Nigeria's diversification with climate mitigation outcomes – CGE applied to policy analysis

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Grzegorz Peszko[1], Maksym Chepeliev and Dominique van der Mensbrugghe[2]

[1] World Bank

[2] GTAP Center for Global Trade Analysis, Purdue University

ABSTRACT

Fiscal policy reforms could fulfill Nigeria's diversification aspirations, prevent the low-middle income trap and increase economic resilience to energy transition risks. The paper explores how fiscal policy reforms in Nigeria would interact with alternative carbon pricing, green industrial policies and trade-related measures applied by its trading partners. Scenarios simulated with the global CGE model ENVISAGE-NGA assume that the rest of the world form alternative hypothetical climate clubs. In some non-cooperative scenarios Nigeria is assumed to align its fiscal policies with a climate club (small or large). In other scenarios Nigeria aligns with OPEC+ and BRICS+ following business as usual policies The fiscal reforms with potential climate mitigation outcomes simulated in this study include removal of petrol subsidy implemented in 2023, but facing policy reversal, broadening the VAT base to remove waiver for petroleum products, increasing uniform VAT rate to 15 percent, carbon tax announced in Nigeria's 2024 National Fiscal Policy , alternative uses of fiscal savings and additional revenues of the above tax reforms (transfer to households through reduction of income taxes and investments in innovation and education to increase productivity. Fiscal reforms simulated in this study can significantly reduce domestic carbon emissions, while enabling diversification with mitigation outcomes and increasing resilience to transition risk. The model explores fiscal reforms that would support Nigeria's aspirations towards higher income status but also identify a trade-off between long-term GDP growth and short-term welfare impact. Result-based climate payments (RBCP) for policy reforms could cumulatively amount to US$ 9.2 billion over 25 years, assuming US$10 per ton of reduced CO2. Mitigation outcomes of petrol subsidy removal could yield $459 million and of carbon tax $8.7 billion with increasing annual revenues.

1. Background, goals and boundaries of this study

Climate change poses dual systemic macro-fiscal risk for Nigeria. The first risk is rooted in the physical impacts of climate change, such as sea level rise and climate-induced extreme weather events. Second, the transition risk (Carney 2015) is rooted in the climate mitigation actions undertaken by other countries, particularly Nigeria's main trade partners. The world's largest economies, including OECD countries and China aggressively pursue green industrial policies. EU and a handful of other countries combine such policies with significant economy-wide carbon prices. Global low carbon transition, if implemented, will peak the demand for oil and gas on which Nigeria depends and affect their export prices (Mercure et al 2018 and 2021; Van der Ploeg and Rezai 2019; Peszko et al 2020 and 2021). On the top of that, border carbon adjustment measures (implemented by EU and planned by a handful of countries – World Bank 2024) would affect demand for oil-derivatives and carbon-intensive manufacturing goods that are at the core of Nigeria's diversification aspirations (Peszko, van der Mensbrugghe, Golub 2020). Global low-carbon transition will also increase demand for "green" goods, technologies and climate action minerals, in which other countries have comparative advantage over Nigeria.

Transition risk became more visible at the 2023 climate COP in Dubai, when Parties for the first time in the history of UNFCCC called for "a just and equitable transition away from fossil fuels". This risks is disproportionally larger for countries that heavily rely on exports of fossil fuels, like Nigeria (Peszko et al. 2020).

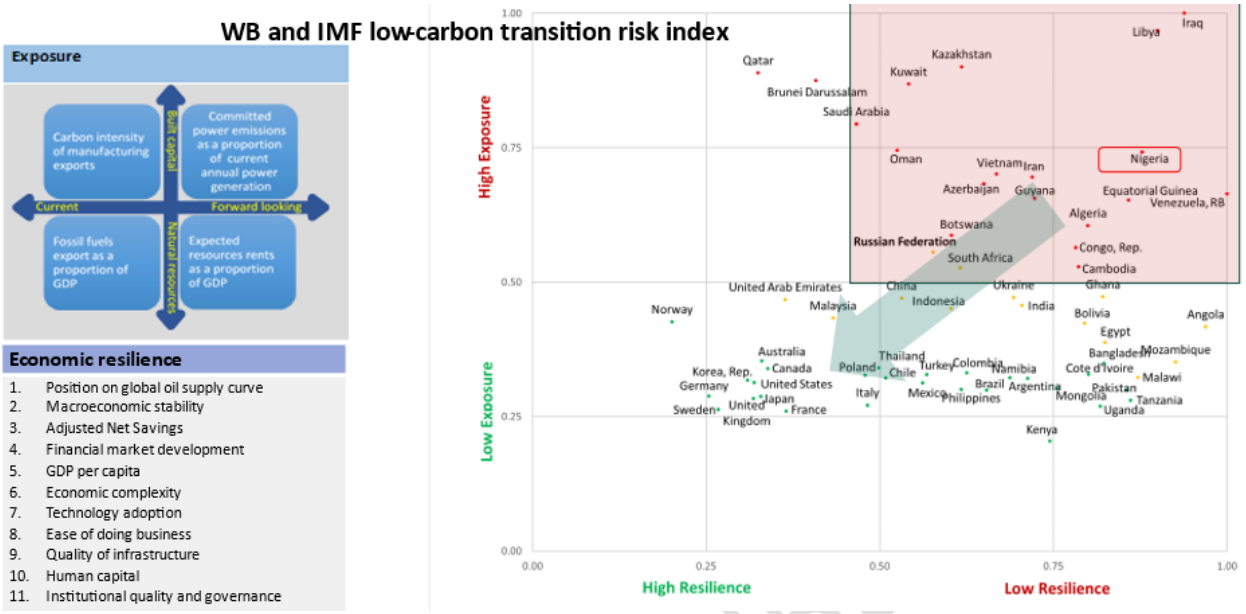
This paper identifies conditions, under which low-carbon transition could be in the self-interest of present Nigerians. The question that this paper addresses is how Nigeria can supercharge its development by maximizing the value of its fossil fuel assets and using oil rents to break into fast-growing global green value chains, while also making its own national contribution to the climate goals of the Paris Agreement. The objective is to find policy pathways to pull Nigeria out of the low-middle income trap and make growth more resilient to external shocks created by the global megatrends and the poli-crisis.

Not all policy issues could have been addressed in this paper. For example, social-distributional impact on households and the role of ecosystems' services are beyond the scope of this paper.

1.1. Nigeria and low-carbon transition

World Bank diagnostics found Nigeria the third most vulnerable country to low-carbon transition risk (Peszko et al, 2020). The transition risk index developed under the World Bank work on climate strategies for fossil fuel-dependent countries, positions Nigeria as one of the most exposed and the least resilient to the impacts of global decarbonization. The pathway to reduce vulnerability requires reducing exposure and enhancing resilience to low-carbon transition as represented by green arrow in figure 1.

Figure 1. Nigeria is one of the most vulnerable countries to low-carbon transition risk



Source: The World Bank

Nigeria has limited control over the sources of transition risk, which originates abroad. Net oil and gas importers have a natural strategic interest in reducing their commodity imports. Hence, they were first to develop a competitive advantage in modern, low-carbon technologies and business models. Nigeria's economy can be impacted by the green industrial policies in other countries (involving production subsidies for green industries and high effective carbon prices) and related trade policies such as domestic content requirements and/or carbon border adjustments mechanisms (tariff or non-tariff based). They can reduce global demand and prices for oil and potentially disrupt Nigeria's main source of export and government revenues. Furthermore, the trade-related policies could also interfere with Nigeria's diversification efforts. Carbon Border Adjustment Measures (CBAMs), would reduce export competitiveness of downstream refined and manufacturing products with high carbon content, unless Nigeria implements comparable domestic climate policies. Subsidies offered by China or the U.S. (Inflation Reduction Act) for mass production of green goods, such as renewable energy equipment, EVs or batteries, are pulling most profitable segments of these green technology value chains to these countries because of preferences offered to domestic producers and import protection. Later in this paper we discuss the mechanisms through which Nigeria could break into these green value chain with a combination of domestic policy reforms and international partnerships.

The strategic decision making of major oil and gas exporters is additionally complicated by the fact that the drivers of peak oil demand are deeply uncertain. Deep uncertainty means that it is impossible to assign or agree on exact probabilities on when and how major importers of oil and gas will permanently reduce global demand for hydrocarbons.

Transition risk manifests through actions not words. Several countries made nationally determined commitments to net-zero greenhouse gas emissions by 2050 or 2060. Although commitments and policy targets can be an important element of policy signaling and building expectations of investors, their political lifetime may be short. Long-term targets give rise to transition risk for oil and gas exporters only

if they are followed by immediate decarbonization policy actions on the ground. Action on the ground is already happening, as major global economies are competing heavily for their shares in rapidly growing markets for green technology, equipment, and related minerals. Yet thus far the consistent and strong market signal through carbon pricing comes from Eurozone. The demand for fossil fuels keeps growing, even though in 2023, green energy investments outpaced fossil fuel investments for the first time (IEA 2023). Uncertainty remains on how these trends unfold in the long term. Policy reversals are possible.

1.2. Interplay between transition risk and Nigeria's diversification

Like everyone else, Nigeria will eventually run of oil, but it is unlikely that it will run out of the proved reserves in the modeling period of 33 years. US EIA (2023) and OPEC (2024) concur with the Nigerian Upstream Petroleum Regulatory Commission (NUPRC 2024) estimates that Nigeria's total proved oil reserves are about 37 billion barrels, representing 2.1 percent of total world's oil reserves. This allows for 50-60 years of production at current annual production rates (Reserves-to-Production ratio). Current low levels of production, well below the Nigeria's OPEC product quota, are therefore constrained not by scarcity, but by security issues and related under-investments upstream and midstream.

For now, hydrocarbon revenues remain essential for fiscal and trade balances of Nigeria. Hydrocarbons represent almost 90 percent of the country's exports, most of which is derived from crude oil, gas (more than 10 percent) and small volumes of refined products. Among non-oil major foreign exchange earners chemical fertilizers, which are produced from petroleum gas, play a major role with around 3 percent of total exports, more than all agricultural products taken together. In the short term, an increase of foreign exchange inflows from hydrocarbon exports would strengthen the naira and improve the fiscal and external balances. According to the IMF a recent package of macro-fiscal policies implemented by FGN aims to restore macroeconomic stability, rein in inflation, and reduce pressures on the naira. Structural reforms try to ease trade barriers, strengthen the business environment, incentivize investments and job creation and support climate resilience.

The dependency on oil revenues is a well-recognized source of systemic risk, but it is less recognized that this risk will be augmented by the global low carbon transition. When oil demand sets off for structural decline, the higher cost and more carbon-intensive oil producers, like Nigeria, will face mounting challenges with access to markets and finance in the environment of more erratic market and more volatile prices. Nigeria's oil companies are not well prepared to navigate such future. As a result, future economic rents and financial revenues from national oil reserves may be lower and more volatile than currently expected. Some of the Nigeria's otherwise valuable oil assets may have to be abandoned and stranded. As global energy transition gathers momentum the diversification beyond oil becomes more urgent (IMF 2024).

The success of diversification beyond oil and gas is usually measured by the extent to which countries "domesticate" more value by processing crude commodities at home and exporting hydrocarbon-derived products. Traditional diversification replaces revenues from export of crude hydrocarbon commodities with export revenues from downstream manufacturing such as refining, processing, petrochemicals that use oil and gas as inputs. This is how oil producers such as Norway, Australia, Canada, Netherlands, the U.S. or more recently Malaysia, Thailand, Vietnam, Indonesia, UEA, Saudi Arabia and Qatar escaped the lower-middle income trap, although the success is still fragile for some emerging

economies (Ross 2019; Sayeed, Desha, Goonetilleke 2023; Kularatne, Miyajima, and Muir 2024). In several industrialized economies such diversification was one of the key sources of primary accumulation of capital, skills, and increased productivity.

Diversification is likely to significantly increase Nigeria's carbon emissions, and this is not included in the baseline emissions of the most recent Nigeria's NDC. Until recently Nigeria has exported most of its oil as crude and imported most of its petroleum products. Therefore, carbon emissions from downstream operations were recorded in the inventories of the countries, where petrol, diesel and other petrochemicals were produced. Import substitution by domestic refined and petrochemical products will also domesticate these emissions. As a result, the emissions from Nigerian manufacturing sector will increase. Dangote refinery and petrochemical complex alone will emit about 12 Mt of CO_2e per year according to environmental impact assessment. For comparison, total industrial emissions in 2018 were about 18 Mt according to Nigeria's NDC, or around 5 per cent of total emissions. In the NDC this share was expected to stay constant in the baseline until 2030, as if Dangote was not planned.

