consumption is allocated between domestic production and imported goods (the Armington Assumption explains this). This relationship depends on the level of elasticity. The different agents receive and make payment within the system. For example, households receive income from labour and capital income and also transfer from other agents which are spent on consumption on goods and services, payment of taxes, transfer and the remaining is saved. Firms or business units in the model derive income from their share of capital income and transfers received from other agents while also paying business taxes to the government. The government draws income from household and business income taxes and other forms of taxes on production, goods and imports (Decaluwe et al., 2013). In addition to this, income is received from its share of capital remuneration and transfers from other agents including the ROW. The foreign sector which is considered the ROW collects payments for imported goods and services, transfer from domestic agents and its share of capital income. On the other hand, the ROW spends on the domestic economy in form of payment for exports and transfer to domestic agents and the difference between foreign income and payment is ROW savings which is equal to the current account balance.

The data set and calibration procedure used for the model is the 2006 Nigerian SAM that shows the flow of transactions in the economy presented in rows and columns. A description of the the SAM for the Nigerian economy for 2006 is presented in Nwafor et al. (2010). The model is calibrated to this SAM structure which is further re-aggregated to suit the objective of the current study. The re-aggregated SAM contains three factor of production namely land, labour and capital; two types of households (rural and urban), one firm, the government and the ROW. It also contains eight sectors/productive industries with nine different commodities.

3.3. Simulation Design and Macro Closures

The model simulated an increase in import tariff on refined oil in order to ascertain the changes in the economy especially in terms of its effects on carbon emission changes. The study performed three simulations which involved a partial (SIM1), gradual (SIM2) and complete (SIM3) removal of subsidy paid on fuel by increasing import tariff on refined oil (petroleum). Relating to the closure rules, the study adopted the neo-classical savings driven macro closure rules as it best describes the structure of the Nigerian economy. The current account balance and the budget deficit were fixed; foreign savings by the ROW is assumed exogenous with fixed international prices and flexible exchange rate (real) which is the numeraire of the model (nominal exchange rate). The elasticity of substitution between imported refined petroleum and the domestically produced is assumed inelastic as a large percentage of refined petroleum consumed is imported since the local refineries only produced a very minimal proportion. Thus, degree of substitutability between the two is considerably low in the Nigerian economy.

4. SIMULATION RESULTS AND IMPLICATIONS FOR POLICY

The study conducted the simulation exercise of the extent to which the removal of fuel subsidy influences the level of carbon emissions in Nigeria. The policy experiments follow a 50 percent removal, gradual removal and a one shot removal of fuel subsidy measured by increase in import tariff on refined oil. Table 1 presents the estimated carbon co-efficients for each of the eight sectors analysed in the study. These carbon co-efficients were generated from the 2006 re-aggregated Nigerian SAM employed to achieve the objectives of the study. It essentially indicates how energy intensive each sector is based on the ratio of their energy expenditures to value added. The road transport was found to be the most energy intensive of all the sectors. The discussion of the simulation results presented follows each result table.

Table 1: Estimated sectoral carbon co-efficients

Sector	Carbon co-efficient
Agriculture	0.04
Manufacturing	2.62
Petroleum	1.10
Refined oil	21.11
Utility	9.10
Road transport	30.90
Services	6.02
Public Administration	22.78

Source: Calculated by Author from 2006 Nigerian SAM

The results of the simulation exercises provided results on percentage changes in macroeconomic variables, price of refined oil, household income and carbon emissions. Table 2 presents the simulation results for macroeconomic variables which included GDP, total investment, government savings and income. On the average, these variables were found to increase when a gradual and complete removal were simulated. However, a 50% increase in import tariff of refined oil resulted to decline in all the macroeconomic variables. In SIM2, the value of GDP increased on the average by 0.85%. In the case of government income (YG) and government savings (SG) there was an overall average of 3.48% and 11.40%. Also, the simulation procedure showed an increase in total investment (IT) as against the experience in SIM1 since the variable reflected an increase of about 20.67%. Similarly, the macroeconomic aggregates increased in SIM3 given that GDP, YG, SG and IT increased by 0.39%, 3.33%, 10.96% and 17.14% respectively in the first period. These increases can be attributed to the fact that with the complete removal of the fuel subsidy, funds are freed up immediately for investment purposes while in the partial removal, the funds through savings slowly accumulates for investment over the period. For all the macroeconomic variables, the rise peaked in the fifth year with percentage change of 1.98 for GDP, 5.38 for YG, 17.95 for SG and 35.14 for total investment. On the average, the variables recorded 1.12, 4.38, 14.35 and 26.31 positive percentage variation. It is important to note that the complete elimination scenario (SIM3) recorded the largest increase as the magnitude of government savings and total investment increased significantly compared to SIM1 and SIM2.

