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PROMOTING A PANDEMIC RECOVERY: EVIDENCE TO SUPPORT MANAGING THE GROWING DEBT CRISIS PROJECT

DETERMINING THE OPTIMAL CARBON PRICING POLICY FOR NIGERIA

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DETERMINING THE OPTIMAL CARBON PRICING POLICY FOR NIGERIA

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Red Sur led the project "Promoting a pandemic recovery: evidence to support managing the growing debt crisis", aimed at restructuring public debt for socio-economic recovery and sustainability in Africa and Latin America and mobilized seven research centres from both regions.

The project was led by Fernando Lorenzo (Centro de Investigaciones Económicas, CINVE/Red Sur). The academic direction of the project and the process of elaboration of this document was carried out by Red Sur Regional Technical Coordination team, composed of Andrés López (IIEP-UBA-CONICET/Red Sur), Ramiro Albrieu (Red Sur), Luis Miguel Galindo (Universidad Nacional Autónoma de México, UNAM) and Álvaro Ons (CINVE/Red Sur).

The researchers and centres by country that made up the project's research consortium in Latin America were: the ARU Foundation of Bolivia, under the leadership of researchers Omar Velasco, Wilson Jiménez, Josué Cortez and Diego Peñaranda. The study in Honduras was led by Luis Miguel Galindo (UNAM), Gerson Urtecho and Sergio Sánchez. The study in Paraguay was conducted by Centro de Análisis y Difusión de la Economía Paraguaya (CADEP), under the leadership of Belén Servín, Juan Cresta, Fernando Masi, Fernando Ovando and Dionisio Borda.

The researchers and centres per country that made up the project's research consortium in Africa are listed below. In Nigeria: Centre for the Study of the Economies of Africa (CSEA), under the leadership of Mma Amara Ekeruche, with the participation of Chukwuka Onyekwena; Chris Heitzig; Oreoluwa Adenuga; Oludele Folarin and Kashema Bahago. In Ethiopia, Addis Ababa University - UAA and Institute of Development Policy Research (IDPR), under the leadership of Alemayehu Geda, with the participation of Addis Yimer and Getnet Alemu. In Uganda, the Economic Policy Research Centre (EPRC), under the leadership of Corti Paul Lakuma, with the participation of Sarah N. Ssewanyana; Ibrahim Kasirye; Wilson Asiimwe; Brian Sserunjogi; Rehema Kahunde; Ambrose Ogwang and Smartson Ainomugisha.

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The series of publications resulting from the project includes the following titles that are published as Red Sur Working Papers and Policy Briefs, available at www.redsudamericana.org:

Number	Title	Authors/Institution
Policy Brief No 1/2022	G20 Policy Brief Indonesia 2022. Policy Proposals for External Debt Management and Sustainability in Developing and Low-Income Countries TF7 - International Finance and Economic Recovery	Fernando Lorenzo (Centro de Investigaciones Económicas), Luis Miguel Galindo (Universidad Nacional Autónoma de México), Ramiro Albrieu (CIPPEC), Dionisio Borda (Centro de Análisis y Difusión de la Economía Paraguaya), Paul Lakuma (Economic Policy Research Centre), Mma Amara Ekeruche, Alemayehu Geda (Addis Ababa University), and Arjan de Haan (IDRC)
Policy Brief No 2/2023	LAC Policy Brief "Results and Policy Implications in Latin America"	Miguel Galindo (UNAM), Fernando Lorenzo (CINVE/Red Sur) and Ramiro Albrieu (Red Sur)
Policy Brief No 3/2023	Construyendo un futuro sostenible en el Sur Global	Ramiro Albrieu (Red Sur)
Policy Brief No 4/2023	Policy Brief I - Ethiopia: Profile of Ethiopian Debt and its Institutional Challenges: An Exploratory Analysis	Getnet Alemu and Alemayehu Geda (Addis Ababa University/AAU)
Policy Brief No 5/2023	Policy Brief II - Ethiopia: Fundamental and Proximate Drivers of Public Debt in Ethiopia (1980-2023)	Alemayehu Geda and Addis Yimer (Addis Ababa University/AAU)
Policy Brief No 6/2023	Policy Brief III - Ethiopia: A Two-Edged Sword: The Impact of Public Debt on Economic Growth—The Case of Ethiopia	Addis Yimer and Alemayehu Geda (Addis Ababa University/AAU)
Working Paper No 1/2023	Background Document 'Fiscal and Financial Challenges of Climate Transition in Latin America'	Luis Miguel Galindo (UNAM) and Fernando Lorenzo (CINVE/Red Sur)
Working Paper No 2/2023	Climate Change, Fiscal Risks and Public Debt Management in Latin America	Luis Miguel Galindo (UNAM) and Fernando Lorenzo (CINVE/Red Sur)
Working Paper No 3/2023	Consumption Patterns and Environmental Taxation in Latin America	Luis Miguel Galindo (UNAM) and Fernando Lorenzo (CINVE/Red Sur)
Working Paper No 4/2023	Investment Incentives and Sustainable Productive Transformation in Latin America	Andrés López (IIEP-UBA-CONICET/Red Sur) and Alvaro Ons (CINVE/Red Sur)

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Working Paper No 5/2023	Estudio País: Construyendo un Futuro Sostenible en Bolivia (in Spanish)	Omar Velasco, Wilson Jiménez, Josué Cortez and Diego Peñaranda (Fundación ARU)
Working Paper No 6/2023	Estudio País: Construyendo un Futuro Sostenible en Honduras (in Spanish)	Gerson Urtecho, Sergio Sánchez and Luis Miguel Galindo (UNAM)
Working Paper No 7/2023	Estudio País: Construyendo un Futuro Sostenible en Paraguay (in Spanish)	Dionisio Borda, Juan Cresta, Fernando Masi, Fernando Ovando, Belén Servin (CADEP/Red Sur)
Working Paper No 8/2023	Effects Of Gender-Inequality During Global Health Emergencies: Evidence from Nigeria	Centre for the Study of the Economies of Africa (CSEA)
Working Paper No 9/2023	Debt for Climate and Development Swaps in Nigeria	Centre for the Study of the Economies of Africa (CSEA)
Working Paper No 10/2023	Determining the Optimal Carbon Pricing for Nigeria	Centre for the Study of the Economies of Africa (CSEA)
Working Paper No 11/2023	Sustainable, Inclusive and Environmentally Responsive Debt in Uganda: Implication of COVID 19	Economic Policy Research Centre (EPRC)
Working Paper No 12/2023	Profile of Ethiopian Debt and Its Institutional Challenges: An Exploratory Analysis	Getnet Alemu and Alemayehu Geda (Addis Ababa University/AAU)
Working Paper No 13/2023	Fundamental and Proximate Drivers of Public Debt in Ethiopia	Alemayehu Geda and Addis Yimer (Addis Ababa University/AAU)
Working Paper No 14/2023	A Two-Edged Sword: The Impact of Public Debt on Economic Growth: The Case of Ethiopia	Addis Yimer, African Child Policy Forum (ACPF) and Department of Economics Addis Ababa University (AAU) and Alemayehu Geda, Addis Ababa University (AAU)

CONTENT

EXECUTIVE SUMMARY

The challenge of climate change has made it imperative for Nigeria to follow a low- emission climate-resilient development path. To facilitate carbon emission reduction and align with the Paris Agreement, Nigeria developed and updated its Nationally Determined Contribution (NDC) to reduce emissions. In the updated NDC, Nigeria pledged to unconditionally, by 2030, reduce greenhouse gas (GHG) emissions by 20% and 47%, conditionally below business-as-usual. To achieve the emission reduction target, there is a need for Nigeria to apply effective policy instruments in managing the key emitting sectors. Policy instruments required to facilitate low carbon transition are grouped into three: carbon pricing and market-based instruments, interventions to support the use of low-carbon technology, and regulatory instruments to remove some obstacles to low emissions (OECD/IEA/NEA/ITF, 2015).