Higher carbon footprint of traditional diversification will increase Nigeria's exposure to low-carbon transition risk. Trade policies, such as carbon border adjustment measures (CBAM) are already implemented in EU, with the phase-in period until 2035. Different forms of CBAM are also included in draft bills in US, Canada, Australia and Japan (World Bank 2024). These instruments are designed to protect domestic clean emission-intensive and trade-exposed (EITE) industries from unfair competition from foreign "dirty" producers. They also aim to prevent emissions' leakage abroad. Should Nigeria introduces carbon prices that are at similar level as in its export markets, CBAM will not apply to Nigerian exporters If Nigeria continues business as usual climate policies, or even relapse petrol subsidies (negative carbon taxes), CBAMs will restrict access to foreign markets for its carbon intensive manufacturing products. Some of downstream manufacturing assets will lose international competitiveness and may become stranded.

Domestic carbon pricing will also increase after-tax profits in traditional, emission-intensive industries, but will create stronger incentives for efficiency and leave revenues in national budgets. Domestic carbon prices would have a broader price base than CBAM, as they would cover all sales, as opposed to only export sales of domestic industries. Therefore, the impact of carbon pricing on costs of Nigeria's polluters will be larger than of CBAM for any tax rate. But because of the broader base, the incentives for industrial firms to modernize technologies, change product mix and reduce emission intensity would be stronger. Furthermore, with domestic carbon prices, tax revenues will go to the national budget, rather than being collected by foreign importers of Nigerian products. Nigeria's federal and state governments can use these revenues to alleviate social difficulties of green transition, build more infrastructure or help Nigerian industry modernize, increase productivity, employ more people and pay them higher wages. On the other hand, it needs to be paperd that domestic carbon pricing and removal of fossil fuel subsidies would decrease domestic oil consumption thereby increasing exports of crude oil and gas. This could amplify the exposure of the Nigeria's economy to oil price shocks (Almutairi et al 2024).

Reducing vulnerability to transition risk requires leapfrogging to diversification beyond the oil and gas value chain (figure 3). The rents and profits extracted from economic activities within the oil and gas value chain can be redirected to investments in new skills, capabilities and assets that are paper exposed to transition risks. This could unlock innovation and adaptation of new, cleaner and greener technologies and help Nigerian entrepreneurs achieve international competitive advantage in new products and business models, for which the market is likely to grow in the global low-carbon transition. The major challenge is

however, that other countries have already revealed their comparative advantage in these products and increasingly protect their producers from international competition. Breaking into the global green technology value chains will require extra effort and enabling international cooperation around trade, investments and technology transfer.

Nigeria's NDC includes several policy targets, but few details on policy instruments and market reforms to achieve them. Low tariffs are mentioned as a problem in the electricity sector and gas flaring in upstream oil operations. NDC includes several specific targets that should be achieved in different sectors and technologies that should be deployed. It stops, however, short of committing to energy price or any other regulatory reforms to change market incentives for Nigerian firms and households. Such market signals are necessary, though not sufficient, conditions to change their behavior and deliver NDC targets. No policy reforms are listed as unconditional or conditional mitigation contributions. Diversification is mentioned among the fundamental macroeconomic objectives but without consideration that it can increase baseline emissions. This may pose a challenge for implementability of Nigerian NDC, which halved baseline emissions in 2021 NDC compared to the first 2015 NDC.

National Fiscal Policy opens opportunities to send market signals for more productive and resilient diversification and private sector-led growth. In August 2024, the Presidential Committee on Fiscal Policy and Tax Reforms[3] published draft of the National Fiscal Policy, based on the set of guiding principles including primacy of national interest[4]. Its core objectives are to improve fiscal sustainability, stimulate productivity, support investments, provide infrastructure and reduce poverty. Taxes on investment or production will be reduced in favor of taxes on returns, income and consumption. New taxes or increases of tax rates will be guided by the principle of revenue neutrality (World Bank 2023, IMF May 2024).

National fiscal policy contains several tax reforms with potentially large impact on climate mitigation outcomes although they are not included in Nigeria's NDC. Among them, petrol subsidy was already removed in 2023 but is now facing the risk of policy reversal. Broadening the VAT base to include petroleum products and increasing uniform rate to 15 percent is not mentioned explicitly but aligned with the National Fiscal Policy preference for indirect taxes over direct taxes on income. Importantly, Nigeria's fiscal strategy explicitly calls the FGN to *design and implement a carbon tax regime to deter activities that harm the environment…*". The Nigeria's Climate Change Act of 2021 mandated cooperation between the National Council on Climate Change and the Nigerian Federal Inland Revenue Service to develop and implement a carbon tax system for Nigeria. The concept of carbon tax was initially explored by the NCCCS and its international and domestic partners, as well as the Federal Ministry of Environment with UNFCCC Secretariat. According to several sources, carbon tax is also embedded in the Nigeria's Energy Transition Plan.

Tax reforms simulated here are also aligned with the National Fiscal Policy principle to use taxation as a tool for economic diversification (section 2.6). The uses of revenues from fiscal savings of petrol subsidy removal, increased rates of VAT and carbon tax to reduce income taxes, strengthen social safety nets and to invest in innovation and productivity improvement, simulated in this study, is strongly aligned with this principle. Section 2.5.5 of the National Fiscal Policy stipulates that increases in indirect tax rates should be

[3] https://fiscalreforms.ng/ accessed on June 13, 2024
[4] https://fiscalreforms.ng/index.php/guiding-principles/ accessed on June 13, 2024

accompanied with the decrease of the direct taxes and section 2.5.1 stipulates that that tax system should promote productivity and innovation. Furthermore, reform options are aligned with section 3.1.1 on spending policy which stress principles of productive spending and sustainability.

This paper for the first time quantifies the impacts of the planned fiscal and innovation policies on Nigeria's diversification and emissions. Phasing out of the explicit subsidy on petrol and the implicit fossil fuel subsidy, such as the VAT waiver on petroleum products, would correct market incentives that currently lock Nigerian economy in the brown diversification exposed to transition risk. Excise taxes on carbon content of fuels would further correct market failures and further strengthen incentives for green innovation across sectors. Besides correcting perverse incentives, these fiscal reforms would also enhance capabilities to pursue green industrial polies in the country in at least two ways. First, by enhancing fiscal space to address possible social impacts of the green structural transition, and second by facilitating external wholesale financial and technology transfers in return for the quantified global public good created by these reforms. Therefore, in section 6, this paper analyses a few promising opportunities for Nigeria's climate diplomacy, such as results-based climate finance (RBCP) for policy reforms and green trade and investment/technology agreements.

2. The model

The focus on the diversification agenda and transition risk management requested by the FGN authorities determined the analytical tools selected by the team. The global computable general equilibrium (CGE) model ENVISAGE (Van der Mensbrugghe 2024), was selected as state of the art for this purpose. It allows for detailed representation of Nigeria's economic structure as well as fiscal flows between the government and economic actors, labor, capital and energy flows across sectors, as well as trade and financial flows with other countries.

2.1. Features

The latest version of the ENVISAGE model was used to support the findings in this study. ENVISAGE—originally developed at the World Bank—is a global and recursive dynamic computable general equilibrium (CGE) model (van der Mensbrugghe 2024). The model is calibrated to the latest release of the Global Trade Analysis Project (GTAP) Power Data Base, V11, which has a 2017 reference year (Aguiar et al. 2023 and Chepeliev 2023). ENVISAGE follows the circular flow of an economy paradigm. Firms purchase input factors (for example labor and capital) to produce goods and services. Households receive the factor income and in turn demand the goods and services produced by firms. Equality of supply and demand determines equilibrium prices for factors, goods and services. The model is solved as a sequence of comparative static equilibria where the factors of production are linked between time periods with accumulation expressions. Production is implemented as a series of nested constant-elasticity-of-substitution (CES) functions the aim of which is to capture the substitutability across all inputs. The modular setup of the model allows to turn on and off different modules of the framework depending on the purpose of the simulations.

For the purposes of the current study, the most recent version of ENVISAGE (v10.4) was calibrated specially for Nigeria (ENVISAGE-NGA). The key model features are:

- Recursive-dynamic with modeling horizon till 2050 and beyond
- Global: 160 regions, of which 141 are individual countries including Nigeria with a 2017 social accounting matrix (SAM)
- National economy represented by 76 interlinked sectors (aggregated to most relevant 20 for papering purposes)
- Calibration to the detailed IEA energy balances
- Four fossil fuels and seven electricity generation technologies
- Detailed multilateral trade flows based on the GTAP 11 database.
- Greenhouse gas (GHG) emissions (energy and process related)[5]
- Quasi-endogenous national R&D sector (R&D investments increase labor productivity with a lag over time, representing a growing stock of knowledge) (first introduced by Peszko, van der Mensbrugghe, Golub 2020)
- Endogenous global oil, gas and coal extraction module calibrated to Rystad database of oil and gas reserves, extraction volumes and cost curves by country. (Peszko et al 2020)
- Simulates impacts of exogenous fiscal, energy, industrial, climate, and trade policies.

The main strength of the CGE modelling framework, like ENVISAGE, is the detailed and consistent representation of the inter-dependencies between different sectors, agents and markets in the national and global economy. By capturing both the supply and demand sides, the model represents adjustments in quantities and prices following the implementation of policy shock. For instance, if carbon pricing is implemented in the model, this leads to increasing prices of energy, reducing energy supply and demand, as well as corresponding shifts in the energy supply and trade mix, with increasing share of the low-carbon technologies and potential leakage of emissions abroad.

2.2. Sectors

The 76 activities (sectors) in the GTAPV11 Power database are aggregated into 20 activities, of which 8 are various power activities (table 2). The number of commodities reduces to 13 as the electricity activities produce a single electricity commodity. To capture geoeconomics of low carbon transition, the 161 regions in the GTAPV11 Power database are aggregated into 24 countries/regions, with Nigeria and its key trading partners being represented as individual countries. For scenario simulations these countries and regions are assumed to form alternative alliances behaving differently with respect to a hypothetical climate club. Table 2 provides the activities papered by the model and their super-aggregation into broader categories for most policy papering purposes.

Table 1. Aggregated activities represented in the model

No.	Aggregated activities represented in the model	Super aggregates
1	Grains and crops	Agriculture
2	Livestock and meat products	
3	Coal	Other extractives

[5]The model calculates CO_2 emissions from fossil fuel combustion and industrial processes reduced and avoided against BAU. Other gases and sources are beyond the scope of this analysis.

4	Oil	Oil and gas
5	Gas	
6	Other extraction	Other extractives
7	Other manufacturing	Other manufacturing
8	Heavy manufacturing (emission-intensive sectors in oil and gas value chain)	Heavy manufacturing
9	Refined oil	
10	Electricity transmission and distribution	Services
11	Coal-fired electricity	
12	Gas- and oil-fired electricity	
13	Nuclear electricity	
14	Hydro-electricity	
15	Solar electricity	
16	Wind electricity	
17	Other renewable electricity	
18	Construction	
19	Transport	
20	Other services	

2.3. Model tailored to explore transition risk management

The impacts of climate change on the Nigerian economy are not calculated. The ENVISAGE-NGA model is not an integrated assessment model by choice. First, the focus of this study is on decision making regarding structural change for low-carbon transition under deep uncertainty about mitigation actions of other countries. Second, uncertainty of the climate models and economic damage functions at national level is also deep. According to the IPCC the direct impacts of climate change would be relatively small within scenarios with a 2050 horizon. Temperature differences would probably not exceed 0.3C-0.5C in this period. So, the damages of the slow, onset climate change (such as sea level rise) will not reach their peak levels, while frequency and intensity of extreme weather events in Nigeria are deeply uncertain. The results of two overlapping deep uncertainties (physical and transition) would be difficult to understand. Third, the way many macroeconomic aggregates—especially GDP—are calculated would not capture the impact of climate induced extreme weather events properly anyway. When the house burns or is flooded, the GDP grows as a result, because fire brigade is paid to extinguish it, and following market transactions lead to construction of a new house, purchases of new appliances etc. Nonetheless, physical impacts of warmer climate can be imputed from these simulations in a way that is useful for Nigeria's decision problem. There are two scenarios with 'HOT' notations where the global climate club is too small to keep climate change in safe boundaries of 1.5-2 degrees below preindustrial times. In these scenarios GDP and welfare of Nigeria is likely to experience physical impact risks. These risks are explored in other studies on climate risks and adaptation for Nigeria (sources). This paper helps understand how Nigeria's policies and climate diplomacy can mitigate them by contributing to cooperative climate mitigation actions.