A positive shock to import taxes on refined oil makes the imported fuel relatively more expensive and this reflected in the import price of SIM2 and SIM3 in Table 3 where there was an increase on the average. However, it fell with a 50% increase by an average of 14.82%. Thus, given a complete removal, import price of refined oil will remain constant over the 5 year period with steady increase for a gradual removal. A slightly different scenario was the case for

Table 2: Simulation results of macroeconomic effects

Year	GDP			YG			SG			IT		
	SIM1	SIM2	SIM3	SIM1	SIM2	SIM3	SIM1	SIM2	SIM3	SIM1	SIM2	SIM3
1	−0.24	0.25	0.39	−1.89	2.05	3.33	−6.20	6.75	10.96	−10.18	10.63	17.14
2	−0.42	0.48	0.69	−2.23	2.75	3.85	−7.32	8.96	12.61	−12.75	15.55	22.30
3	−0.65	0.78	1.06	−2.61	3.43	4.35	−8.56	11.24	14.23	−15.61	20.37	26.36
4	−0.92	1.15	1.49	−3.03	4.18	4.89	−9.93	13.69	16.00	−18.78	25.56	30.59
5	−1.23	1.59	1.98	−3.51	4.99	5.48	−11.47	16.38	17.95	−22.33	31.22	35.14
Average	−0.69	0.85	1.12	−2.65	3.48	4.38	−8.69	11.40	14.35	−15.93	20.67	26.31

Source: Author’s computation based on simulation results from GAMS. GDP: Gross domestic product, YG: Government income, SG: Government savings, IT: Total investment domestic price change. The simulation produced a negative change with a 50% removal while in the last two scenarios; there was a decline in the domestic price over the years under consideration. This is a slight departure from theoretical expectation as a subsidy removal should make price become competitive. However, the implicit nature of subsidy in the Nigerian economy might explain this change.

Tables 4 and 5 present the result of changes in sectoral imports after the three simulations were performed. The petroleum sector experienced the greatest changes in total imports with a year average of 13.27% in SIM2 and 13.35% in SIM3, with a 6.14% decline in SIM1. A 50 percent increase in import tariff resulted in a decline across all the sectors while the largest increase was recorded for the case of a complete removal. The transport sector recorded an average decline of 2.09% when a partial removal was simulated while there was a 2.96% and 3.70% increase for a gradual and complete removal respectively.

In the case of sectoral export, all the sectors' exports fell under SIM2 and SIM3 while they increased in SIM1. A 50% positive shock to import tariff will bring about an average decline of 0.51% in agricultural sector, 0.23% in the manufacturing sector and 1.15% in the petroleum sector. However, the road transport and service sector's export increased by 2.92% and 0.42% respectively.

The results in Tables 7-9 suggests that domestic output in agricultural sector, manufacturing, petroleum and refined oil depressed by 0.33%, 1.25%, 1.19%, and 8.55% respectively when subsidy is partially removed. On the other hand the other sectors output expanded by 0.11% (utility), 2.05% (road transport), 0.78% (services) and 1.41% (public administration). However, in SIM2 only the output of utility and public administration decline while all other sectors' output increased. In the same vein, SIM3 produced an expansion of output in the agricultural, manufacturing, petroleum, refined oil, services and public administration sectors while the utility and road transport sectors declined by 1.39% and 3.38% respectively.

Tables 10-12 present the simulation results for the percentage change in the level of carbon emission in Nigeria. Emissions were found to only decline when fuel subsidy was partially removed.

Table 3: Import and local price changes for refined oil

Year	Import price			Local price		
	SIM1	SIM2	SIM3	SIM1	SIM2	SIM3
1	−14.82	17.78	29.64	−12.64	15.01	24.89
2	−14.82	20.75	29.64	−9.94	9.07	8.15
3	−14.82	23.72	29.64	−7.59	6.94	4.49
4	−14.82	26.68	29.64	−5.64	5.92	2.79
5	−14.82	29.64	29.64	−4.05	5.31	1.82
Average	−14.82	23.71	29.64	−7.97	8.45	8.43

Source: Author's computation based on simulation results from GAMS

Table 4: Sectoral imports

Year	agr			mfc			pet		
	SIM1	SIM2	SIM3	SIM1	SIM2	SIM3	SIM1	SIM2	SIM3
1	0.19	−0.41	−0.74	−0.57	0.45	0.66	−0.97	0.87	1.36
2	−0.32	0.36	0.78	−1.27	1.57	2.52	−4.17	9.69	19.12
3	−0.87	0.95	1.53	−2.01	2.54	3.61	−6.72	14.85	23.68
4	−1.44	1.52	2.18	−2.81	3.55	4.65	−8.68	18.77	25.75
5	−2.06	2.13	2.81	−3.68	4.66	5.72	−10.15	22.19	26.84
Average	−0.90	0.91	1.31	−2.07	2.55	3.43	−6.14	13.27	19.35