Carbon pricing has been identified as an effective policy instrument in the global effort for greenhouse gas reduction. Carbon pricing, such as carbon tax and Emission Trading Scheme (ETS) are the main policy instruments applied by countries to facilitate emission reduction. The carbon tax imposes a tax rate on carbon emissions by setting a price directly on carbon to reflect the social costs of climate change. A carbon tax has been significant in reducing emissions across countries and equally serves as a source of climate finance, which is critical to promoting economic growth and development and fostering an inclusive green economy. However, despite the importance of a carbon tax in reducing emissions and generating climate finance, currently, Nigeria does not have an explicit carbon tax, or emission trading system for CO2. Therefore, to facilitate carbon tax policy for Nigeria, this study determined the optimal carbon pricing policy for Nigeria. It identified the scope of taxation, that is, the fossil fuel types, sectors, and activities to be covered; determined the regulation point, production or consumption; and ascertained the optimal tax rate that will result in specific emissions abatement level and generate substantial revenue.

We used a modified version of the IFPRI CGE model and a 2019 Social Accounting Matrix of Nigeria for the study to achieve the objectives. We examined three key shocks only: (1) Introduction of production carbon taxes in the economy (2) Introduction of consumption carbon taxes in the economy, and (3) The combined introduction of the two taxes as well as ameliorative measures. Because the removal of fuel subsidy is planned in the country, we did not impose carbon taxes on the fuel sector rather, we simulated the removal of the fuel subsidy, which in effect is the same as the imposition of a carbon tax on the sector. The model has eight sectors and is static in nature. This means that it can only, in effect, address the more immediate short-term effects of policies where dynamic factors (e.g. labour supply and capital stock growth) are not captured. In the SAM, GDP at factor cost is 144.2 trillion while GDP at market prices is about 145.6 trillion, as reported by the National Bureau of Statistics. In the SAM, we captured the fuel subsidy payment for 2019, as reported by the Nigerian National Petroleum Corporation (NNPC) (551 Billion Naira). Trade levels were taken from the Balance of payments accounts and National Accounts. Government income and expenditure represent the General government – Federal, State and Local – and were obtained from Central Bank of Nigeria reports. These reports indicate a general government deficit of 5.78 trillion and general government revenue of 13 trillion which are captured in the SAM. We obtained additional external sector data from the Central Bank of Nigeria, indicating a positive current account balance of 4.5 trillion, with imports exceeding oil and non-oil exports. Household income and expenditure patterns were obtained from the National Bureau of Statistics 2018/2019 Nigeria Living Standards Survey (NLSS), which surveyed over 22,000 households across the country.

Three categories of policy experiments were carried out in the study: (a) the introduction of production carbon taxes, (b) the introduction of consumption carbon taxes (c) the introduction of the two combined, including the introduction of ameliorative measures. Categories (a) and (b) make up scenarios one and two respectively while scenarios three to six fall under (c). In scenario three, both production and consumption carbon taxes are implemented without transfers. In scenario four, consumption taxes are implemented with transfers to households due to their relative advantage of over production taxes. We implemented scenarios five and six to obtain the best benefits from a possible policy package - from an overall encompassing macro perspective considering the revenue, emissions and poverty aspects of potential impacts. They both considered additional taxes to improve emissions reduction, given the success of transfers in helping to address negative poverty impacts. Scenario five includes a five percent production tax on oil and other mining, while scenario six increases this to ten percent to observe the impacts on emissions reduction. The experiments were designed to observe which set of taxes better achieves the objectives of reducing emissions and generating additional revenue for the government, with attention paid to the poverty effects. The removal of fuel subsidies was taken as an action that would almost certainly occur soon. It was therefore taken as given in the analysis. As such, policy experiments were conducted with the background that additional policies will be implemented in an economy where the fuel subsidy has been removed. While five production sectors emit greenhouse gases, only three were selected for introducing carbon taxes – Oil and other mining, Manufacturing and services. The two that were left out are the Agric (other) and firewood sectors, both in the broader agriculture sector. The reason for this is the importance of the sector to people experiencing poverty, the difficulty in implementing such a policy in the rural areas, and the highly informal nature of the agriculture sector. Under consumption taxes, two commodities were also excluded: Fuel and Firewood. Fuel was excluded as it is socially challenging to introduce a carbon tax on fuel on top of the removal of fuel subsidy as the latter is in effect, an 'inverted' carbon tax. Firewood is again left out due to the reasons explained above.

Implementing the production carbon tax rates and removing fuel subsidies causes average (composite) commodity prices to increase in the fuel, diesel, service and firewood sectors. Average commodity prices reduce in the manufacturing, agriculture and oil sectors. These price changes and nominal demand equally translate into the sector's GDP. Under this scenario, the Fuel, Agriculture, Service, and firewood sectors expand in size while others contract, with the manufacturing sector contracting the most. Under this scenario, emissions reduced by 0.1 percent from 367 MtCO2e to 366.68 MtCO2e. This is a challenge as a five percent tax can be considered high, yet it only achieved a 0.1 percent reduction in emissions.

As with the introduction of production carbon taxes, the introduction of consumption carbon taxes causes average commodity prices to change. This, in turn, affects demand and, eventually, sectoral GDP growth. Under this scenario, the fuel, Agriculture, Service, and firewood sectors expand and others contract. In this scenario, emissions reduce significantly (0.5 percent) than under the production carbon tax scenario.

Under a combined introduction of production and consumption carbon taxes scenario, average commodity prices for all sectors except the oil sector increase. Interestingly, the nominal demand for all sectors increases as well. However, only the fuel, Agriculture, Service, and fire wood sectors expand in size. Surprisingly, emissions were reduced by the same level as seen under the production carbon tax scenario.

Regarding the impact on poverty, the production carbon tax scenario (Scenario one) has an overall impact of reducing household incomes by 1.62 percent, with urban households having a stronger negative impact of 2.24 percent reduction compared to rural households at 1 percent. Among the poor in urban areas, male-headed households experience worse impacts, while among the non-poor the reverse is the case. In the consumption carbon tax scenario (Scenario two), the overall poverty impact is less, with a negative impact of 1.39 percent. Again urban households are more negatively affected than rural households. Also, in the urban areas, poor households are more affected on average, although for female-headed households, the impacts are about the same for both poor and non-poor households. The gap between the impacts for male-headed households is large for poor and non-poor households (3.17 percent and 0.14 percent) respectively. The combination of both taxes and the removal of fuel subsidies lead to a more substantial reduction in household incomes, with household income reducing by
2.76 percent, implying, expectedly, that the shock of the combination is much stronger.

Here also, the impact is more substantial on urban households. This means there is a stronger negative impact with less emissions reduction than when only consumption taxes are implemented.

To address the lack of value addition (in terms of emissions reduction) in combining both production and consumption carbon taxes, Scenario four implements the introduction of consumption taxes only and the introduction of transfers to households from the carbon tax related revenue. These transfers are equivalent to about one-quarter of the existing transfers from the government to households and about a quarter of the increase in government revenue in Scenario Two. Introducing transfers leads to a sizeable reduction in the poverty rate from 1.39% to 0.37%. This is encouraging as it indicates strong prospects for using carbon tax revenue to reduce the negative impacts of introducing carbon taxes.

