CARBON TAXATION, RENEWABLE ENERGY ADOPTION AND SOCIO-ECONOMIC DEVELOPMENT: THE NEED FOR AN INTEGRATIVE APPROACH

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ABSTRACT
The escalating risks and disastrous consequences of the rapid increase in carbon emission over the years has prompted international organisations including the United Nations and the World Health Organisation to advocate for nations to adopt carbon emission reduction policies such as carbon tax and renewable energy adoption. However, for developing countries, the pathway to achieving low to zero carbon emissions has been challenging as these nations contend with limited fiscal capacities, institutional weakness and competing socio-developmental priorities. This paper is a desk-based review of literature with the objectives of examining whether carbon taxes engender the adoption of renewable energy in developing countries that are also faced with the challenge of poverty alleviation, and analyze how developing countries balance environmental sustainability through carbon taxation and renewable energy adoption without undermining socio-economic development. This paper recommends that low-income countries adopt harmonious and inclusive approaches that enable them achieve their carbon emission targets without compromising socio-economic development by appropriately re-cyclyng carbon tax revenue, integrating, mapping and analyzing policies, and application of ex-ante simulation modelling.

Keywords: Carbon Tax, Renewable Energy Adoption, Socio-Economic Development.

JEL Classification: H23, Q56, Q58, Q4

1.0 INTRODUCTION

The escalating risks and disastrous consequences of climate change, coupled with the inadequacy of market mechanisms to offer viable solutions, has prompted some nations to implement carbon tax as a means of curtailing carbon emissions and minimizing environmental degradation. According to the Organisation for Economic Corporation and Development (OECD, 2021), global carbon dioxide (CO_2) emission increased from 22.5 billion tons to 31.5 billion tons between 1990 and 2008. As of 2024, over 40 billion tons was emitted, and currently rising, causing serious threat to the environment and sustainable development (World Meteorological Organisation [WMO], 2025). Carbon dioxide (CO_2) is a naturally occurring gas and a major component of greenhouse gas emissions that is kept balanced in the atmosphere by generated human and animal respiration, and decomposition that are kept balanced by emissions capturing processes such as photosynthesis and ocean absorption (United Nations [UN], 2021). CO_2 can also be produced by the burning of fossil fuel (anthropogenic emissions).

Human activities since the industrial revolution have caused an increase in green-house gas (GHG) emissions thereby exacerbating the natural greenhouse effect and retaining heat in the atmosphere which results to global warming (Bhattacharya et al., 2023). Some of the recent consequences of global warming include deadly wildfires (Hawaii), long-term drought (Africa, Asia, America), severe flooding (Somalia, Ethiopia), and increased food insecurity, and unusual climate change (UN, 2021; World Meteorological Association, 2024). As a result of the foregoing, there has been a global advocacy from international organisations such as the Organisation for Economic Corporation and Development (OECD), United Nations (UN), and the World Health Organisation (WHO), to adopt carbon pricing, a policy tool that incentivizes behavior towards the reduction of carbon emission in mitigating the adverse effects of climate change (Carbon Pricing Leadership Coalition, 2021). Several international environmental agreements have been established to justify the adoption of carbon pricing instruments such as carbon tax and emissions trading schemes, examples include the United Nations Framework Convention on Climate Change (UNFCCC), the principal legislation, established in 1992; the Kyoto Protocol signed in 1997, and the Paris Agreement (a legally binding international treaty among 195 countries) of 2015.

Recently, at the 2023 United Nations Climate Change Conference (Conference of Parties [COP28]) held in Dubai, United Arab Emirates, the Renewable Energy Efficiency Pledge was launched, and signed by 116 nations with the aim of accelerating energy transition. The signatories to the pledge committed to tripling energy capacity by 2030. Furthermore, in order to achieve emission reduction targets, the Intergovernmental Panel on Climate Change (IPCC, 2023) and United Nations (UN, 2023) are calling for transition to renewable energy (a type of naturally replenishing energy from sources such as the sun, wind and rain) as a means of accelerating CO_2 emission reduction. However, for low-income developing countries, renewable energy transition is not only an issue of sustainability and GHG emission mitigation, but also a concern about economic development, energy security and energy poverty alleviation. With the primary goal of

poverty reduction, it appears that developing countries are concerned about the associated cost of carbon tax implementation and renewable energy transition which could restrict their fiscal ability to develop economically, and also aggravate poverty levels. Other research (Dyarto & Setyawan, 2020; Leonardo et al, 2024) have also shown that the nexus between carbon taxation and renewable energy adoption can enhance socio-economic development. Revenue generated from carbon tax can be re-invested into renewable energy projects technology, therefore enhancing energy supply, creating jobs and stimulating economic activities such as foreign direct investments. Currently, South Africa remains the only African country with a Carbon tax. While Nigeria is yet to implement a carbon tax, As Nigeria seeks to meet its carbon emission reduction target.