Source: Author's computation based on simulation results from GAMS

Table 5: Sectoral imports (contd)

Year	rtrans			ser			food		
	SIM1	SIM2	SIM3	SIM1	SIM2	SIM3	SIM1	SIM2	SIM3
1	−1.72	1.99	3.30	−0.96	0.93	1.47	0.89	−1.22	−2.09
2	−1.89	2.42	3.37	−1.58	1.96	3.01	0.41	−0.51	−0.36
3	−2.08	2.91	3.63	−2.24	2.88	3.95	−0.07	−0.09	0.27
4	−2.27	3.45	3.93	−2.94	3.85	4.87	−0.55	0.25	0.74
5	−2.49	4.02	4.26	−3.71	4.90	5.82	−1.03	0.58	1.14
Ave.	−2.09	2.96	3.70	−2.29	2.90	3.82	−0.07	−0.20	−0.06

Source: Author's computation based on simulation results from GAMS

Table 6: Sectoral exports

Year	agr			mfc			pet			rtrans			ser		
	SIM1	SIM2	SIM3	SIM1	SIM2	SIM3	SIM1	SIM2	SIM3	SIM1	SIM2	SIM3	SIM1	SIM2	SIM3
1	−0.95	1.33	2.29	−0.19	0.31	0.55	0.006	−0.005	−0.008	2.89	−3.23	−5.26	0.17	−0.14	−0.21
2	−0.65	0.75	0.69	−0.16	0.13	0.05	−0.46	0.39	0.59	2.92	−3.56	−4.79	0.30	−0.42	−0.68
3	−0.43	0.68	0.58	−0.18	0.18	0.16	−1.03	1.03	1.51	2.94	−3.95	−4.69	0.43	−0.58	−0.81
4	−0.29	1.83	0.79	−0.25	0.34	0.41	−1.72	1.86	2.58	2.93	−4.33	−4.62	0.54	−0.71	−0.88
5	−0.21	1.14	1.18	−0.39	0.59	0.74	−2.54	2.86	3.77	2.92	−4.69	−4.55	0.64	−0.82	−0.92
Average	−0.51	1.15	1.11	−0.23	0.31	0.38	−1.15	1.23	1.69	2.92	−3.95	−4.78	0.42	−0.53	−0.70

Source: Author's computation based on simulation results from GAMS

Table 7: Sectoral output-SIM1

Year	agr	mfc	pet	roil	util	rtrans	ser	adm
1	−0.05	−0.47	−0.01	−1.19	0.41	2.18	−0.33	1.09
2	−0.16	−0.78	−0.49	−5.61	0.28	2.14	−0.51	1.24
3	−0.29	−1.17	−1.08	−9.25	0.12	2.07	−0.74	1.39
4	−0.48	−1.64	−1.79	−12.18	−0.04	1.99	−1.00	1.57
5	−0.69	−2.19	−2.62	−14.54	−0.22	1.89	−1.30	1.75
Average	−0.33	−1.25	−1.19	−8.55	0.11	2.05	0.78	1.41

Source: Author's computation based on simulation results from GAMS

Table 8: Sectoral output-SIM2

Year	agr	mfc	pet	roil	util	rtrans	ser	adm
1	0.07	0.52	0.02	1.06	−0.49	−2.46	0.34	−1.20
2	0.16	0.89	0.48	12.55	−0.29	−2.63	0.59	−1.53
3	0.35	1.41	1.16	19.46	−0.14	−2.84	0.89	−1.84
4	0.61	2.07	2.02	24.92	0.03	−3.02	1.25	−2.16
5	0.95	2.85	3.05	29.88	0.23	−3.17	1.67	−2.49
Average	0.43	1.55	1.35	17.57	−0.13	2.82	0.95	−1.84

Source: Author's computation based on simulation results from GAMS

Table 9: Sectoral output-SIM3

Year	agr	mfc	pet	roil	util	rtrans	ser	adm
1	0.13	0.86	0.01	1.66	−0.80	−4.02	0.54	−1.96
2	0.22	1.28	0.75	24.48	−0.28	−3.52	0.86	−2.13
3	0.49	1.91	1.71	30.78	−6.67	−3.31	1.20	−2.29
4	0.85	2.66	2.80	34.10	0.26	−3.13	1.59	−2.46
5	1.26	3.51	4.00	36.29	0.52	−2.93	2.02	−2.64
Average	0.59	2.04	1.85	25.46	−1.39	−3.38	1.24	2.29