3. Scenarios

3.1. Scenario strategy

The scenarios have been designed to mimic uncertainties about global geoeconomics of low-carbon transition. These scenarios are neither predictions of the future, nor *a priori* recommendations for Nigeria. The objective of the scenario strategy is to explore different plausible stylized futures of how transition away from fossil fuels could unfold. The goal is to inform Nigeria's decision makers on the consequences of their policy choices amid uncertainty about when and how others will implement their low-carbon policies. Equipped with these insights Nigeria's climate diplomacy will be more strategically prepared to possible surprises and ways to hedge country's bets. Policy makers can then flexibly adjust their current tactics depending on external geoeconomic and geo-political developments. This approach builds on the previous Bank Experience with such analyses for large oil and gas producers (Peszko et al 2020, Peszko et al, 2021, Makarov et al. 2021), and on the literature on climate clubs, including Ostrom (2009), Ederington (2010), Gelves (2012), MacKay, et al. (2015), Nordhaus (2015, 2021a, 2021b), McGinty, Milan, Cramton et al (2017); Kuhn, Pestow, Zenker (2017 Mercure et al. (2018, 2021). It adapts and extends the emerging conceptual work by the Network for Greening the Financial Systems (NGFS) on the short-term climate scenarios. The scenarios strategy was agreed with Nigeria's National Council on Climate Change Secretariat (NCCCS), and the senior officials of the Ministry of Environment and the Ministry of Budget and Economic Planning, the Ministry of Environment, and the Presidential Energy Transition team.

The effectiveness of the Paris Agreement hinges on the willingness of the parties to cooperate in their individual self-interest. In the absence of a global government, an effective climate agreement must be self-enforcing (Barrett 2001; Botteon and Carraro 2001; Eyckmans and Finus 2007; Bosello, Buchner, Carraro 2003; Carraro, Eyckmans, Finus 2006). This is embedded in the architecture of the Paris Agreement, where all contributions can only be determined nationally. There are no top-down enforcement mechanisms, except moral suasion and peer pressure. MacKay, et al. (2015) likened it to the highway where each driver independently determines her/his own speed limit. Thus, a successful global decarbonization under the Paris Agreement must be initiated by a club of primary movers who act in their own interest (climate club).

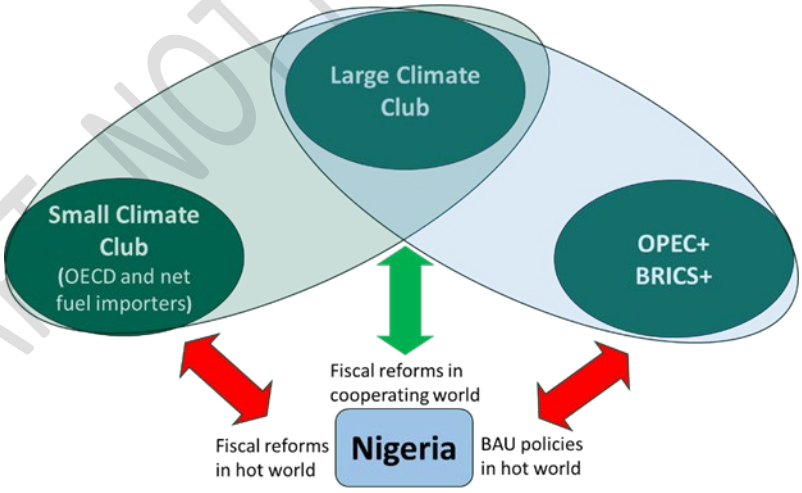
Once created, the climate club must grow to increase its market and geopolitical gravitational pull. The members must have sufficient incentives to stay in the club, and non-members to join. Motivations may differ among the parties but each of them will transition away from fossil fuels only if it is in its own perceived self-interest, under external and internal conditions. Therefore, if the leaders of the club are serious about the goals of the Paris Agreement, they need to go beyond long-term virtue signaling, such as committing the next generation to net zero carbon emissions targets. They need to offer convincing incentives for current generations in hesitating countries to accelerate their decarbonization in their own self-interest, shaped by each unique initial conditions, path-dependency, and capabilities. Recent history shows that dependency on production and exports of fossil fuels is a better predictor of countries' self interest in green transition than the income level (Peszko at all 2020). Climate action leaders such as Beyond Oil and Gas Alliance, or High Ambition Coalition include several low-income countries, while large exporters of oil and gas are rare and not quite active.

In different scenarios the rest of the world is assumed to form alternative hypothetical climate alliances based on their alternative strategic geoeconomic choices with respect to transition away from fossil fuels (figure 5):

1. **Small climate club (SCC)** consisting of the OECD+ countries (OECD members and several middle-, and low-income countries that are net importers of oil and gas). The SCC countries are united by common long-term economic interests in reducing their dependency on oil and gas imports and pursuing green industrial policies as a key driver of their future comparative advantage. Some SCC hypothetical members are large producers and even net exporters of oil and gas (such as the U.S., Canada, Norway, Australia, or the UK), but nonetheless modern and greener technologies are by far the larger strategic growth driver for these countries than oil and gas extraction. In some scenarios SCC accelerates decarbonization policies alone as primary movers.
2. **Large climate club (LCC)** is formed in some scenarios when China, India, Brazil and South Africa (original BRICS minus Russia) align their green industrial strategies and domestic climate policy instruments with the Small Climate Club.
3. **OPEC+ countries** are assumed (for the illustrative purpose of this analysis) to delay their transition away from fossil fuels. As discussed earlier, whether they successfully diversify or not, fuel extraction and downstream value chains represent the key foreign exchange revenues for their economies, comparative strength in the global division of labor and a "comfort zone" in terms of familiar skills, networks, and institutions

In these scenarios Nigeria despite being an OPEC+ member is assumed to make independent alternative strategic policy choices (figure 5). In some scenarios Nigeria is assumed to align with SCC or with LCC when pursuing ambitious diversification policies with climate mitigation outcomes. In other scenarios Nigeria delays its green transformation policies together with OPEC+ and BRICS+ and doubles down on traditional "brown" diversification.

Figure 2. Nigeria's fiscal reforms amid alternative climate policy alliances



Three exploratory narratives about the future of low-carbon transition were developed and vetted through multistakeholder consultations with Nigerian government counterparts.[6] These narratives were found most relevant for Nigeria's strategic decision problem. Three hypothetical but plausible futures represent possible stylized developments of the geo-economics of climate and green industrial policies. Together, they lay out a navigational map for Nigerian decision makers to inform their own strategic

[6] More scenarios were simulated with the model, including alternative Carbon Border Adjustment Measures (CBAM) and other trade measures, but were not selected for detailed discussion in this paper.

choices how to best navigate external low-carbon transition with domestic policy reforms. The narratives are turned into model scenarios by assumptions about specific policy instruments applied by different countries at specific dates (Table 3).

Table 2. Three narratives for possible Nigeria's interactions with external low-carbon transition.

Global narratives	Climate clubs	Nigeria
Highway to Paris through Large Climate Club (LCC)	OECD countries, China, India, Brazil and South Africa pursue green industrial policies. Despite competition for market shares in green technologies and climate action minerals, the green and knowledge-intensive economic development implies an accelerated domestic transition away from fossil fuels. Geoeconomic strategic interests in scaling up green economy prevails over other geopolitical tensions between superpowers and leads to the formation of the Large Climate Club with overwhelming market power. To enhance stability of LCC, its members, individually or multilaterally offer incentives for other countries to join in the form of result-based climate payments (RBCP) for mitigation outcomes of ambitious green policy reforms, complemented by green trade agreements (GTA), and investment and technology transfers. This makes transition away from fossil fuels economically attractive, equitable and just, especially for countries dependent on exports of oil and gas. LCC also announces that it will apply tariff and non-tariff carbon border adjustment mechanisms (CBAM) to protect their emission-intensive and trade-exposed (EITE) firms against unfair competition from "pollution havens" and emission leakage. Facing a combination of "carrots" and "sticks" from the LCC with large market power, the OPEC+ countries gradually align the level of ambition of their green diversification policies with the policy ambitions of LCC.	(I) Nigeria does not risk trade tensions with such a large economic bloc like LCC and seeks bilateral agreements (including RBCP and GTA) for climate mitigation outcomes of its ambitious policy reforms towards green diversification. These cooperative agreements help address social, economic, and financial frictions of its transition to green and resilient economic growth and social development driven by productive and low-carbon economic activities outside the comfort zone of the oil and gas value chains.
Diverging priorities between Small Climate Club (SCC) and ROW	Geopolitical tensions between OECD+ and BRICS+ prevail over common geoeconomic interests around green transition. Political conflicts and competition for market shares in green industries and climate action minerals deepen mutual mistrust and rivalry. A small Climate Club (SCC) consisting of OECD+ countries introduce ambitious climate policies and reduces consumption of fossil fuels but fails to incentivize similar low-carbon transition away from fossil fuels by BRICS+ and OPEC+. LCC is not formed. BRICS+ countries do not subsidize fossil fuels, continues its green industrial policy in certain niches (especially China), but do not ramp-up carbon prices beyond BAU. OPEC+ continues BAU policies. Facing large market power of the rest of the world, the SCC does not apply CBAM on its borders increasing exposure its EITE industries and risk of emission leakage.	(II) Nigeria aligns its policies with SCC, pursues green diversification policies and leverages RBCP and GTA. (III) Nigeria sides with BRICS+ and OPEC+, maintains 2017 policy status quo, foregoes RBCP and does not face CBAM from SCC.

This approach of policy-driven simulations follows Peszko et al (2020) and differs from most of the climate mitigation modeling literature. Most macroeconomic models are used to "backcast" the impacts of specific 'policy outcomes', such as specific emission quota, applied in the models as exogenous future constraints. The model typically *optimizes* the technology pathways to meet such constraints at least cost. In this analysis, the model is applied in *simulation mode* and calculates emissions endogenously as climate mitigation outcomes of specific policy instruments applied in different scenarios, assuming that they are

applied and enforced. The analytical approach used in this study better mimics uncertainty about the future climate action of different countries. It was introduced and successfully tested in a series of the World Bank analytical and advisory services for climate strategies of countries dependent on fossil fuels. More recently this approach was also adopted on experimental basis by the Network for Greening the Financial System through the Conceptual Paper on Short-Term Climate Scenarios published in October 2023 (NGFS 2023). It is a more policy relevant way of modeling alternative national strategies in the real and uncertain world, in which there is no external global authority with powers to impose specific constraints on individual countries. All contributions must be nationally determined and voluntarily implemented.

3.2. Nigeria's policy instruments simulated in policy reform scenarios.

The fiscal reforms that are inputs to scenarios have either been recently implemented or are part of the Nigeria's own development and fiscal strategy. Most notably they align with (1) Nigeria's Medium Term Economic Framework (MTEF) which outlines reforms to improve domestic revenue mobilization and diversify the economy; (2) revenue mobilization strategy included in the National Fiscal Policy, and (3) National Climate Change Act of 2021. The alignment with NDC is discussed in section 2. The scenarios' design was vetted by the agencies of the Federal Government of Nigeria during consultations in the week of March 18, 2024.

Phasing out of the petrol (Premium Motor Spirit (PMS) subsidy. Nigeria has already implemented some fiscal reforms with climate mitigation outcomes. In 2004 direct diesel subsidies were eliminated. In 2023 direct petrol (PMS) subsidies were removed after the first failed attempt in 2012. The petrol subsidy made domestic oil refining unprofitable and pushed the largest oil producer in Africa to export crude oil and import all petrol used in the country at unsustainable costs to the national budget. Instead of supporting the Nigerian poor and domestic infrastructure, the scarce public funds went to support foreign producers. Low consumer prices triggered massive inefficient use of petrol (for example for off-grid electricity generation), shortages of petrol for cars, long lines at the pumps and a massive black market for petrol, including smuggling to neighboring countries. Following subsidy removal in 2023, prices originally tripled, queues for petrol disappeared, and the government, with support of Nigeria's development partners redirected fiscal transfers from encouraging wasteful use of petrol to boosting incomes of the poorest households and strengthening social safety nets (including a World Bank $US800 million loan to help cushion the impact of high fuel prices after ending a petrol subsidy). A risk of return of the petrol subsidy is high. The enforcement and maintenance, of the petrol subsidy removal proved to be challenging. Years of artificially low petrol prices made poor people dependent on often wasteful use of petrol (for example in small household power generators). It created a sense of entitlement to low prices, while powerful interest groups that grew around shadow petrol economy also resist change. The IMF (2024) argues that adequate compensatory measures for the poor were not scaled up in a timely manner and subsequently paused over corruption concerns. On top of that high inflation and freefalling Naira depreciation in late 2023 and early 2024 led fuel prices to more than triple from N197 to between N620 and N700 per liter, fanning inflation and protests. This prompted authorities to begin capping fuel pump prices below cost, reintroducing implicit subsidies in place of the explicit subsidies (fiscal transfers) from before the reform. The national monopoly importer and distributor of fuels (NNPCL) was papered to maintain the price of

petrol below N700 per liter despite an increase of an import cost to about N1,000 or higher, implicitly subsidizing the product for Nigerian consumers. The IMF (2024) estimated that the implicit subsidy will consume almost half of the oil revenues and cost Africa's largest crude producer almost 3 percent of GDP, up from 1 percent in 2023 and higher than 2.2 percent during pre-subsidy removal period (IMF May 2024). According to some estimates the IMF forecasts are similar to the Bank of America's, which projects it could cost Nigeria between $7 billion and $10 billion in 2024 if it imports between 18 and 25 billion liters of gasoline (Orjinmo, Osae-Brown 2024).