Regarding macroeconomic impacts, introducing production carbon taxes increases the price level by 0.6 percent, while consumption carbon taxes increase prices by 2.5 percent. Expectedly, the combination of the two pushes the increase in the price level to 3.8 percent. Scenario four also raises the price level but not up to 3.8 percent. The introduction of five percent and ten percent production taxes in Scenarios Five and Six led to lower increases in the price level. In terms of GDP, the simulation that has the best impact is scenario Four, where consumption taxes are combined with household transfers. Here the impact on GDP is -0.0021 percent. The scenario with the worst impact is scenario six, which reduces 0.25 percent in GDP. In terms of revenue, we obtained the best result under scenario three, which combines both types of carbon taxes. However, its poverty and emissions effects are relatively poor compared to other scenarios. Scenario Five raises the least additional revenue where consumption carbon taxes, household transfers and a five percent production carbon tax was levied on the oil and other mining sectors.

While the analysis has given perspectives on necessary elements for a possible carbon pricing policy, we also implemented a sub-simulation to ascertain the magnitude of taxes that may be necessary to achieve a substantial reduction in emissions enough to allow Nigeria to be on track to achieving a 20 percent unconditional reduction by 2030 as targeted. Using the tax rates structure applied in scenario Six as a base, the simulation indicated that up to a 30 percent production carbon tax on the oil sector and consumption taxes of 7.5 percent to 15 percent would be needed to achieve the short-term target of reducing emissions from 367 to 351 by 2021 (which would put the country on track to achieving the 2030 target. These rates are relatively high and indicate the need for a gradual approach to implementing the carbon tax[1].

Based on the findings, the following recommendations are made:

1. Preference should be given to consumption carbon taxes in the short term, while production taxes can be introduced later and possibly in a gradual manner to allow the economy absorb each round of increase/change.
2. Transfers should be used to target the most vulnerable households to reduce the negative effect of the taxes' introduction.
3. Over shocking of the economy can lead to counterproductive results. As such, it is necessary to implement both consumption and production carbon taxes in a phased way that does not overload the actors and the economy as a whole into counterproductive outcomes.

[1] Addressing this would require a dynamic model while this present analysis is a static analysis

I. INTRODUCTION

I.1. BACKGROUND

Climate Change due to greenhouse gas emissions is one of humankind's most significant challenges, and its effects are enormous. Like most developing countries, Nigeria is highly vulnerable to climate change, and with a score of 37.1, the country is ranked 161 out of 182 countries in ND-GAIN[2] index of climate change vulnerability in 2019. Scientific estimates suggest that with global warming at 1◦C and 2◦C, the country could lose 4.528% and 9.689% (%change/year) of its GDP in the long run (Kompas, 2018). In 2012 Nigeria experienced a flood disaster that caused damage equivalent to US$9.5 billion in the twelve most affected states (FGN, 2013). The challenge of climate change has made it imperative for Nigeria to follow a low-emission, climate-resilient development path

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To facilitate carbon emission reduction and align with the Paris Agreement, Nigeria developed and updated its Nationally Determined Contribution (NC) to reduce emissions. In the updated NDC, Nigeria pledged to unconditionally, by 2030, reduce greenhouse gas (GHG) emissions by 20% and 47%, conditionally below business-as-usual. As recorded in the NDC, out of the total emission in 2018 amounting to 347MTCO2e, energy, with 60.2 percent of total emissions (209 MtCO2e in 2018) was the largest source of GHG emission, followed by Agriculture, forestry and other land uses (AFOLU) contributing 25 percent of total emission, waste contributing 9.4 percent and industrial processes and other products use contributing 5.3 percent (FMEnv, 2021). To achieve the target regarding emission reduction, there is a need for Nigeria to apply effective policy instruments in managing the key emitting sectors. Policy instruments required to facilitate low carbon transition are grouped into three, and they include carbon pricing and market-based

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[2] The ND-GAIN "(Notre Dame Global Adaptation Initiative) Index summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience".

instruments, interventions to support the use of low-carbon technology, and regulatory instruments to remove some obstacles to low emissions (OECD/IEA/NEA/ITF, 2015).

Carbon pricing has been identified as an effective policy instrument in the global effort for greenhouse gas reduction. Over time, the emissions trajectories of countries with and without carbon prices often diverge, with emissions being lower in countries with carbon prices (Best, et al 2020). Carbon pricing, such as carbon tax and Emission Trading Scheme (ETS) are the main policy instruments applied by countries to facilitate emission reduction (Carattini et al. 2019). The carbon tax imposes a tax rate on carbon emissions by setting a price directly on carbon to reflect the social costs of climate change. ETS is a "cap and trade" scheme that puts a price on emissions and limits the right to emit. Unlike ETSs, carbon taxes are easy to administer, have price certainty to encourage investment, and have the potential to generate substantial income (Parry, et al., 2022). Carbon tax has been effectively implemented across countries and have been significant in reducing emissions (Andersson, 2019; Gupta, et al., 2019; Sterner, 2020) and. equally serves as a source of climate finance, which is critical to promote economic growth and development as well as fostering an inclusive green economy.

However, despite the importance of a carbon tax in reducing emissions and generating climate finance, currently, Nigeria does not have an explicit carbon tax, emission trading system for CO2 or specific taxes on energy use (OECD, 2021), notwithstanding the energy sector is the number one driver of emissions in Nigeria (Federal Ministry of Environment (FMEnv), 2021). This situation persists even as research evidence (Dioha and Kumar, 2020) shows that carbon tax can decarbonize the energy system of Nigeria by 77% and thus serves as an effective policy instrument for achieving the NDC. Therefore, there is a need to find out, through action research, how a carbon tax can work in Nigeria.

I.2. SCOPE OF THE STUDY

This study determined the optimal carbon pricing policy for Nigeria. It:

1. Identified the scope of taxation, that is, the fossil fuel types, sectors, and activities to be covered;
2. Determined the point of regulation, that is, production or consumption; and
3. Ascertained the optimal tax rate that will result in specific emissions abatement levels and generate substantial revenue.

I.3. OBJECTIVE OF THE STUDY

Specifically, **EfD Nigeria** carried out the following:

i. Provided the required database, including producing a Social Accounting Matrix (SAM) for developing a CGE Model

ii. Developed a CGE model to examine the optimal tax rate that is consistent with the emissions target of Nigeria

iii. Determined in conjunction with CSEA the appropriate policy scenarios for use in the CGE model simulations in line with the objectives of the study

iv. Prepared the results of the CGE modelling exercise in a standard report for dissemination to stakeholders.

II. LITERATURE REVIEW

Carbon pricing has attracted the attention of researchers and policymakers across countries as a viable instrument of climate action for transiting towards managing GHG emissions. A carbon pricing policy includes using either a carbon tax or cap-and-trade systems (Emissions Trading Schemes) to limit carbon emissions and raise much-needed revenue for governments.

The cap-and-trade policy's design is more complicated as it often involves numerous mechanisms to improve its efficiency or equity. A carbon tax can be levied directly on energy production, consumption, or trade to limit GHG emissions and raise revenues for governments. Therefore, a carbon tax has greater appeal to most developing countries, and for now, South Africa remains the only country in Africa that has introduced a carbon tax policy. However, countries like Nigeria and Kenya have already officially indicated an impending introduction of either a carbon tax or a combination of both a carbon tax and cap-and-trade systems. The United Nations Development Programme, UNDP (2021) suggests that explicit carbon pricing policies are desirable given their low-cost nature and potential to support government financing. Carbon pricing yields the lowest-cost emissions reductions of all mitigation instruments and, if well designed, can also raise valuable fiscal revenues, which could support a range of public financing objectives, including delivery of the SDGs. Once implemented, a tax on emissions may serve as a deterrent to pollution as it may encourage society to explore and embrace new approaches that reduce carbon emissions and avoid paying a carbon tax.