This paper focuses on carbon taxation due to its potential to generate much needed additional revenue for low-income developing countries, especially at a time when financial support by developed countries is not forthcoming, while mitigating climate change effects, albeit at a slower pace (Black, 2017). Several empirical studies affirm that carbon tax policies can incentivize both corporate entities and individuals to adopt cleaner technologies such as renewable energy, reduce pollution, and promote sustainable practices (Bhat & Mishra, 2019; Lam et al., 2023; Telatar & Birinci, 2022; Wang et al., 2016). Other scholars argue that carbon tax policies alone are not enough to meet the urgency of emissions reduction, considering the associated risks (Gutierrez, 2017; Köppl & Schratzenstaller, 2022). These studies highlight the need to consider integrating carbon tax policies with renewable energy policies in order to accelerate the achievement of the net-zero targets and efficient policy design free of duplication and policy overlap (De Guevello, 2020; Gutierrez, 2017). However, this may not necessarily yield similar results in developing countries due to lack of fund, infrastructure and high cost of renewables.

This paper is relevant within the framework of Goals 7 and 11 of the United Nations Sustainable Development Goals (UNSDG) 2030, which underscores the importance of ensuring universal access to affordable, reliable, sustainable, and modern energy for all, and making cities safe, resilient and sustainable respectively. In order to attain these goals, the implementation of carbon tax and transition to renewable energy is important, especially as it relates sustainable development and environmental preservation of low-income countries.

Despite the potential benefits associated with the interplay between carbon taxation, renewable energy adoption, and socio-economic development, several developing countries continue to face significant developmental and financial constraints in their efforts to achieve sustainable energy targets set by international organizations (Dorband et al., 2019; Steckel et al., 2021). The unique socio-economic contexts of these countries, characterized by limited fiscal capacity, institutional weaknesses, and competing developmental needs, create critical challenges that hinder the effective implementation of carbon tax policies and adoption of renewable energy. Therefore, this raises the question: how can carbon tax be implemented in developing countries and incentivize the adoption of renewable energy without compromising their socio-economic development?

Addressing this issue requires a unique policy approach that balances environmental sustainability objectives with socio-economic developmental goals by ensuring that fiscal and regulatory policies are adapted to the specific needs of each country.

Against this backdrop, the objectives of this paper are to:

a) examine whether carbon taxes engender the adoption of renewable energy in developing countries that are also faced with the challenge of poverty alleviation, and
b) analyze how developing countries balance environmental sustainability through carbon taxation and renewable energy adoption without undermining socio-economic development.

In order to address the objectives of this research, this paper is organized as follows: section 2 reviews the main concepts used in this paper, section 3 reviews related theories of carbon taxation, section 4 reviews literature on carbon tax and carbon emission, renewable energy adoption, relationship between carbon tax and renewable energy adoption, section 5 presents a discussion on balancing carbon taxation, renewable energy adoption and socio-economic development, and sections 6 and 7 provides recommendations and conclusion respectively.

2.0 LITERATURE REVIEW

2.1 Conceptual Review and Definitions

This section provides an in-depth examination of key concepts such as carbon pricing, carbon taxation, renewable energy, and socio-economic development. It explains the definitions and their underlying principles in order to facilitate a comprehensive understanding of this paper's objectives.

Carbon Pricing

Carbon Pricing (CP) is an economic and environmental policy tool that attributes a monetary cost on the emission of carbon dioxide and other greenhouse gases into the atmosphere (Platform for Collaboration on Tax [PCT], 2023). It is based on the pigouvian theory of 1920 which opines that economic agents generate externalities through the production (such as fossil fuel based energy) of goods and services. Externalities such as carbon emissions are secondary effects of economic activities that may have positive or negative effects on other economic agents such as households or firms. Consequently, the environmental costs of the externalities associated with such production or consumption activities are not entirely borne by the responsible economic agent, but are passed onto society (in this case, as carbon emissions). Though this paper focuses only on carbon tax as a form of carbon pricing, other types may include emissions trading schemes (ETS), or a combination of both (carbon tax and ETS). According to Andersson and Atkinson (2020), carbon pricing involves imposing a charge on carbon pollution to incentivize emitters to curtail their greenhouse gas emissions. By internalizing the future environmental costs associated with carbon emissions, carbon pricing alters behavior and generates revenue streams that can be allocated towards infrastructure, reduction of distortionary taxes and eco technology (Black,

2017). Furthermore, integrating carbon pricing into broader policy frameworks, may create the potential to foster synergies between environmental objectives and economic imperatives, thereby advancing the collective pursuit of sustainable development (Hu et al., 2020).