An increase in the value-added tax (VAT) rate, from 7.5 percent to 10 percent in 2025 and 15 percent in 2026, and broadening the tax base are planned by the Nigerian fiscal authorities to address low domestic revenue mobilization (IMF 2024). According to the World Bank (2023) one of the key distortions that narrows the VAT base is the exemption of petroleum products, which is another implicit consumer subsidy of these products, with incentives for wasteful use of fuels and excessive GHG emissions. The broadening of the VAT base to petroleum products and a uniform rate increase to 15 percent is implemented in scenarios with annotation 'VAT' or 'FISC' as an increase in sales taxes for households compared to the BAU.

Carbon pricing in the model is a proxy for economy-wide climate policies. It is implemented as an increase of excise taxes on fuels imported and produced domestically levied at the point of fossil fuels combustion by intermediate and final users (e.g., use of petroleum in private vehicles or use of natural gas in power plants). The carbon tax is not explicitly included in the government fiscal strategy but is in principle consistent with the strategy to broaden the base of excise taxes, especially on products that are harmful to health.

Carbon border adjustment mechanism (CBAM) is implemented by climate club members in selected scenarios (HOT_NG+BRICS and HOT_T-NG+BRICS) as an excise tax on imports based on the carbon content of imported commodities and using the difference in the carbon price of importer and exporter. In the cases when the exporting country has "0" carbon price, the full level of the importer's carbon price is used to estimate the corresponding excise tax. The CBAM rate is calculated taking into account the entire value chain emission intensity, i.e., Scope 1, Scope 2 and Scope 3 emissions.

Results Based Climate Payments (RBCP) for Policy Reform are implemented as payments from other countries for mitigation outcomes of the petrol subsidy removal and implementation of a carbon tax. RBCP is implemented in scenarios with annotation 'RBCP' as multiplication of the CO2 price of 10 US$ per ton multiplied by the mitigation outcome of specific policy reform. The RBCP price (10US$/tCO2) is rather conservative and corresponds to the prices that can be observed on voluntary carbon markets. This is much lower price than the level of the carbon tax applied in Nigeria in the cooperative FISC scenarios. The mitigation outcome is the difference in emissions between the LCC scenario and the scenario where only the petrol subsidy is removed and the one where the petrol subsidy is removed together with an increase in the VAT and implementation of carbon tax beyond Nigeria's BAU policies (captured within the LCC scenario).

3.3. Scenario structure applied in ENVISAGE-NGA

All together fourteen policy scenarios (in addition to the BAU) were simulated with ENVISAGE-NGA with various permutations of policy instruments to operationalize narratives described in table 3. Six of them

and limited results were chosen to be presented in this policy paper to avoid information overload (Table 4). Full results and metrics were made available to the counterparts in the Nigeria Federal Government.

Table 3. Six scenarios presented in the policy paper

Scenario code	Narrative
LCC	LCC, consisting of all countries, except Nigeria emerges under the Paris Agreement and implements cooperative climate policies. Nigeria continues BAU policies without facing CBAM. This scenario aims to isolate the impact of ambitious climate action abroad on Nigeria's economy before its own policy reforms.
LCC_FISC-HH	LCC prevails. In scenarios with annotation "FISC" Nigeria implements fiscal reform, including (1) removal of petrol subsidy, (2) removal of VAT exemption for petroleum products, (3) general increase of VAT rate to 15%, and (4) carbon excise tax. The petrol subsidy removal is implemented as an elimination of the negative sales taxes on petroleum products that is present in the reference year of the GTAP 11 Data Base. Fossil fuel subsidies in the GTAP 11 Data Base are represented based on the IEA data following an approach developed in Chepeliev et al. (2018). Revenues from fiscal reforms are recycled to households by reducing personal income taxes (or increasing net transfers to households). No RBCP is received.
LCC_FISC_RBCP-HH	LCC prevails. Nigeria implements the same green fiscal reforms (FISC) but receives RBCP for the mitigation outcomes of petrol subsidy removal and carbon tax. Revenues are recycled to households through equivalent reduction of income tax revenues.
LCC_GREEN FISC_RBCP-RD	LCC prevails. Nigeria implements the same green fiscal reforms, receives RBCP, but recycles net revenue to investments in a notional R&D sector, increasing labor productivity across the economy with the empirically determined scale and lag.
HOT_NG+BRICS	Only SCC is created by advanced OECD countries with larger unilateral carbon prices than in LCC scenarios. Nigeria aligns its policies with BRICS+ and OPEC+ and thus continues domestic BAU fiscal policies. Global mean temperature increases beyond safe levels.
HOT_NG+SCC_RBCP-RD	Only SCC is created by advanced OECD countries as above. Nigeria aligns its policies with SCC, pursues fiscal reforms (FISC) and leverages RBCP. Global mean temperature increases beyond safe levels.

PAPERS: LCC=Large Climate Club; SCC=Small climate club; VAT= value added tax; RBCP=Results Based Climate Payments for policy reform as US$10 * climate mitigation outcomes of petrol subsidy phase out and carbon tax.

3.4. Business-as-Usual Scenario

The business-as-usual (thereafter BAU or baseline) scenario represents the most neutral assumption about the future evolution of Nigeria and other economies from the reference year of 2017 through 2050. The key drivers of the economies are anticipated population growth and growth of per capita GDP.

Assumptions from the International Monetary Fund, the World Bank and national authorities are used to drive the medium-term projections—typically through 2027—and longer-term projections are taken from the Socio-Economic Pathways (SSPs), which have been developed by the Integrated Assessment Modeling community for assessing the long-term economic trends in the context of climate change. For the purposes of this study, the so-called middle-of-the-road scenario (SSP2), was used. GDP growth assumptions for Nigeria applied in this study are well-aligned with the long-term growth trajectories implemented in the modeling of Nigeria's Long-Term Low-Carbon Development Strategy (NCCCS 2023). Labor productivity is calibrated to the exogenous GDP pathway in the reference simulation, subject as well to the assumption on R&D expenditure. Other adjustments also occur in the baseline. The average propensity to save is calibrated under the assumption that the return to capital remains in a relatively narrow band. The baseline also assumes several structural shifts to the energy sector—independent of the structural changes driven by changes in relative prices and final demand. These include increasing electrification of selected agents, an increasing share of renewables in the power sector, and declining costs in the production of renewables. In addition, the reference scenario incorporates so-called 'servitization', which allows for an increasing share of services in the cost structure of production.

To account for the ongoing development of the Dangote complex, domestic petroleum products output was increased in the baseline scenario by the planned capacity and the imports of oil products was reduced by the same amount. As a result, by 2030 over 80 percent of all oil products consumed domestically in the BAU is supplied by domestic refining. This share increases to around 87% in 2050.

The baseline scenario includes assumptions about evolution of climate and green industrial policies abroad. ENVISAGE can simulate different designs of explicit and implicit carbon prices. The macroeconomic and sectoral impacts of carbon taxes and prices generated by emission trading systems are similar, however. Therefore, in this study a carbon tax rate and coverage represent the level of ambition of national climate policies. A carbon price is levied in China, Western Europe, Canada, the U.S. and other high-income fossil-fuel importers. China begins with a small carbon tax of $7.8 in 2021 rising to $62 by 2050. For the U.S., the range is $7.8 in 2021 rising to $124 by 2050. In the other three regions, the carbon price starts from $35 in 2021 and rises to $124 in 2050. In the baseline, the carbon price is only imposed on the EU ETS sectors, i.e., carbon-intensive manufacturing, including oil refineries, and power generation. Furthermore, China and the U.S. maintains subsidies to the production and consumption of renewable energy and their domestic intermediate inputs to mimic existing industrial policies, such as IRA. In policy reform scenarios, the rates of baseline fiscal instruments are increased and new instruments are assumed to be implemented. For example, higher and broader carbon taxes or fuel subsidy removals are assumed based on FGN plans or considered options.

Sectoral labor productivity is an important policy variable in this study. In the CGE models, labor productivity is calculated by the model in the baseline scenario to match assumed exogenous GDP trends. In the policy reform scenarios, the reverse is the case. Productivity becomes exogenous and is held fixed at the baseline level, while GDP and other macro-variables are endogenously calculated by the model for different fiscal, economic and trade policy shocks. It implies that any exogenous productivity changes from the baseline will have an additional impact on GDP in policy reform scenarios. In the scenarios with 'RD' annotations the labor productivity is exogenously gradually increased relative to the baseline scenario in proportion to resources invested in innovation, technology adoption and human capital (education), with the empirically estimated time lag. This mimics the high-level impact of innovation and education policy measures that would improve productivity across Nigerian economy.

Not all likely impacts of the BAU could be captured by the model. The BAU, and policy scenarios without fiscal reforms, do not capture the adverse impact of systemic social and macro-fiscal imbalances of not implementing these reforms, such as inflation and forex volatility, poor investment climate, infrastructure backlog, poverty, inequality, social unrest, insecurity, or oil theft (IMF 2023, World Bank 2024). The BAU scenarios in CGE models are calibrated to the exogenous assumptions about GDP growth, which in this case were validated by Nigeria's government representatives[7]. The BAU scenario should be therefore considered a highly vulnerable, unstable and risky scenario, while domestic green fiscal policy with support from Nigeria's partners in the global cooperative action on green economic transition is a more robust development strategy. Robust means that it would make Nigerian economy more resilient to external risks, more stable and investment friendly, increasing the odds of a permanent breaking away from the lower-middle income trap.

4. Simulation Results

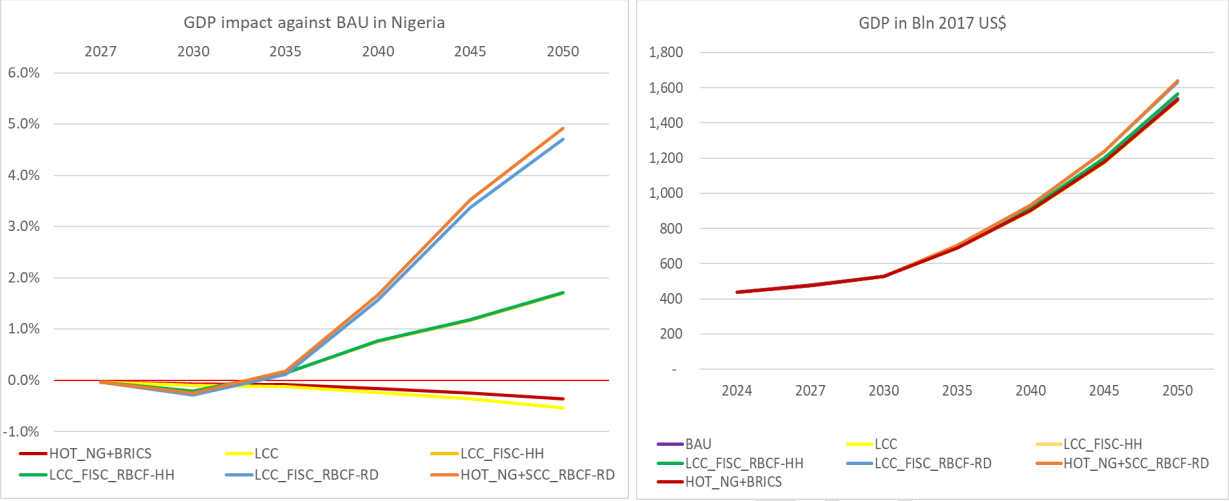
4.1. GDP

No matter how large the global climate club would be, domestic green fiscal policies can help Nigeria escape lower-middle income trap (figure 6). The BAU involves petrifying existing extractive economic structure with low productivity. Even if Nigeria does change its domestic policies, climate policies abroad, whether implemented by large or small climate club will have a detrimental impact on Nigeria's GDP mainly because of the reduction of export demand and prices for oil. But three scenarios of global low-carbon transition are consistent with Nigeria's aspirations towards higher income status. Their common feature is the comprehensive green fiscal reform consisting of the removal of the petrol subsidy, increase of the VAT rate to 15 percent for all products (including petroleum products which are currently implicitly subsidized with full VAT exemption) and an excise tax on the carbon content in fuels.