Most studies that have examined the impact of introducing a carbon tax in developing and developed economies use some form of ex-ante analysis. As net-zero transition has become a global trend, computable general equilibrium (CGE) models have been widely employed in economic, social, and environmental impact assessments for low-carbon policies. An, Zhang, Zhou, and Wang (2023) noted that climate targets, carbon pricing, and energy policy are the main policy focuses of CGE analysis, while land policy, demand- side actions, and several other policies are less studied. In addition, CGE analysis generally focuses on the economic impacts of carbon reduction, with a growing amount of attention on social and environmental consequences. It will be interesting to undertake this literature review by examining the question of what has been or would be the impacts of introducing a carbon tax on emissions, government revenue, GDP, and household income/poverty across countries. Hopefully, the review is also intended to cover the points the carbon taxes are applied – production, sales, or consumption, and finally highlight differences in impacts when the taxes were placed at different points.

Mengistu, Benitez, Tamru, Medhin, and Toman (2019) did a collaborative study with the World Bank on exploring carbon pricing in developing countries – with a focus on a macroeconomic analysis in Ethiopia using a dynamic computable general equilibrium (CGE) modelling approach. The major emphasis of the work was on a better understanding of the potential benefits and potential costs to the economy associated with carbon pricing and on investigating potential distributional impacts of carbon pricing and measures that can help address unwanted distributional impacts. The paper found that with a carbon tax, GDP in 2030 is only 0.7 percent to 1.6 percent lower than the base case, depending on the scenario. Using the carbon tax revenues to cut sales tax or business income tax leads to a smaller impact on GDP compared to the other scenarios. Both of those tax cuts reduce economic distortions, which encourages investment. The paper also found that GHG emissions are lower than in the baseline under all policy scenarios and that significant revenue can be raised from a carbon tax. For example, with the price of carbon rising to $30/ton in 2030, total revenue from the carbon tax can be as high as $800 million in that year, depending on the scenario. The paper also observed that the distributional consequence of the carbon tax on fuels depends on the importance of those fuels in different sectors. As industry and service sectors are more transport and fuel-intensive, a carbon tax has a larger proportionate effect on them. As for the impact of a carbon tax on households, since most urban households receive a large proportion of their income through employment in the service and industrial sectors, a carbon tax tends to affect income and consumption of urban households more than rural households.

Rajbhandari, Limmeechokchai, and Masui (2019) analyze the macroeconomic effects of limiting GHG emissions by using a computable general equilibrium (CGE) model on Thailand's economy from 2010 to 2050. Besides the business as usual (BAU) scenario, the paper assesses the macroeconomic effects of ten low to medium GHG mitigation scenarios under varying GHG reduction targets of 20% to 50%. In addition, the study also assesses three different peak emission scenarios, each targeting a GHG reduction of up to 90% by 2050, to analyze the feasibility of zero GHG emissions in Thailand to pursue efforts to hold the global temperature rise to 1.5 °C above pre-industrial levels. The results based on the BAU scenario indicate that the GHG emissions from the electricity, industry, and transport sectors would remain the most prominent throughout the planning period. The modelling simulation results indicate that the medium to peak emission reduction scenarios could result in a severe GDP loss compared to the BAU scenario. Therefore, attaining such mitigation targets could be very challenging for Thailand. Results further suggest that the development and deployment of energy-efficient and renewable energy- based technologies would play a significant role in minimizing the GHG emissions and overcoming the macroeconomic loss and lowering the price of GHG emissions.

Alton, Arndt, Davies, Hartley, Makrelov, Thurlow, & Ubogu (2012) evaluated the potential impacts of introducing a carbon tax in South Africa using a dynamic economy-wide model linked to an energy sector model. Simulation results indicate that a phased-in carbon tax reaching US$30 per ton of CO2 by 2022 achieves the ambitious national emissions reduction targets for 2025. Relative to a baseline with free disposal of CO2, constant world prices and no change in trading partner behaviour, the preferred tax scenario reduces national absorption and employment by 1.2 and 0.6 per cent, respectively, by 2025. However, if South Africa's trading partners impose a carbon consumption tax unilaterally, welfare and employment losses exceed those of a domestic carbon tax. The paper also found that border tax adjustments will improve welfare and employment while maintaining the same emissions reductions. The paper concluded that mode for recycling carbon tax revenues strongly influences distributional outcomes, with trade-offs between growth and equity.

Nemavhidi and Jegede (2023) examined the potential of a carbon tax to either aid or hinder some fundamental human rights of people experiencing poverty in South Africa. The paper notes that by slowing down the emission underlying extreme events such as sea level rise and flooding, the Carbon Tax Act can positively impact the right to life of the most vulnerable groups. However, the paper also noted that implementing a carbon tax may increase living costs for poor people, thereby worsening their living conditions. If a Carbon Tax Act covers activities around food processing, beverages and tobacco, road transportation and agriculture, forestry, and fishing, such may be counterproductive for food security. The introduction of a carbon tax may be a gain for the environment, but pushing the cost of production of food services may have adverse effects on food prices and undermine the right of people experiencing poverty to food. The paper advocates for the channeling of revenues from the carbon tax to invest in alternative energy to demonstrate that climate mitigation is the long-term focus of the Carbon Tax Act, and the State may also target and utilize the revenue generated from the implementation of the Carbon Tax Act to address its negative consequences on key human rights.

Sanderson, Mukarati, Jeke, & Le Roux (2023) conducted a static computable general equilibrium (CGE) model of South Africa to investigate the relationship between a carbon tax and environmental quality in the country. The results show that environmental tax negatively affects gross domestic product (GDP), with the energy sectors, which are generally the most polluting sectors suffering higher output losses due to the environmental tax. Household consumption is significantly reduced by 2.34 percent due to the reduction in emissions because of a carbon tax policy. The paper suggested that policymakers should consider an initial five percent carbon tax policy which may achieve reasonably good environmental quality without significantly damaging investment, fixed capital investment and government revenue.

In the case of Nigeria, only a few economy-wide studies on a carbon tax potential impacts on the economy have been conducted. Fortunately, Dorband, Jakob, Steckel, & Ward (2022) utilized a microsimulation analysis to investigate the potential adverse impacts of a carbon tax on poverty and inequality in Nigeria. The paper estimates which absolute and relative equity effects a comprehensive carbon pricing reform would have on households within and between income groups in the country. The paper also analyzes the distributional effects of revenues being recycled into basic infrastructure development and social safety nets. The study then assesses the expected consumption effects of six policy packages across rural and urban income groups, combining environmental-extended input-output data with detailed household survey data. The results suggest that relative to their income, lower-income households would bear a smaller consumption burden from carbon pricing than high-income households, while enjoying greater gains from uniform cash transfers or access to improved water, sanitation, electricity, or telecommunication infrastructure. Additionally, if spent efficiently, such investments could disproportionally benefit the poorer rural population due to larger initial access gaps.

While the overwhelming weight of the evidence emanating from the review of the related literature indicates that studies reviewed agree on the inevitability of introducing a carbon tax as an effective means of regulating the behaviors of or, at best, incentivizing economic agents to make consumption and production decisions that are less harmful to the environment; the question of how best to balance the trade-offs between environmental health and economic health of countries introducing a carbon tax remains a running debate. One other fact from the reviewed literature is that climate change itself and improperly designed climate change mitigation policies, such as introducing a carbon tax, will always leave the poor highly vulnerable. A carbon tax policy should be thoughtfully designed considering the poor and most vulnerable groups in society.