Source: Author's computation based on simulation results from GAMS

Table 10: Sectoral carbon emission-SIM1

Period	agr	mfc	pet	roil	util	rtrans	ser
2	−0.46	−0.52	−0.49	−4.79	−0.40	−0.19	−0.48
3	−1.04	−1.17	−1.09	−8.70	−0.94	−0.55	−1.10
4	−1.76	−1.97	−1.79	−11.83	−1.61	−1.06	−1.87
5	−2.61	−2.92	−2.63	−14.33	−2.43	−1.73	−2.80
Average	−1.47	−1.65	−1.50	−9.91	−1.35	−0.88	−1.56

Source: Author's computation based on simulation results from GAMS

Table 11: Sectoral carbon emission-SIM2

Period	Agr	mfc	pet	roil	util	rtrans	ser
2	0.43	0.49	0.48	11.88	0.35	0.09	0.45
3	1.09	1.27	1.17	18.97	0.95	0.41	1.17
4	1.96	2.27	2.03	24.54	1.75	0.90	2.11
5	3.01	3.50	3.06	29.56	2.73	1.56	3.29
Average	1.62	1.88	1.69	21.24	1.45	0.74	1.76

Source: Author's computation based on simulation results from GAMS

Table 12: Sectoral carbon emission-SIM3

Period	agr	Mfc	pet	roil	util	rtrans	ser
2	0.65	0.77	0.75	23.89	0.51	0.08	0.69
3	1.61	1.88	1.72	30.56	1.41	0.57	1.73
4	2.73	3.18	2.81	34.07	2.47	1.26	2.97
5	3.99	4.67	4.02	36.37	3.66	2.12	4.39
Average	2.25	2.63	2.33	31.22	2.01	1.01	2.45

Source: Author's computation based on simulation results from GAMS

The greatest decline was recorded for the refined oil sector with 9.91% followed by manufacturing and service sector with 1.65% and 1.56% respectively. On the contrary however, emissions from all sectors were found to increase with a gradual and complete removal though the magnitude increased only marginally. In SIM2, emissions in agricultural sector increased by 1.62% and 2.25% in SIM3. Also, the manufacturing sector recorded a percentage increase of 1.88 in SIM2 and 2.25 under SIM3. Incidentally, the road transport sector was observed to have the lowest increase of 0.74% and 1.01% with a gradual and complete removal respectively.

Overall, it is evident from results analysed that emission increased on the average in sectors where output increased and likewise carbon emissions declined in the sectors where output fell at the aggregate level under the various scenarios simulated in the study. Furthermore, the simulation exercises that had favourable outcomes for macroeconomic variables all recorded an increase in emission level. This further highlights the trade-off effect between driving economic growth and environmental sustainability at the same time. The results showed that removing subsidy on imported petroleum in Nigeria was not sufficient to reduce carbon dioxide emissions, especially as even a one shot removal did not reduce carbon emissions.

5. CONCLUSION

The government of Nigeria has indicated the desire to join in the effort at tackling climate change impact in addition to mitigating and adaptive measures especially as the country is one of those identified as been vulnerable to climate changes. Different approaches have been proposed as a means to targeting emission reduction levels, one of which is the introduction of energy or carbon tax. Others include low carbon growth strategy and clean development mechanism. However, given the fact that fuel subsidy increases consumption of fossil fuel, thereby contributing to increased CO_2 emission; a scarce amount of empirical evidence exists on the extent to which or how useful the reform of fuel subsidy will be in reducing carbon emissions in an oil-producing country such as Nigeria. This is essential in the transition towards a greener economy in order to enhance environmental sustainability.

In view of this, the result from the present study show that the extent to which the removal of fuel subsidy is a useful tool in enhancing environmental quality in Nigeria. It suggests that emission level reduced only when subsidy was partially removed, however, under the gradual removal and complete removal simulation, carbon emissions increased marginally. This may be attributed to the fact that in Nigeria, there is no alternative to petrol for petrol engines. Thus even with price increase of fuel due to subsidy removal, consumers initially reduce their consumption but with time increase consumption so as to meet their energy demand. They only adjust to the new price mechanism, thereby driving up carbon emission levels from fossil fuel.

It is recommended that in addition to removing subsidy, either gradually or completely, complementary policies should be put in place by government to drive low-carbon growth strategy as a means to sustainable development. There are on-going efforts by the Department of Climate Change Unit under the Ministry of

Environment targeted at reducing carbon emissions level to tackle climate change impact; however, intensified efforts should also be on obtaining finance for green growth projects, development of cleaner alternatives to fossil fuel (e.g., fuel blending), sustainable drive for renewable energy, among others.

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