The use of revenues matters. Two scenarios (LCC_FISC_RBCP-RD and HOT_NG+SCC_RBCP-RD) have particularly strong GDP multiplier effect because additional net fiscal space is used for investments in productivity enhancing industrial policy which fosters innovation and adoption of new technologies that increase labor productivity across the economy. Nigeria's GDP also grows faster than in the BAU when the revenues from the comprehensive green fiscal reform are transferred to households (LCC_FISC_RCBF-HH scenario), although the growth multiplier is lower than with productivity-driven investments.

[7] Ministry of Budget and Economic Planning and National Council on Climate Change Secretariat (NCCCS)

Figure 3. GDP impact against BAU (left panel) and in constant 2017 US$ (right panel)



The macroeconomic gains of investing additional fiscal revenue in productivity-enhancing innovation comes with delay but increases economic resilience. It can take about a decade for Nigeria to see the return on these investments to invigorate GDP growth above the BAU (which by construct cannot be observed). But these simulations indicate that doing nothing implies setting the country for a growth path that is vulnerable to the sovereign policy decisions of other countries, increasing volatility of the global oil market and the risks of climate-induced extreme weather events. Absence of domestic policy reforms increases the risk of long-term lock in lower-middle income trap.

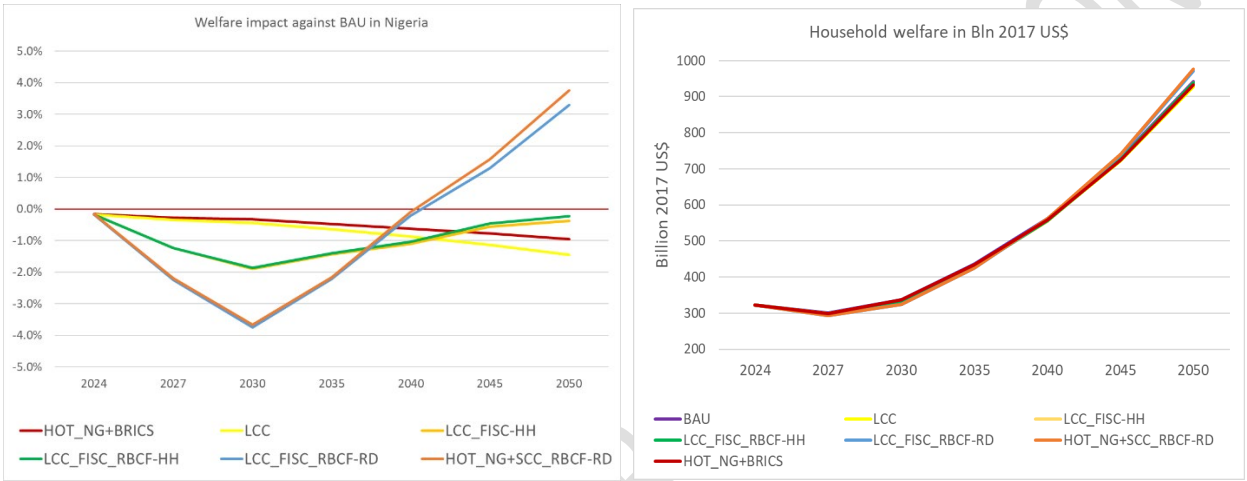
4.2. Welfare

Households' welfare eventually grows faster than in the BAU in the same green transition scenarios, albeit with a longer delay and deeper temporary dive than GDP[8]. There is medium-term (by around 2035) trade-off at the macro level between recycling revenue from green fiscal reform to households that benefits their immediate welfare at the expense of future growth and recycling these revenues to innovation and human capital development where households need to sacrifice their consumption during some period before receiving the income (GDP) benefits from higher savings/investments in the longer run. Therefore, the green transition can take a heavier temporary toll on disposable income and on consumption of households than on economic growth. This is visible both relative to the BAU and in constant dollars (left and right panel figure 7 respectively).

[8] This version of the model does not differentiate the impact by households' income. Social-distributional analysis is beyond the scope of this paper. Additional modeling would be needed with the microsimulation model linked to ENVISAGE.

The policy impact on welfare further stresses the importance of how revenues are recycled in the economy. Transferring additional net fiscal revenue to households (LCC_FISC_RCBF-HH scenario) would reduce the short-term adverse impact but forego the mid-to long term recovery of welfare above BAU. Investing in productivity (innovation and technology) in RD scenarios requires higher initial investments. Therefore, it creates higher welfare loss initially, but over time higher income boosts households' consumption well above BAU.

Figure 4. Impact on households' welfare as percentage difference from BAU (left panel) and in Billion 2017 US$ (right panel)



The temporary welfare cost of the green transition is an argument that Nigeria's climate diplomacy can use in seeking mutually beneficial partnerships with climate clubs. External support for Nigeria's green transition is particularly important to mitigate the social hardship related to it. Partnership agreements can include green trade, investment and technology agreements and a wholesale result-based climate finance (RBCP) for policy reforms that could be used to protect the most vulnerable and poor households and create new development opportunities for them. Additional sensitivity analysis conducted in this study suggests that financial transfers through RBCP alone will not be enough to ensure just transition. Paper that the RBCP price ($10/tCO2) chosen here is on the conservative side benchmarked to prices in voluntary carbon markets). Higher RBCP price assumptions might change this result. Options for more comprehensive agreements between Nigeria and climate clubs are discussed in the section on policy implications.

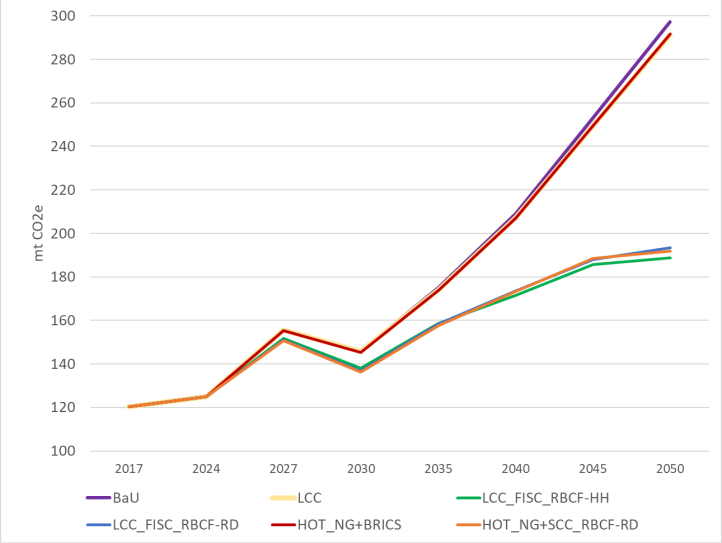
4.3. Climate mitigation outcomes

Climate policies in the rest of the world slightly reduce domestic carbon emissions in Nigeria even if a country continues BAU domestic policies (LCC and HOT_NG+BRICS scenarios). The difference with BAU emissions is however small and comes as a side effect of reducing overall domestic economic activity primarily induced by the lower export demand for Nigeria's exports of fossil fuels and energy-intensive manufacturing in the rest of the world as the latter decarbonizes.

Domestic green fiscal policy reforms would have significant climate mitigation outcomes without reducing economic activity. In the green fiscal reform scenarios emissions are 12-14 percent below BAU

in 2030 and 45 percent lower in 2050 (figure 8). A small positive emission reduction premium is associated with recycling some revenues to R&D rather than all to households. Comprehensive fiscal reform with revenue recycling to innovation and productivity enhancement can almost stabilize absolute volumes of emissions below 170 Mt per year by about 2045[9]. Additional major policy push for structural reforms and massive deployment of emission sequestration and retention measures, such as reforestation, would be necessary to reduce GHG emissions in absolute terms towards net zero in the future, as per some government announcements. The policies to stimulate negative emissions have not been simulated here.

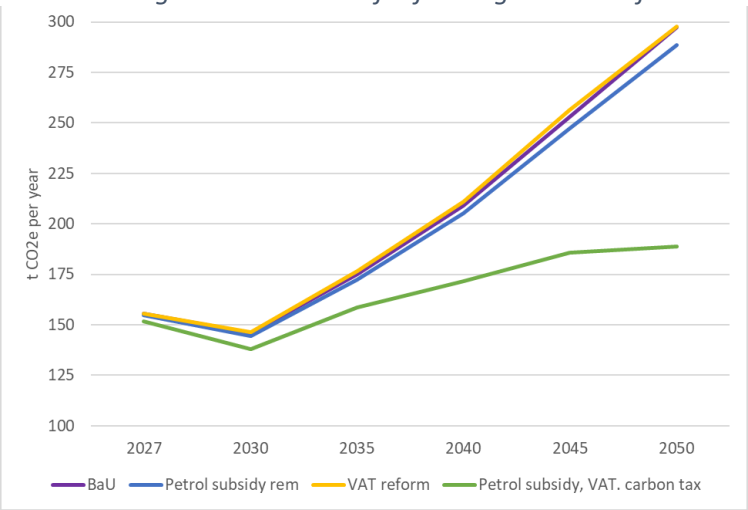
Figure 5. Nigeria's energy-related carbon dioxide emissions by scenario



Mitigation outcomes of comprehensive green fiscal reform dwarf emission reduction that could be achieved by removing petrol subsidy as stand-alone reforms. A c**arbon excise tax would have a decisive impact on stabilizing the CO_2 emissions trajectory in Nigeria** (figure 9)**.** Simulations of individual fiscal instruments conducted as part of this study are important for considering the scale of RBCP associated with quantifiable and monitorable mitigation outcomes of specific reforms.

[9] Caution when comparing these results to Nigerian NDC or Deep Decarbonization paper is recommended. CO_2 emissions both from fossil fuel combustion and industrial processes, but other GHGs, such as methane, nitrous oxide and F-gas emissions are not included in this version of the model. These gases account for significant amount of AFOLU, waste and fugitive oil and gas emissions. The CO_2 emissions/sequestration by land use, land -use change and forestry (LULUCF) are also not included.

Figure 6. Climate mitigation outcomes of reforming individual fiscal instruments



4.4. Result-based climate finance (RBCP)

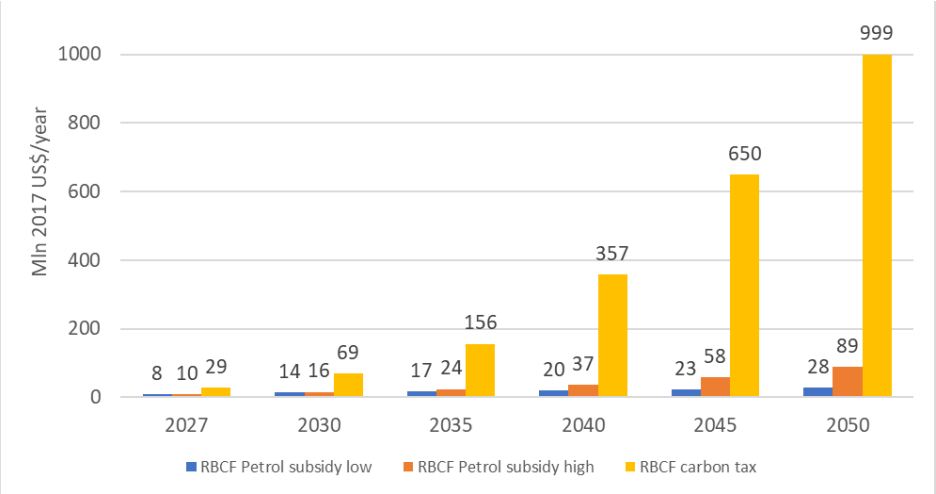
Potential revenue of result-based climate finance (RBCP) for emission reduction outcomes of green fiscal reforms could reach $38 million in 2027, $85 million in 2030 and over $1 billion in 2050. These potential revenues are calculated at 10 US$ per ton of CO_2e mitigated. The RBCP for mitigation outcomes of petrol subsidy removal alone would be relatively modest in 2027 – around $10 million against BAU. This is about three times less than the RBCP revenue that could be leveraged for climate mitigation outcomes of carbon tax—$29 million in 2027. In the longer run the revenues could be much larger (figure 10), especially if the carbon tax as proposed here is implemented, reaching in 2050 just over $1 billion, including $28-89 million for removal of the petrol subsidy and $999 million for mitigation outcomes derived from the carbon tax (11 times more that optimistic RBCP revenue for petrol subsidy removal).