III. METHODOLOGY

III.1. INTRODUCTION

We employed a modified version of the IFPRI CGE model (Lofgren et al., 2002) and a 2019 Social Accounting Matrix of Nigeria for the study. We examined three key shocks only: (1) Introduction of production carbon taxes in the economy (2) Introduction of consumptio carbon taxes in the economy, and (3) The combined introduction of the two taxes as well as ameliorative measures. Because the removal of fuel subsidy is planned in the country, we did not impose carbon taxes on the fuel sector rather, we simulated the removal of the fuel subsidy, which in effect is the same as the imposition of a carbon tax on the sector. The model has eight sectors as shown below, and is static in nature. This means that it can only, in effect, address the more immediate short-term effects of policies where dynamic factors (e.g. labour supply and capital stock growth) were not captured. A full description of the IFPRI model is found in Lofgren et al. (2002). We describe the main features of this version further below.

1. A-Kerosene
2. A-Fuel (Premium motor spirit or ‘petrol’)
3. A-Diesel
4. A-Manufacturing (other)
5. A-Agriculture (other)
6. A-Firewood
7. A-Services
8. A-Oil and other mining

III.2. THE SOCIAL ACCOUNTING MATRIX

We developed a 2019 Social Accounting Matrix (SAM) and used for the study. The structure of the SAM is shown in Table 1 below. In the SAM, GDP at factor cost is 144.2 trillion while GDP at market prices is about 145.6 trillion as reported by the National Bureau of Statistics. We captured the fuel subsidy payment in 2019, as reported by the Nigerian National Petroleum Corporation (NNPC), amounting to 551 Billion Naira in the SAM. Trade levels were taken from the Balance of payments accounts and National Accounts. Government income and expenditure represent the General government – Federal, State and Local – and were obtained from Central Bank of Nigeria report revenue of 13 trillion, captured in the SAM. Additional external sector data from the Central Bank of Nigeria indicates a positive current account balance of 4.5 trillion, with imports exceeding oil and non-oil exports. Household income and expenditure patterns were obtained from the National Bureau of Statistics 2018/2019 Nigeria Living Standards Survey (NLSS), which had over about 22,000 households across the country surveyed.

s. These reports indicate a general government deficit of 5.78 trillion and general government

Table 1: Aggregate SAM (2019, Trillions of Naira)

	Activities	Commodities	Factors	Households	Firms	Government	Taxes	Import Subsidy	Savings-Investment	Rest of the World	Total
Activities		187.3									187.3
Commodities	41.7			94.5		12.4			50.1	21.0	219.6
Factors	144.21										144.2
Households			68.6	13.4	27.0	3.4				8.2	120.6
Firms			65.3			2.0				0.6	67.9
Government			6.9				5.6			0.6	13.0
Taxes	1.39	2.0		0.5	1.7	0.0					5.6
Import Subsidy		-0. 551				0.551					0
Savings-Investment				12.2	39.2	-5.78				4.5	50.1
Rest of the World		30.9	3.5			0.4					34.8
Total	187.3	219.6	144.2	120.6	67.9	13.0	5.6	0	50.1	34.8	843.2

III.3. MAIN FEATURES OF THE MODEL

Production

We modelled output using the Leontiff production function, aggregating value-added and intermediate inputs. There are five production factors: agricultural capital, non-agricultural capital, agricultural labour, non-agricultural labour and land. Capital in each sector was fixed while labour was mobile across sectors. Land was fixed. CES functions were used to aggregate factors into value-added.

Subsidy

The SAM and the model captureed the 2019 level of subsidy on Petrol – 551 Billion Naira and the value of domestic production and petrol imports. In this way, the magnitude of the subsidy was properly captured. Domestic consumption of petroleum products was met through importation and domestic production. Prices of imported products are subsidized up to the subsidy rate, ESR, so that the final sales price of imported products was a fraction of the full cost of importation. The ESR is the ratio of the explicit subsidy to the border value of imported products. The subsidy is part of government expenditure. As the domestic prices of the products increase, the profit level in the sub-sector increases and government revenue through tax increases as well.

Investment and Savings

As the model is static, investment does not increase capital stock. An endogenous adjustment factor adjusts household and firms' savings rates to equate total savings with investment. Government savings was determined by its revenue less expenditure. Foreign savings is exogenous. The equality of savings and investment was thus achieved through the endogenous adjustment factor and firm savings. In the analysis, government savings are allowed to vary to note changes as carbon taxes are implemented.

Households

There are eight households in the model based on location (Urban/Rural), Gender of Household head (Male/Female) and Poverty Status (Poor/Non-poor). Due to the differences in the income and expenditure patterns of urban and rural households, it is important to separate them, especially as there is often a substantial gap between urban and rural incomes. Similarly, across gender and poverty status there are differences in income and expenditure patterns which are important to capture. The households in the model are

HU-P-MH : Urban – Poor – Male headed households

HU-P-FH : Urban – Poor – Female headed households

HU-NP-MH : Urban – Non Poor – Male headed households

HU-NP-FH : Urban – Non Poor – Female headed households

HR-P-MH : Rural – Poor – Male headed households

HR-P-FH : Rural – Poor – Female headed households

HR-NP-MH : Rural – Non Poor – Male headed households

HR-NP-FH : Rural – Non Poor – Female headed households

In the 2018/2019 Nigerian Living Standards Survey, information exists on the classification of households according to the above criteria. Household income is made up of factor incomes and transfers from other households, the government and the rest of the world. In the model we distributed incomes according to observations from the survey as indicated below.

Table 2: Income sources for different households

	Agric land and labour income	Non-agric labour income	Transfers from Households	Capital	Transfers from Government	ROW	Total
HU-P-MH	25.54	60.00	6.07	4.61	1.53	2.26	100.00
HU-P-FH	20.44	48.32	15.91	6.17	3.22	5.94	100.00
HU-NP-MH	9.12	36.37	8.10	37.54	1.06	7.81	100.00
HU-NP-FH	3.58	26.92	18.68	6.53	25.24	19.04	100.00
HR-P-MH	61.70	21.89	6.97	5.30	0.91	3.23	100.00
HR-P-FH	34.02	22.25	31.08	10.86	0.85	0.94	100.00
HR-NP-MH	40.38	27.66	12.69	13.22	1.31	4.74	100.00
HR-NP-FH	28.74	22.49	35.28	9.77	0.90	2.81	100.00

The table above shows the income sources of households. This is important because it determines how policies would affect them. Policies which affect their major sources of incomes would affect them more than otherwise. Urban households, for example, depend more on capital income than rural households do. The reverse is the case for Agriculture related incomes which rural households depend more on.

Households consume all products except oil and other mining. Household consumption was modelled with the Linear Expenditure System. Households pay income tax to the government. In the model and analysis, changes in poverty level are proxied by changes in household income – an increase in household income was taken as an indication of a likely reduction in the poverty level. We expect the opposite to occur when household income decreases. This proxying assumes that income distribution within urban and rural households will not change as different scenarios are analysed. This approach indicates the general direction of impacts on urban and rural households (and their components), which would not be ascertained if only one household represents all households in the economy.

External Trade

Based on available trade data, two products are not exported: Diesel and fuel. All products are imported. Domestic consumption specification was based on the Armington hypothesis. The exchange rate is an exogenous variable in the model. The output of tradeable sectors was allocated to export and domestic markets via a CET function.

Government

Government revenue was made up of import taxes, income taxes and other indirect taxes. The government also received a share of the profits from firms, representing earnings from the oil sector. The government spent on commodities, transfers to households, payments to firms, explicit subsidies and payments to the rest of the world. Government commodity expenditure was treated as consumption expenditure. In the base year government savings was negative.