Cumulatively the revenue of result-based climate payments (RBCPs) for emission reduction outcomes of green fiscal reforms could reach US$9.2 billion over 25 years, including US$459 million for the petrol subsidy removal and US$8.7 billion for the carbon tax (without discounting). US$38 million in 2027, US$85 million in 2030 and over US$1 billion in 2050. The RBCP for mitigation outcomes of petrol subsidy removal alone could begin from US$8-US$10 million per year in 2027 million, increasing to US$28-89 million in 2050. This is dwarfed by RBCPs for climate mitigation outcomes of carbon tax (US$29 million and US$999 million, or 3 and 5 percent of carbon tax revenue in 2027 and 2050 respectively). By 2050, joint revenue for these two fiscal reforms could reach over US$1 billion. The exact numbers will depend on the availability of RBCP supply and individually negotiated transactions.

Comprehensive VAT reform has two countervailing effects on CO_2 emissions. First, removal of the waiver for petroleum products reduces emissions and creates climate mitigation outcomes. Second, increasing the general VAT rate from 7.5 percent to 15 percent more than offsets this environmental outcome by increasing emissions due to increased level of economic activity. The transmission mechanism is the following: VAT increases consumer prices and reduces final consumption. Consuming less, people save more and increase investment rate. Higher investments lead to higher economic growth, especially in relatively capital-intensive heavier industries. As a result, national GHG emissions increase as well.

Nigeria's negotiators would need to find a RBCP or carbon market partners willing to discuss ways to isolate the impact of removal of VAT exemption on petroleum products, as de facto fossil fuel subsidy removal from the impact on general increase of VAT tax rate, which would not have climate mitigation outcomes.

Figure 7. Potential RBCP revenue for climate mitigation outcomes of green fiscal reforms @10US$ per ton of CO2e emission reduction below BAU



Cumulative RBCP transfers of US$ 9.2 billion (in 2017 prices) over the period of 25 years are much lower than the international financial aid of US$ 880 billion (in 2021 prices) assumed until 2060 in the Nigeria's Deep Decarbonization paper (Chukwumerije Okereke et al 2024). For the sake of what-if illustration, using EU ETS futures as of March 2024 with December 2024 delivery of EUR 70 (US$ 76) as a benchmark, the cumulative (undiscounted) RBCP revenue could amount to 64 billion US$, which is comparable to our simulations given assumed price of 10 US$ per ton of CO2e mitigated. Even such realistic amounts calculated here, however, would help the country manage social adjustments during the first decade of transition before investments in productivity deliver growth and welfare returns. These funds would not overwhelm absorptive capacity of Nigerian institutions to disburse funds with integrity and efficiency (see initial difficulties in disbursing 800 million US$ loan to cope with social effects of the petrol subsidy removal). These funds could be used to build capacity for policy implementation and enforcement, or to strengthen social safety nets for the poor and vulnerable households affected by the reforms.

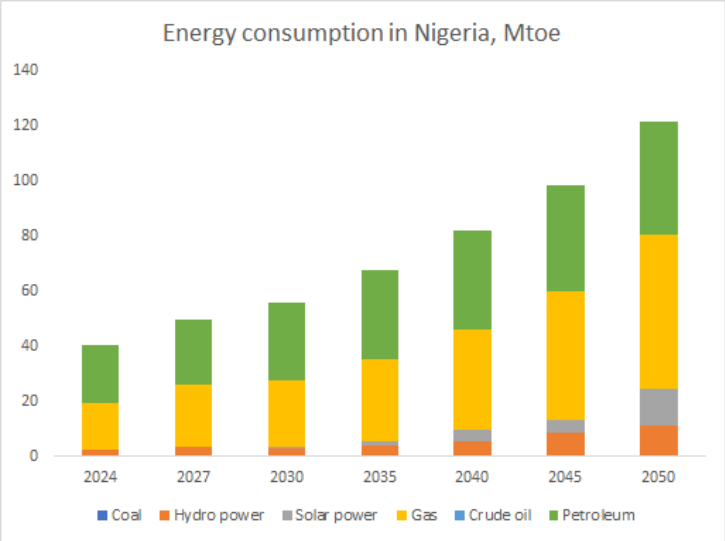
The figures presented here are illustrative estimates and should not be taken as the basis for any specific RBCP contract. Should Nigeria's climate diplomacy choose to pursue RBCP negotiations, contractual values can be lower or **higher** than those estimated here depending on the willingness to pay of the buyers (who can offer less or more than 10 US$ per ton of CO2e assumed here), the baseline agreed by both parties, detailed design of a fiscal reform, actual verified mitigation outcomes or other conditions that both parties will include in the RBCP agreement. See for example section 5.1 on the World Bank approach to RBCP, where the value of the financial transfer is linked not to emission reductions and carbon price but to the cost of implementing the policy reform. The carbon price of 10 US$ per ton of CO2e is a conservative, albeit realistic estimate benchmarked to the only more or less functioning international carbon market, which is voluntary. When trading of the internationally transferred mitigation outcomes (ITMOS) under

article 6.2 or emission reduction units under article 6.4 becomes operational, new price benchmarks will become available and Nigerian negotiators should adjust their bargaining strategy.

4.5. Domestic energy system

Energy demand substantially increases over time, while fossil fuels continue to dominate the energy mix under the baseline scenario in Nigeria. The baseline scenario sees a substantial expansion in energy demand over time (Figure 11). As the size of the economy (read GDP) increases by over 3.5 times between 2024 and 2050, expansions in production and final consumption lead to rising energy demand. As a result, by 2050 energy consumption grows to over 120 Mtoe – around three times above the 2024 level. Without targeted diversification or climate mitigation efforts, the energy mix continues to be dominated by fossil fuels – primarily natural gas and petroleum products. While renewable energy sources expand the most in relative terms over the analyzed period, their share reaches only 20% in 2050 (though more than triples between 2024 and 2050).

Figure 8. Energy consumption in Nigeria under the baseline scenario, Mtoe

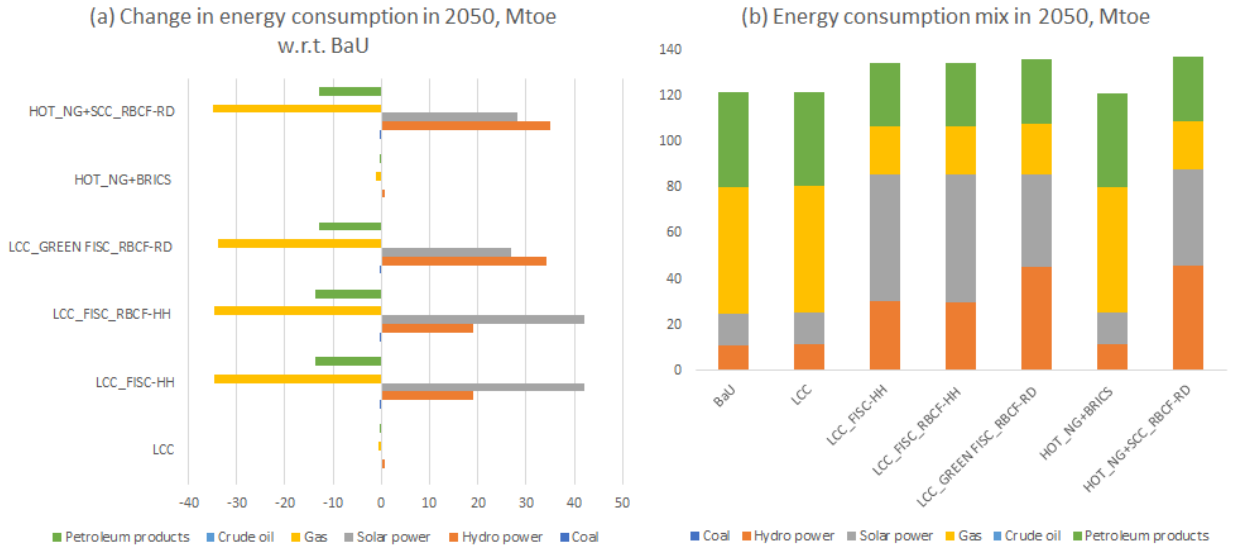


With growing electrification rates, renewable energy sources play a more important role in the generation mix under the baseline scenario in Nigeria. While overall energy demand increases by three times between 2024 and 2050, demand for electricity experiences much higher growth rates – an increase of almost five times over the same period. Growing use of electricity in the residential and industrial sectors, driven by higher penetration of electric vehicles, stovetops, furnaces and other electricity-power technologies, lead to a partial substitution of the direct use of fossil fuels (e.g., in transportation) for electricity. When combined with declining costs of renewable generation technologies, solar power generation experiences the most substantial expansion in relative terms compared to other technologies, overcoming hydro power generation by the end of the analyzed period. The share of renewable generation almost doubles over time, reaching 42% in 2050.

Domestic green fiscal policy reforms lead to major transformations in Nigeria's energy system. Climate policies in the rest of the world (by formation of either large or smaller climate clubs) have very limited impact on Nigeria's domestic energy system as its development largely follows the baseline pathway being

dominated by fossil fuels (Figures 12a and 12b). Implementation of the domestic green policy reforms, on the other hand, has a substantial impact on the energy mix. In all considered green policy scenarios the share of renewable energy sources more than triples compared to the baseline scenario in 2050, reaching around 63%. Even a more substantial share of renewable energy is achieved in the electricity generation mix – as the latter becomes carbon free by 2050. Depending on the type of green policy reforms either solar (scenarios with revenue recycling to households) or hydro (R&D-based revenue recycling) sees a more substantial expansion over time. It should be paperd, however, that these simulations are not aimed at predicting the exact renewable generation mix rather indicating incentives for a substantial expansion of the overall renewable generation capacities under different policy reforms.

Figure 9. The share of renewable energy in final energy consumption triples compared to the baseline scenario, reaching around 63 percent in 2050



Papers: The figure illustrates changes in energy consumption (panel 'a') and energy consumption mix (panel 'b') in Nigeria in 2050, Mtoe. Wind energy is not present in simulations because according to the IEA data, there was no wind generation in Nigeria as of 2022 https://origin.iea.org/countries/nigeria/electricity. This is one of the limiting features of the CGE models like ENVISAGE, that if the technology/sector output is zero in the reference year, the policy reforms cannot grow its output, because any multiplication of zero is still zero.

4.6. Diversification and structural change

Nigeria's economic output is already diversified away from oil, but exports and government revenues are not. In 2023 oil and gas accounted for almost 90 percent of Nigeria's exports, and about half of government revenues, but only less than 10 percent of GDP (World Bank 2023; National Bureau of Statics 2024). Since 2010 the oil industry contribution to GDP has been consistently contracting, counterbalanced by the dynamic growth of the vibrant service sector, including trade, and ICT and financial services (World Bank 2023). Services became by far Nigeria's largest sector (approaching 60 percent of GDP), followed by agriculture (around 25 percent) and industry (less than 20 percent). Unfortunately, most services, as well as agricultural and industrial outputs are not internationally traded, and hence, do not accumulate foreign exchange. Neither do they attract capital, knowledge, and technology, that would allow productivity and

the complexity breakthroughs necessary for deep structural transformation. Without that escaping the lower-middle income trap will be a challenge.