Emissions

In this model, we modify the IFPRI model by capturing the release of emissions in the economy. Using information from FGN (2021) and FME (2021), we noted the sources of emissions in the economy and aggregated them according to the sectors in the model. There are broadly two sources of emissions – those that occur in the production process and those that occur in the consumption process of households and government. As such, process emissions such as gas flaring, emissions from rice cultivation etc., were mapped onto production sectors in the model, while those that occur during household consumption, e.g. fuel and diesel consumption, the use of cooking gas etc were mapped onto commodities consumption in the model. In the case of manufacturing, emissions that occur during production e.g. in the production of cement, ammonia etc were mapped onto the production of manufactured goods while those that occur in the process of consumption (e.g. household’s use of cooking gas) were mapped onto the consumption of manufactured goods.

Similarly, in the case of firewood, emissions that occur in the production of firewood, charcoal and related products were mapped onto firewood production while those that occur in the use of charcoal and related products for household cooking, for example, were mapped onto firewood consumption. The table below indicates emissions mapping to production activities (A-

) and consumption of commodities (C-). According to the government's inventory of emissions, emissions in 2018 were 347 Million metric tonnes. When we applied the emissions growth rate of the previous five years to this, the estimated emissions for 2019 were a total of 367 Million metric tonnes.

Table 3: Emissions in the Economy captured in the model

	Sector/Commodity	**Emissions (Million Tonnes of CO2 Equivalent**	**%**
Production sources	A-MANF	19.26	5.2
	A-AG	90.83	24.8
	A-SER	34.15	9.3
	A-FIRE	0.64	0.2
	A-OIL	74.37	20.3
Consumption sources	C-KERO	5.57	1.5
	C-FUEL	48.94	13.3
	C-DIESEL	78.57	21.4
	C-MANF	14.64	4.0
	C-FIRE	0.03	0.0
	Total	367.00	100

In the model, the quantity of goods and services produced (A-) and consumed (C-) in 2019 led to the release of the above levels of emissions. We, therefore, impose carbon taxes in the form of production taxes for the production process and sales taxes for those from the consumption process. This led to increased output and sales prices, which ultimately triggered a reduction in consumption and reduced emissions. It has been noted that while carbon taxes are often discussed in terms of payment per tonne of emissions, they are often implemented or analysed in the form of sales or related taxes[3] as, indeed, producers and consumers ultimately respond to them based on how prices and profit and utility maximization are eventually affected.

$$TOTEMS = \sum_{ProdEmsectors} (EMFACP_{ProdEmsectors} * QA_{ProdEmsectors}) + \sum_{ConsEmsectors} (EMFACC_{ConsEmsectors} * QQ_{ConsEmsectors})$$

where:

TOTEMS – Total Emissions in the economy

ProdEmsectors – set of sectors for which emissions occur in the production process

ConsEmsectors – set of sectors for which emissions occur during consumption EMFACP

– calibrated emission factors for production related emissions EMFACC – calibrated emission factors for consumption related emissions

QA – quantity of Gross output of the sector

QQ – quantity of composite goods supply in the sector

Equilibrium Conditions

The demand for labour = supply of labour

Demand for each composite good = supply of each Demand for

exports = supply of exports

Total investment = savings

[3] Telaye et al [2019]

IV. POLICY EXPERIMENTS

Three categories of policy experiments were carried out in the study: (a) The introduction of production carbon taxes, (b) The introduction of consumption carbon taxes (c) The introduction of the two combined including the introduction of ameliorative measures. The experiments are shown in Table 3 below. The experiments were designed to observe which set of taxes better achieves the objectives of reducing emissions and generating additional revenue for the government, with attention paid to the poverty effects. The removal of fuel subsidy was taken as an action which would almost certainly occur soon. It was therefore taken as given in the analysis. As such, policy experiments were conducted with the background that additional policies would be implemented in an economy where the fuel subsidy has been removed. The results of the experiments are discussed in the next section.

Table 4: Scenarios in the study

Group	Scenario		Description
Production carbon taxes introduction	1	5% Production carbon tax on 3 sectors	● 5% Production carbon tax on Oil and other Mining, Manufacturing and Services ● Removal of fuel subsidy as an 'inverted' carbon tax
Consumption carbon taxes introduction	2	5% Consumption (Sales) carbon tax on 3 sectors	● 5% Consumption (Sales) carbon tax on diesel, Kerosene and Manufacturing ● Removal of fuel subsidy as an 'inverted' carbon tax
Combination of production and consumption carbon taxes	3	5% Production carbon tax on 3 sectors and 5% Consumption (Sales) carbon tax on 3 sectors	● 5% production and Consumption carbon taxes on the above sectors simultaneously ● Removal of fuel subsidy as an 'inverted' carbon tax
	4	Consumption carbon taxes + household transfers	● 5% Consumption (Sales) carbon tax on diesel, Kerosene and Manufacturing ● Removal of fuel subsidy as an 'inverted' carbon tax ● Transfers to households from increase in government income
	5	Consumption carbon taxes + household	● 5% Consumption (Sales) carbon tax on diesel, Kerosene and Manufacturing

		transfers + one production carbon tax (5%)	● Removal of fuel subsidy as an 'inverted' carbon tax ● Transfers to households from increase in government income ● 5% production carbon tax on Mining sector in order to further reduce emissions
	6	Consumption carbon taxes + household transfers + one production carbon tax (5%)	● 5% Consumption (Sales) carbon tax on diesel, Kerosene and Manufacturing ● Removal of fuel subsidy as an 'inverted' carbon tax ● Transfers to households from increase in government income ● 10% production carbon tax on Mining sector in order to further reduce emissions

V. RESULTS

V.1. SECTORAL IMPACTS

V.1.a. Production Carbon Tax Introduction

While five production sectors emit greenhouse gases, we selected three for introducing carbon taxes – Oil and other mining, Manufacturing and services. The two that were left out are the Agriculture (other) and firewood sectors, both in the broader agriculture sector. The reason for this is the importance of the sector to people experiencing poverty, the difficulty in implementing such a policy in rural areas, and the highly informal nature of the agriculture sector.

The implementation of the production carbon tax policy at a rate of five percent affected prices in these three sectors directly and prices in other sectors indirectly through the intersectoral linkages (forward and backwards) in the economy. In addition, the sectors responded to first- round effects and further responded to the responses of other sectors. Eventually, when the ripple effects are accounted for, prices in many sectors and the nominal demand in many sectors would change. At the same time, removing fuel subsidies equally increases prices and affects the economy further.

Implementing the production carbon tax rates and removing fuel subsidies caused average (composite) commodity prices to increase in the fuel, diesel, service and firewood sectors. Average commodity prices were reduced in the manufacturing, agriculture and oil sectors. These price changes and changes in nominal demand equally translate into the sector's GDP. Under this scenario, the Fuel, Agriculture, Service, and firewood sectors expanded in size while others contracted, with the manufacturing sector contracting the most. Under this scenario, emissions were reduced by 0.1 percent from 367 million to 366.68 million. This is a challenge as a five percent tax can be considered high, yet it only achieved a 0.1 percent reduction in emissions.

V.1.b Consumption Carbon Tax Introduction

Under consumption taxes, we also excluded two commodities – these are Fuel and Firewood. Fuel was excluded as it is socially challenging to introduce a carbon tax on fuel on top of the removal of fuel subsidy as the latter is in effect, an 'inverted' carbon tax. Firewood was again left out due to the reasons explained above. As with the introduction of production carbon taxes, the introduction of consumption carbon taxes caused average commodity prices to change. This, in turn, affected demand and, eventually, sectoral GDP growth. Under this scenario, the fuel, agriculture, service and firewood sectors expanded, and others contracted. In this scenario, emissions are reduced by a much greater extent (0.5 percent) than under the production carbon tax scenario. This may be due to greater opportunities for substituting taxed commodities for others, unlike the production sector, where substitution in the short run was more limited.