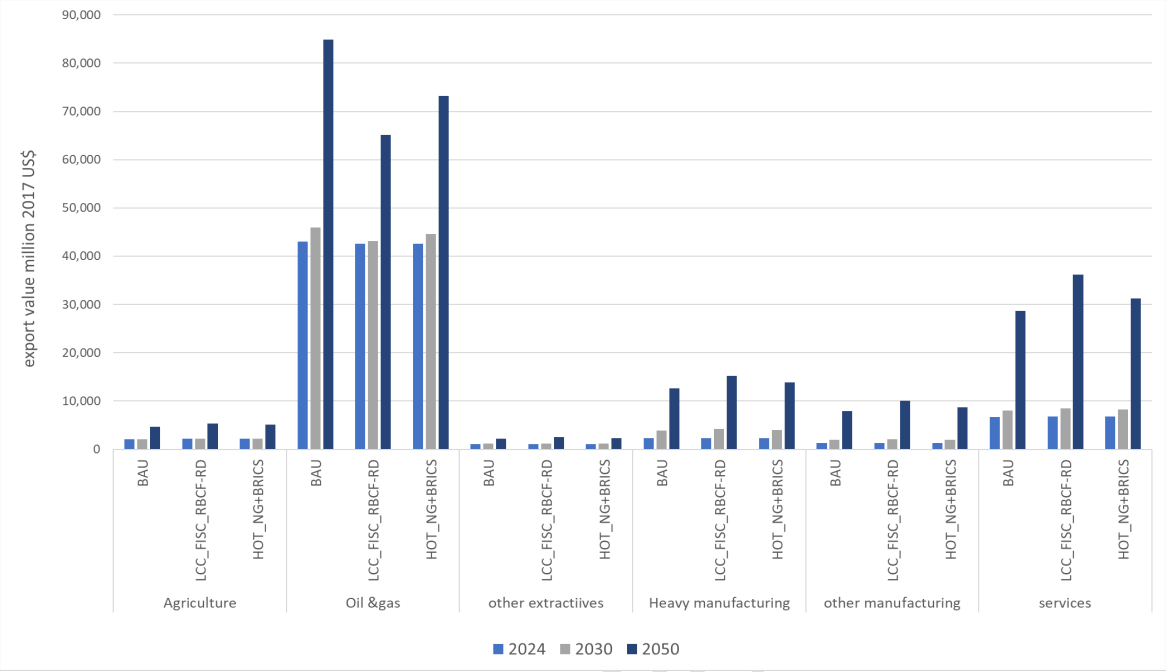
In the past, Nigeria's government tried to foster economic diversification through import substitution and trade restrictions. These efforts hurt investors' confidence, reduced the flow of foreign investments and eroded Nigeria's non-oil export-competitiveness (World Bank 2022). Nigeria arguably needs diversification that is led by export competitiveness, which requires higher productivity, knowledge-intensity, and larger complexity. Therefore, this paper focuses on model simulations results that are most relevant for export diversification.

Ambitious climate policies implemented by foreign trading partners nudge Nigeria to diversify exports beyond oil. Climate actions abroad (whether cooperative in LCC scenarios or unilateral in HOT scenarios) reduce external demand and prices for Nigeria's oil**.** A lower inflow of petrodollars increases export competitiveness of the rest of the economy through the reverse Dutch disease.

Domestic green fiscal reforms in Nigeria further accelerate export diversification away from oil, gas, and oil products. Green fiscal reforms enhance export competitiveness of services, manufacturing (both heavy and clean), and agriculture, while slowing the growth of oil and gas export revenues below the BAU (Figure 13). However, oil and gas revenues do not drop below 50 percent of total exports by 2050 even in the most ambitious green fiscal policy scenario. It indicates strong entrenched comparative advantage of Nigeria in hydrocarbon exports and challenges to increasing export-competitiveness of the non-oil economy with horizontal industrial policy and carbon pricing alone[10].

[10] It is also partly attributed to limitations of the model simulations, as mathematically the activities that had zero or very small export values in the year for which the model was calibrated (2017 in this case) will remain zero or relatively small even if stimulated by strong policy incentives.

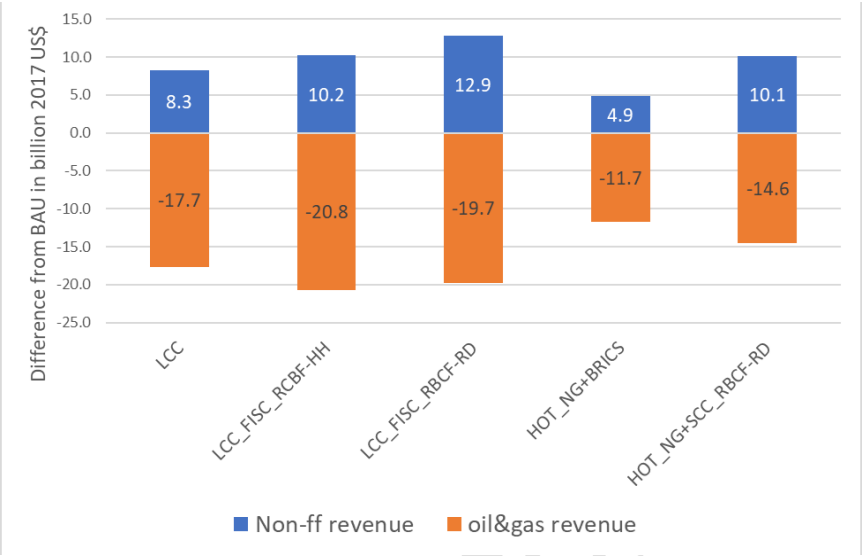
Figure 10. Non-oil exports benefit from domestic fiscal reforms, while oil and gas exports are larger without them, but lower than BAU if OECD countries pursue their climate policies



Paper: The figure illustrates export value by sector in BAU, cooperative and noncooperative climate policy scenarios (in million 2017 US$)

Investments of green fiscal revenue in innovation and human capital help non-oil export revenue to make up for a large share of foregone oil and gas foreign exchange earnings (figure 14). In the two scenarios, in which additional green fiscal revenues are reinvested in technology and human capital (with RD annotations) export revenues of the non-oil economy are initially (by 2030) relatively low (table 5), but by 2050, when upfront investments boost labor productivity across sectors, they make up for 70 percent of foregone oil revenues. In the scenarios with BAU policies in Nigeria and where fiscal revenues of green fiscal reforms go to households (with HH annotations), higher export revenues of the non-oil economy compensate only for less than a half of foregone oil and gas revenues compared to BAU.

Figure 11. In any policy scenario it will take time to make up for lower than BAU oil and gas revenue, but the gap is closing faster as fiscal reforms and revenue recycling to innovation and education accelerates export competitiveness of non-oil economy.



Paper: The figure illustrates loss of oil and gas export revenues and gains in non-oil export revenues compared to BAU in 2050

Table 4. Additional non-oil revenue as a percentage offset of foregone oil revenue (by scenario relative to BAU)

	LCC	LCC_FISC_RCBF-HH	LCC_FISC_RBCP-RD	HOT_NG+BRICS	HOT_NG+SCC_RBCP-RD
2030	40%	42%	33%	39%	32%
2050	47%	49%	65%	42%	69%

Source: World Bank and Purdue University ENVISAGE simulations

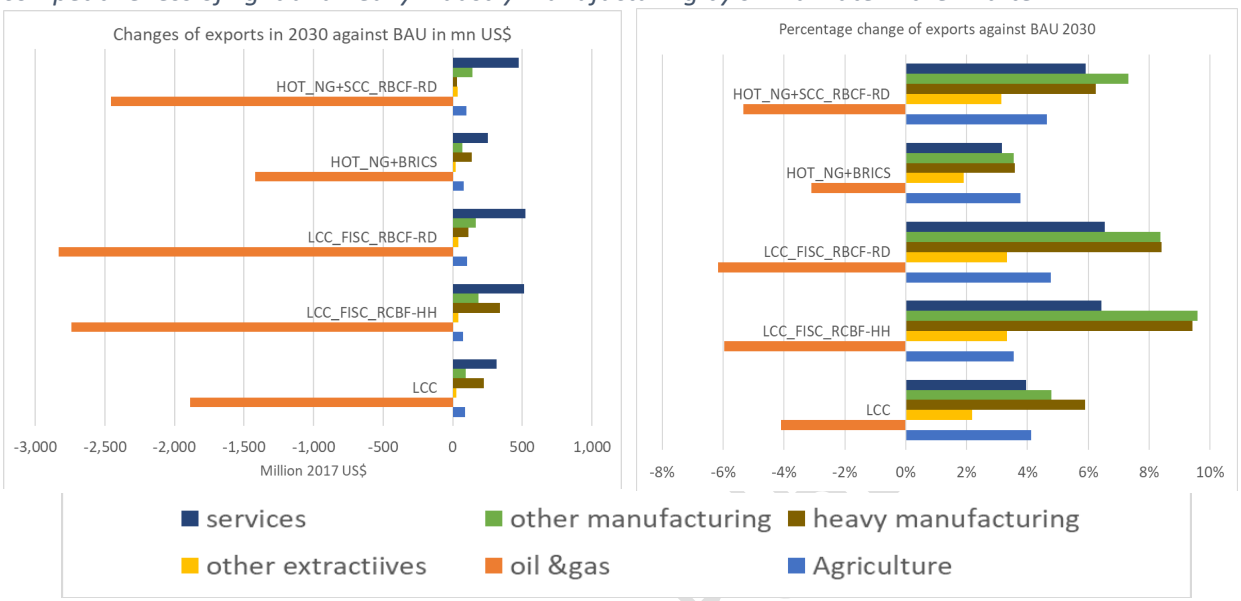
In reality, more than a full offset of oil export revenues by non-oil economy is likely to happen earlier than the model simulates. Paper the previous caveat that the model mathematically finds it difficult to give major rise to the sectors that are miniscule in the base year. Growth of productivity and export expansion for individual green manufacturing champions will depend on policy reforms simulated here as well as on progress with a broader enabling investment environment. Green trade and investment agreements or more targeted green industrial policy favoring specific complex and knowledge-intensive economic activities (not simulated here) can accelerate structural change, technology transfer and productivity growth. This can help Nigeria discover new international comparative advantage, in non-oil economic activities in which the country has a large potential[11].

Green fiscal policies improve export competitiveness of Nigeria's manufacturing sector, while benefitting light industry more than heavy industry. In the shorter term (by 2030) export competitiveness of both manufacturing types increases at a similar rate, although in constant US$ exports of light manufacturing grow relatively faster in RD scenarios (figure 15). In the long term--with green fiscal reforms consistently in place--more technology-intensive, greener industries become more export competitive relative to heavy industry, even when additional fiscal revenues are recycled to households (HH) (figure

[11] Identification of the most promising sectors or products for green transition was not in the scope of this study.

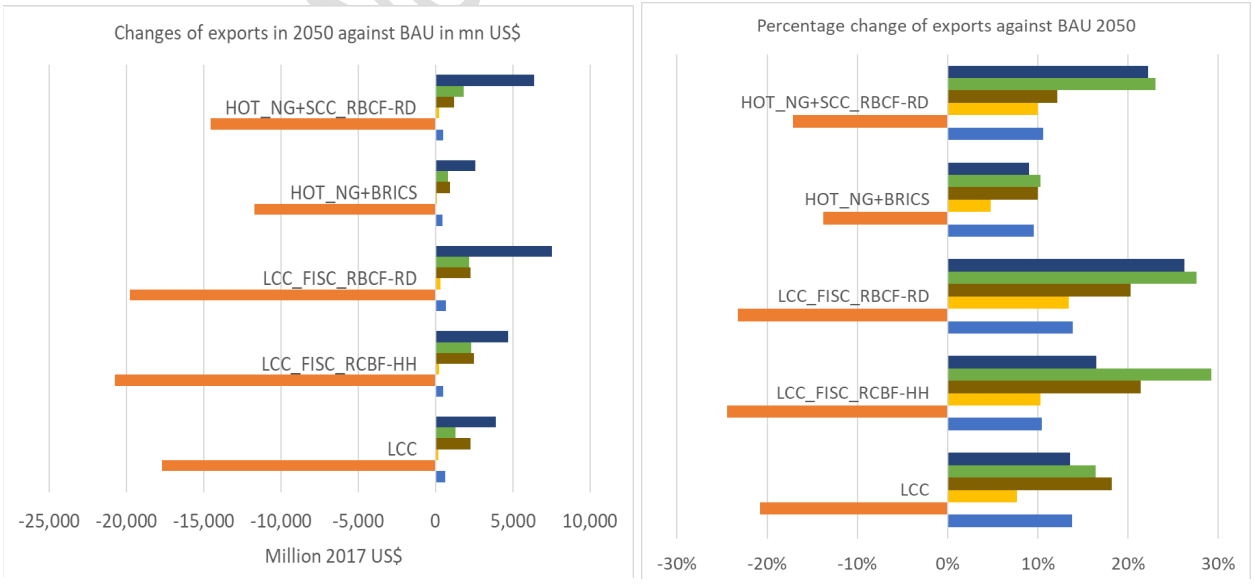
16). By 2050 the greener industry becomes the fastest growing foreign exchange earner among Nigeria's economic sectors.

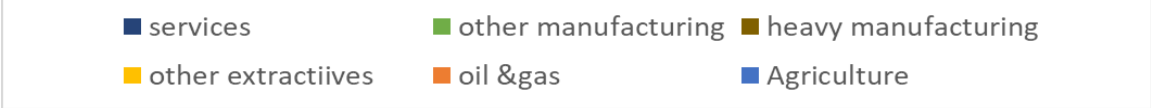
Figure 12. Green fiscal policies reduce Nigeria's oil and gas exports against BAU and improve export competitiveness of light and heavy industry manufacturing by similar rate in the mid-term



Papers: (1) The figure illustrates mid-term changes of exports against BAU in 2030: in constant 2017 US$ (left) and as a percentage change of exports by type of economic activity (right). (2) There is potential aggregation bias when interpreting results. Heavy manufacturing sector in the model includes refining products, chemicals, fertilizers, steel, other metals, non-metallic minerals, etc. Other (light) manufacturing is also an aggregate of several economic activities, some of which do not exist in the base year for which the model was calibrated. In reality, impacts could be rather heterogeneous across these sub-sectors and some of them might be losing while others gaining from the green fiscal policies.

Figure 13. In the longer term green fiscal policies increases exports of Nigeria's light industry by higher rate than heavy, emission-intensive industry.





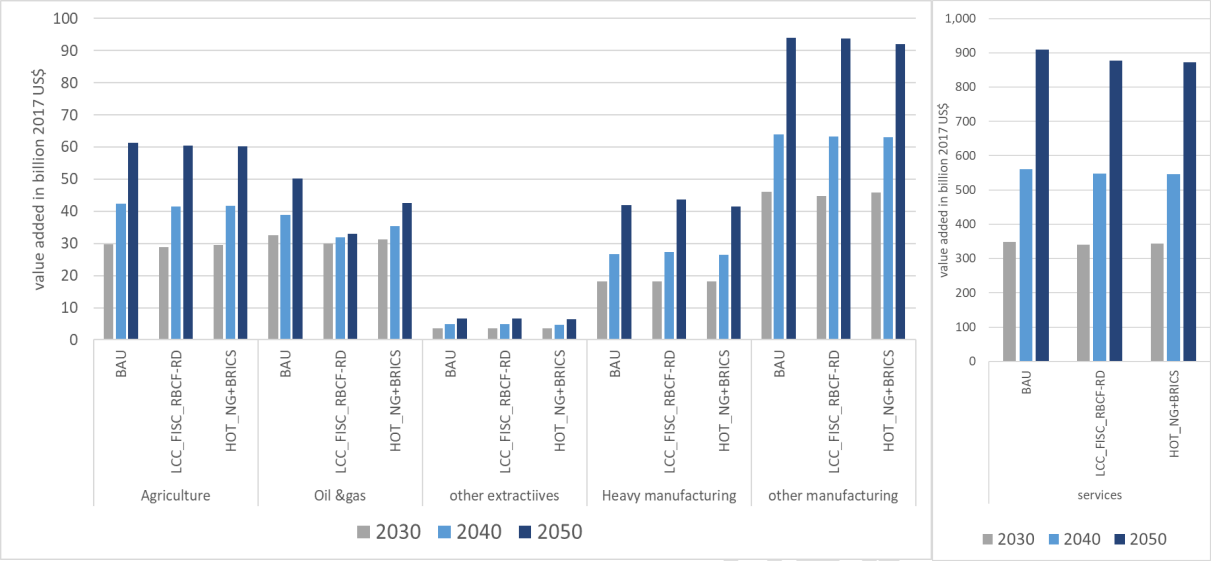
Papers: (1) The figure illustrates long-term changes of exports against BAU in 2050: in constant 2017 US$ (left) and as a percentage change of exports by type of economic activity (right) (2) Paper potential aggregation bias discussed earlier

The analysis shows how interactions between climate action abroad and domestic policy incentives can shape the future industrial structure and export diversification. Climate policies implemented by the buyers of Nigerian oil (in LCC and HOT_NG+BRIOCS scenarios) will lower the cost of fuel inputs to domestic downstream heavy industry and foster traditional brown diversification other things being equal. Some domestic policy reforms, such as the general VAT increase from 7.5 to 15 percent may favor heavy industry as well. It reduces final consumption of households and increases savings and investments. Energy-intensive sectors are usually more capital-intensive and thus they benefit in relative terms when investments increase. But those policy reforms that have stronger climate mitigation co-benefits (removal of petrol subsidy, increase of VAT on petroleum products from 0 to 7.5 percent, and obviously the carbon excise tax), increase the cost of fuel to domestic users by the green fiscal wedge. Such policies benefit less emission/energy-intensive more productive and modern light industries relative to heavy manufacturing. Productivity boost through RD investments further support their export competitiveness.

Looking at the structure of domestic output, the value added of heavy manufacturing grows faster in fiscal policy reform scenarios than light manufacturing, although in absolute terms, light manufacturing benefits more from green fiscal policies than heavy manufacturing[12]. The value added in services grows even faster in all scenarios and continues dwarfing the absolute value of all other sectors. Value added in heavy manufacturing (figure 17) grows faster with green fiscal policies than in scenarios with the BAU policies in Nigeria, even if fiscal savings are reinvested in productivity-enhanced innovation (scenarios with RD notation). This suggests macroeconomic pressures towards brown diversification, even with green fiscal policies in place. Probably more targeted green industrial policies—not simulated here—would be needed to tilt the economic structure more towards lighter, knowledge-intensive sectors. In the same scenarios output of services sector grows a bit slower than in the BAU indicating that industrial output benefits relatively more than services from improvements in productivity

[12] Paper the potential aggregation bias especially in heavy industry discussed earlier.

Figure 14. Value added of heavy manufacturing grows faster in fiscal policy reform scenarios than light manufacturing, although in absolute terms, light manufacturing benefits more from green fiscal policies than heavy manufacturing



Paper: The figure illustrates Nigeria's value added by sector in BAU and LCC_FISC_RBCP-RD scenario (million 2017 US$)

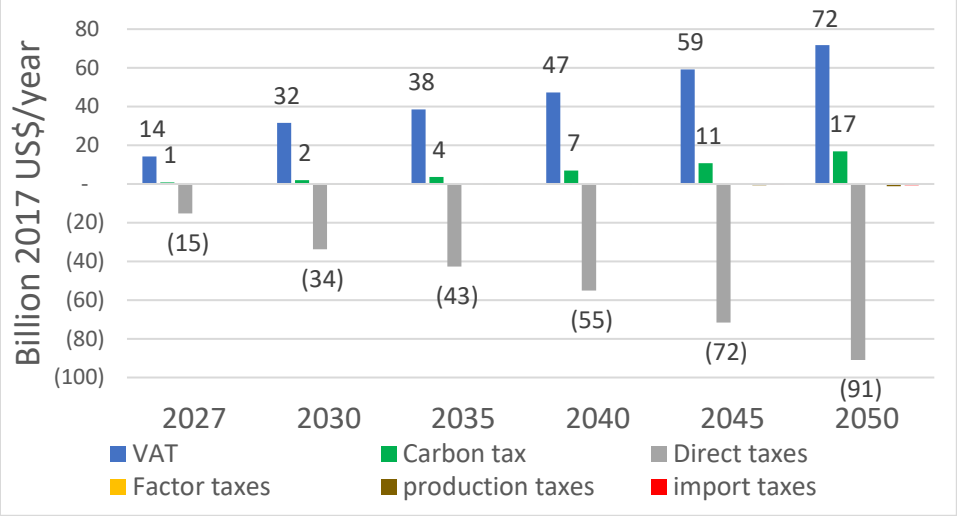
The impact channels of VAT reform on structural change are different than those of carbon pricing. By itself the impact of carbon pricing is most adverse on export competitiveness of energy-intensive heavy industry. The VAT impact channel is different. The VAT increase leads to a shift from final consumption to savings and investments. Energy-intensive sectors are relatively more investment-intensive and thus they benefit in relative terms when investments increase. Therefore, in most scenarios involving green fiscal reform package the positive VAT reform impact seems to outweigh the adverse impact of carbon pricing on heavy industry. The net impacts of combined VAT and carbon tax reform would depend on **a** more granular and targeted recycling of VAT revenue.

The scenario simulations show that diversification of Nigeria's economy beyond oil-related activities will require bold policy reforms, including those that were not simulated here. More targeted green industrial policy would be needed to support export-oriented technology-intensive and greener manufacturing. If the net revenue from fiscal reforms simulated here were reallocated toward specific clean sectors, this might change the sectoral impacts compared to these simulations. Such granular exercise of picking winners was beyond the scope of this analysis. Our R&D scenario assumes improvements in labor productivity throughout the economy. And while services, being more labor-intensive, seem to benefit from the boost to labor productivity, other sectors, including heavy industry also benefit from this productivity improvement and thus increase their output and exports (though less in relative terms than light manufacturing or services). By the same token, additional trade and investment agreements with climate club partners can deepen structural and increase climate mitigation outcomes diversification. They are qualitatively discussed in chapter 6.

4.7. Fiscal system

One of the world's lowest tax revenues to GDP ratio of about 9 percent (IMF 2024, World Bank 2024b) drastically reduces the capacity of the public sector in Nigeria to meet social and infrastructure spending needs, let alone financing green structural transformation. Therefore, the FGN fiscal strategy supported by international partners (IMF, World Bank) is to increase domestic revenue mobilization and boost public spending, while making them better targeted and more efficient. The package of green fiscal reforms simulated here could significantly improve fiscal space for Nigeria. Additional public revenues from VAT subsidy reforms of around $14 billion could reach around 3 percent of GDP by 2027, surpassing the IMF projections of 1.2% of GDP by 2029 (IMF 2024). Carbon excise tax revenue of about $800 million in 2027 increases to almost $17 Billion by 2050 (figure 18). In addition to providing incentive effects to accelerate diversification this would yield non-trivial government revenues accounting for 0.2 percent of GDP in 2027 increasing to 1 percent of GDP by 2050.

Figure 15. Tax revenue shifts from green fiscal reforms in Nigeria



Carbon tax revenues are additional to the external RBCP mobilized for the climate mitigation outcomes of the petrol subsidy removal and carbon tax. The RCBF can potentially mobilize the equivalent of 3 percent of domestic carbon tax revenue in 2027, rising to 5 percent in 2050.

Green fiscal reform creates fiscal space for potential reduction of other distortionary taxes. Additional fiscal revenue can be used to increase public spending for infrastructure, social protection, and education for a more productive, greener economy (as in scenarios with RD annotations), or to reduce other taxes in revenue-neutral way (as in scenarios with HH annotations). Figure 19 also shows the potential for the latter tax shift where VAT and carbon tax increases allow reduction of direct taxes—both personal and corporate income taxes.

5. Policy conclusions

Green fiscal reforms simulated here can create significant climate mitigation outcomes. These outcomes are global public goods, while also delivering long-term economic benefits to Nigeria by enabling diversification resilient to transition risk and escaping the low-middle income trap. To achieve these mitigation outcomes, however Nigeria would have to implement and enforce ambitious structural reforms and mobilize massive investments, which would require households to sacrifice some current consumption and welfare in the short and medium term, not an option in a nation that is a home to one of the most more extreme poverty in the world. This may also backfire to environment, fanning resistance to reforms, and reversing their mitigation outcomes.

Nigeria needs external support to leapfrog to diversification with climate mitigation outcomes. Traditional diversification domesticates downstream processing of hydrocarbons and heavy manufacturing. Such diversification increases national carbon emissions and increases exposure to trade-related climate policies abroad. Green diversification requires leapfrogging into productive economic activities that are beyond the current capabilities of a nation that already struggles with conflicts, extreme poverty, organized crime, corruption, tumbling currency, soaring inflation, capital flight and where hydrocarbons account for over 90 percent of exports. Climate club needs to step up tangible incentives and enabling provisions for Nigerian entrepreneurs to break into fast-growing global green value chains, where higher-income countries have comparative advantage, and to ensure that Nigerian households accept radical structural change.

Green diversification policies combined with international partnerships could change investment behavior of private sector, transform structures, attract result-based climate finance and green FDI. Together these incentives and enablers would "nudge" new comparative advantage and allow Nigerian firms to break into the global value chains of modern green technologies. The whole government engagement in international climate economic diplomacy should create strong partnerships through trade, investment, technology and financial agreements based on the strategic mutual self-interest of Nigeria and its partners. Nigeria's preparedness to such effective climate economic diplomacy will have to focus on what the country needs to receive but also what it would offer in return.

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