V.1.c Combined Introduction of Production and consumption carbon taxes

In this scenario, average commodity prices for all sectors except the oil sector increased. Interestingly, the nominal demand for all sectors increased as well. However, only the fuel, Agriculture, Service, and fire wood sectors expanded in size. This implies that the general price increase (as observed for most sectors) led to some sectors not experiencing nominal growth higher than the growth in the general price level. Surprisingly, emissions were reduced by the same level as seen under the production carbon tax scenario. This could be because of the economy's several forward and backward linkages, causing it to respond to the basket of tax and subsidy changes so that some commodities that caused emissions are consumed more when the final effects settle in. This indicates that simpler carbon tax plans may be better than complex ones that may cause several ripple effects in the economy. It could be better to focus on a few major emitters rather than pursue all at the same time.

Table 5: Percent Change in Composite Prices

Scenario	A-KERO	A-FUEL	A-DIESEL	A-MANF	A-AG	A-SER	A-FIRE	A-OIL
1	0.00	20.97	0.01	-0.32	-0.37	3.96	0.45	-0.11
2	5.26	20.95	5.25	3.70	0.99	-0.26	0.47	1.16
3	5.26	20.97	5.27	4.75	0.82	3.82	1.05	-0.07
4	5.26	20.97	5.26	5.29	1.51	0.12	0.81	-0.02
5	2.56	20.92	2.42	5.87	0.29	-4.27	-0.59	0.36
6	2.56	20.90	2.26	6.65	-0.47	-9.13	-1.84	0.73

Table 6: Percent Change in total nominal demand

Scenario	A-KERO	A-FUEL	A-DIESEL	A-MANF	A-AG	A-SER	A-FIRE	A-OIL
1	0.02	19.27	0.12	-0.19	-0.39	3.69	0.28	0.48
2	4.57	19.90	5.26	3.43	1.05	0.00	0.69	-2.18
3	5.18	19.65	5.32	4.39	0.87	3.53	1.50	0.32
4	5.18	19.88	5.26	4.83	1.60	0.13	1.65	0.08
5	3.24	20.03	2.26	5.15	0.31	-4.14	0.53	-1.03
6	3.74	20.11	1.83	5.62	-0.50	-9.16	-0.18	-2.24

Table 7: Sectoral Growth Under Different Scenarios

Scenario		A-KERO	A-FUEL	A-DIESEL	A-MANF	A-AG	A-SER	A-FIRE	A-OIL
1	14	-1.7	24.6	-1.9	-10.7	3.7	2.0	3.4	-0.7
2	15	-2.1	17.0	-0.8	-3.9	2.1	0.6	2.2	-1.1
3	16	-2.2	24.5	-2.4	-12.7	5.2	1.9	5.2	-0.6
4	18	0.1	26.9	-0.6	-2.0	1.7	-0.1	2.3	0.3
5	19	7.8	17.7	1.3	4.7	3.2	-2.5	4.6	-3.3
6	20	18.0	17.9	3.2	12.3	5.2	-5.7	7.8	-7.1

V.2. POVERTY IMPACTS

The production carbon tax scenario (Scenario 1) overall reduced household incomes by 1.62 percent, with urban households having a more substantial negative impact of 2.24 percent reduction compared to rural households at one percent. This is likely because the sectors involved are sources of income for more of the urban areas than the rural areas. In the urban areas, the tax combined with the fuel subsidy removal had a worse effect on poor households than non-poor households. This is also noted for the rural areas. These effects are important to note as they signify the full impact of the two tax actions that would be in operation at the same time – fuel subsidy removal and the introduction of carbon taxes. To gauge their real impact, they have to be considered together.

Among the poor in urban areas, male-headed households experienced worse impacts, while among the non-poor the reverse was the case. Ultimately, the impacts depend on the extent to which the major income sources of each household type are affected by these two tax actions combined. The gap in the impacts in male versus female-headed households is smaller among rural households, indicating that their income sources are equally affected.

In the consumption carbon tax scenario (Scenario 2), the overall poverty impact was less, with a negative impact of 1.39 percent. Again urban households were affected more negatively than rural households. Also, in the urban areas poor households were more affected on average, although for female households, the impacts are about the same for both poor and non-poor households. The gap between the impacts for male-headed households is large for poor and non- poor households (-3.17 percent and -0.14 percent), respectively. This implies that poor male- headed household income sources are more heavily affected by the taxation of the consumption of the targeted commodities (possibly especially the manufacturing sector). In the rural areas, poor households are more negatively affected. Again, these results indicate the extent to which the income sources of each household type are affected by the basket of actions implemented.

The combination of both taxes and the removal of fuel subsidy leads to a stronger reduction in household incomes, with household income reducing by 2.76 percent, implying, expectedly, that the shock of the combination is much stronger. Here also, the impact is stronger on urban households due to the reasons explained above. This means that there is a stronger negative impact with less emissions reduction than when only consumption taxes are implemented.

To address the lack of value addition (in terms of emissions reduction) in combining both production and consumption carbon taxes, Scenario Four implements the introduction of consumption taxes only and the introduction of transfers to households from the carbon tax- related revenue. These transfers are equivalent to about one-quarter of the existing transfers from the government to households. They are also about a quarter of the increase in government revenue in Scenario Two. Introducing transfers leads to a sizeable reduction in the poverty rate from – 1.39% to -0.37%. This is encouraging as it indicates strong prospects for using carbon tax revenue to reduce the negative impacts of introducing carbon taxes.

Scenarios five and six were implemented to obtain the best benefits from a possible policy package - from an overall encompassing macro perspective considering the revenue, emissions and poverty aspects of possible impacts. They both consider additional taxes to improve emissions reduction, given the success of transfers in helping to address negative poverty impacts. Scenario five includes a five percent production tax on oil and other mining only, while scenario six increases this to ten percent to observe the impacts on emissions reduction. The oil and other mining sectors were selected because, compared to the other sectors (Manufacturing and Services), it is a much stronger source of emissions and is also not a major source of income to production factors that people experiencing poverty rely more on. As such, it is expected to contribute to the twin objectives of reducing emissions and has as low as possible an impact on the incomes of the poor especially. These scenarios are discussed more in the section below that deals with overall and macro impacts.

V.3. OVERALL MACROECONOMIC, POVERTY AND EMISSION EFFECTS

In terms of macroeconomic impacts, introducing production carbon taxes increased the price level by 0.6 percent, while the consumption carbon taxes increased prices by 2.5 percent. This could be because these increases are more easily passed on to consumers than production taxes, whose effects would first be absorbed by the productive sector before being transmitted to the households and government during final goods consumption. Expectedly, the combination of the two pushes the increase in the price level to 3.8 percent. When transfers are made in addition to implementing consumption carbon taxes (Scenario four), the price level equally rises but not up to 3.8 percent. The introduction of five percent and ten percent production taxes in Scenarios

Five and Six led to lower increases in the price level. This may be due to the fall in nominal demand and decreased sectoral GDP. This may also have affected the spending of agents that depend appreciably on oil and other mining revenues.

In terms of GDP, the simulation that has the best impact is scenario four, where consumption taxes are combined with household transfers. Here the impact on GDP was -0.0021 percent. The scenario with the worst impact is scenario six, which led to a reduction of 0.25 percent in GDP. Regarding revenue, the best result was obtained under scenario three, which combined both types of carbon taxes. However, its poverty and emissions effects are relatively poor compared to other scenarios. Scenario five, where consumption carbon taxes, household transfers and a five percent production carbon tax was levied on the oil and other mining sectors, raised the least additional revenue

Pursuing a multi-objective carbon pricing policy requires assessing the impacts of an approach on emissions, revenue and the poverty level – and allowing for trade-offs where possible. While scenario three greatly increases government revenue and wipes out the existing deficit, it adds comparatively little to the goal of reducing emissions. It has a relatively high (and negative) poverty impact. Policy packages performing better across the other two criteria would yield better results. Scenarios five and six appear to be better packaged in this regard as they add more to reducing emissions and still raise considerable revenue for the government.

Table 8: Overall Effects in The Economy

	1	2	3	4	5	6
Base emissions (Millions of Tonnes)	367	367	367	367	367	367
New emissions (Millions of Tonnes)	366.7	365.0	366.6	366.6	365.7	364.6
Change in emissions (millions of Tonnes)	-0.3	-2.0	-0.4	-0.4	-1.3	-2.4
% Change in emissions	-0.1	-0.5	-0.1	-0.1	-0.3	-0.7
% change in price level (CPI)	0.6	2.5	3.8	3.6	2.9	2.2
% change in real GDP	-0.1222	-0.0225	-0.1605	-0.0021	-0.0466	-0.2545
Increase in Government revenue (trillions)	7.5	3.4	11.1	3.6	4.0	4.3
Increase in Government expenditure (trillions)	-0.3	-0.4	-0.5	0.2	-0.5	-1.8
Base government savings (trillions)	-5.8	-5.8	-5.8	-5.8	-5.8	-5.8
New government savings (trillions)	2.0	-1.9	5.8	-2.3	-1.3	0.3
% Change in government savings (trillions)	7.8	3.9	11.6	3.5	4.5	6.0
% Change in real household income	-1.6	-1.4	-2.8	-0.4	-0.7	-0.9

While the analysis has given perspectives on necessary elements for a possible carbon pricing policy, we also implemented a sub-simulation to ascertain the magnitude of taxes that may be necessary to achieve a substantial reduction in emissions enough to allow Nigeria to be on track to achieving a 20 percent unconditional reduction by 2030 as targeted. Using the structure of tax rates in scenario six as a base, the simulation indicated that up to a 30 percent production carbon tax on the oil sector and consumption taxes of 7.5 percent to 15 percent would be needed to achieve the short-term target of reducing emissions from 367 to 351 by 2021 (which would put the country on track to achieving the 2030 target. These rates are relatively high and indicate the need for a gradual approach to implementing the carbon tax[4].

VI. CONCLUSIONS AND RECOMMENDATIONS

The analysis has reviewed the possible elements in designing a carbon pricing policy and indicates potential areas to address to achieve core objectives. The study suggests that production taxes add less to the emissions objective's achievement than consumption taxes and may not be the preferable option. The analysis also indicates that transfers are a powerful tool to ameliorate the poverty effects of introducing these taxes. Based on the findings of the study, the following recommendations are made:

Preference should be given to consumption carbon taxes in the short term, while production taxes can be introduced later and possibly in a gradual manner to allow the economy to absorb each round of increase/change

Transfers should be used to target the most vulnerable households to reduce the negative effect of the taxes' introduction

Over shocking of the economy can lead to counterproductive results. As such, it is necessary to implement both consumption and production carbon taxes in a phased way that does not overload the actors and the economy as a whole into counterproductive outcomes.

VI.1. AREAS FOR FURTHER STUDY

While the study has indicated important elements to consider in designing a carbon pricing policy, there is room for more analysis regarding the sequencing of the taxes over time so that the impacts are manageable in a given period. A dynamic analysis would be required to carry out this. In addition, the study examined the immediate short-term impacts of implementing the taxes when substituting production factors are not easily achieved.

In the longer term, firms would substitute taxed factors for non-taxed ones, easing the negative impacts on production and household incomes. Therefore, it would be useful to carry out further analysis, which allows for factors substitution between different production factors beyond the traditional factors used in the present analysis (for e.g. natural gas and electricity which are not typical production factors). It would also be useful to observe how consumption of these factors by households varies as carbon tax packages are implemented in the economy. This would require further disaggregation of the sectors in the model to bring out natural gas, electricity and

other energy-relevant sectors as individual sectors as opposed to the present analysis where they are under other aggregate sectors.

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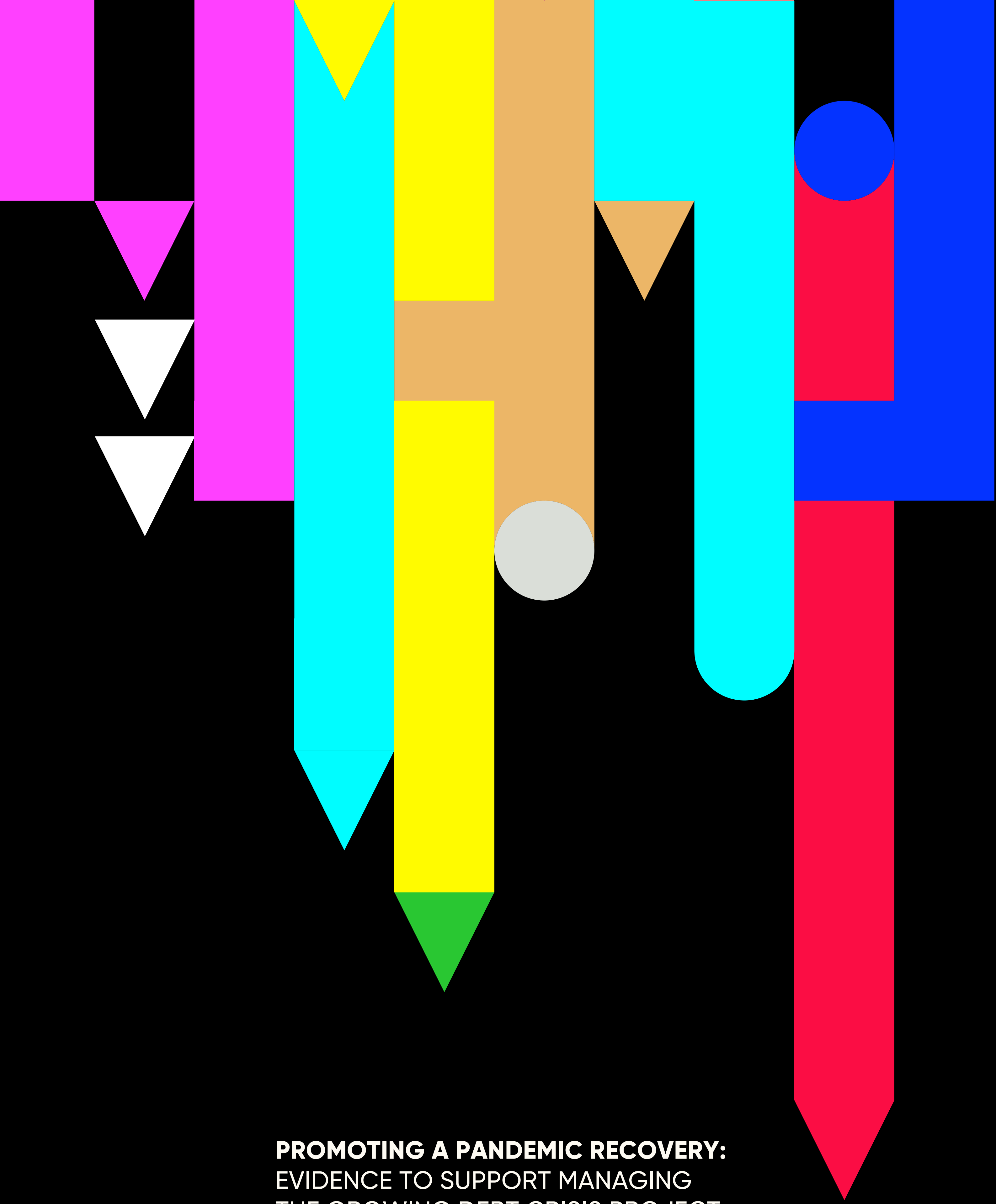

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