Carbon Tax

Carbon Tax, a type of carbon pricing instrument (CPI), is a mandatory payment to the government that is assessed based on actual carbon emissions (per metric ton of CO_2), or its proxy, that can cause a reduction in corresponding carbon-based (equivalent) emissions in the atmosphere; therefore, it is identified as having both environmental purpose and effect (UN, 2021). It may also be identified as a specific type of environmental tax whose "tax base is a physical unit (or a proxy of it) that has a proven specific negative impact on the environment" (OECD, 2023, p. 16), namely carbon dioxide emission. Also, according to the OECD, carbon taxes can be levied at the point of fossil fuel extraction (upstream), refinement (midstream), consumption (downstream), or as trade duties (Carbon Border Adjustment Mechanism). According to the UN, the two approaches for the implementation of carbon tax are the Direct Emissions approach (based on carbon dioxide emission) and the Fuel approach (based on the carbon content of fossil fuel).

As an indirect tax, Carbon tax is also characterized by the imposition of charges on the carbon content of fossil fuels, with the overarching objective of curtailing carbon dioxide emissions and combatting climate change (Stechemesser & Guenther, 2012). Furthermore, as a price-oriented policy instrument, it influences consumer behavior and spurs investment in low-carbon technologies, thereby driving environmental sustainability (Zhang, 2018).

Renewable Energy

Renewable Energy is energy that is derived from naturally replenishing resources such as sunlight, wind, rain, tides, waves, and geothermal heat (Khalid et al., 2021). According to the OECD (2021) renewable energy is the contribution of renewables to total primary energy supply (TPES). Also, energy from solid biofuels, biodiesels, other liquid biofuels, hydro, geothermal, solar, wind, tide, and wave energy, as well as the renewable portion of municipal waste, are all considered renewable energy sources. These energy sources have the potential to reduce greenhouse gas emissions, diversify energy sources, and lessen reliance on fossil fuels (Majlingová et al., 2020). Furthermore, renewable energy is considered an inexhaustible energy source resulting from continuous regeneration, making it a sustainable alternative to non-renewable energy sources (Ravichandran et al., 2022).

Similar to Carbon taxation, renewable energy adoption also plays a crucial role in mitigating climate change by reducing greenhouse gas (GHG) emissions from fossil fuels (Bölük & Mert, 2014). Additionally, for developing countries, renewable energy provides access to fossil fuel-free affordable energy services with the potential of significant economic development (Gutierrez, 2020).

Socio-Economic Development

Socio-Economic Development is an interplay of economic and social factors within a specific geographical area (Fritz, 2004). The concept of Socio-economic development encompasses social development and economic development, and environmental stewardship for the improved standard of living, quality of life and social equity of the society (Gordeev et al., 2020, UNDP). Social development focuses on fostering inclusiveness, social justice and the common good of the people based on indices such as income, poverty, employment, education, health, environmental sustainability, while economic development focuses on the level of material prosperity of the people based on increased production, distribution and consumption of goods and services (Fritz, 2004; Ortynskyi et al.,2021).

Studies (He et al., 2019; Wu et al., 2021; Yin et al., 2024) have shown that carbon taxes can impact the adoption of low-emission technologies such as renewable energy, thereby supporting environmental sustainability and socio-economic development (He et al., 2019). As a key policy instrument, carbon taxation is designed to reduce carbon dioxide emissions by internalizing the environmental cost (Pigouvian theory); as a result, impacting the energy sector by facilitating a transition toward renewable energy sources and, ultimately, promoting socio-economic development.

2.2 Theoretical Underpinning

This section discusses the Pigouvian theory and the double-dividend theory. The pigouvian theory is the theoretical foundation for assessment of carbon taxation while the double-dividend theory suggests the possibility of achieving both environmental and economic benefits.

Pigouvian Theory

The Pigouvian theory, formulated by Arthur C. Pigou, is presented in his book "The Economics of Welfare" published in 1920. The British economist stated that when a market activity's marginal social cost deviates from its marginal private cost, the market is inefficient and will cause a surplus of the product; also, the producer is not inclined to absorb the marginal societal cost, thereby resulting in economic externalities. In his book, Pigou discussed the concept of externalities and argued for government intervention to address the divergence between private and social costs associated with certain economic activities. The Pigouvian theory advocates for the internalization of externalities through the use of taxes or subsidies to correct market failures caused by external costs or benefits. The theory suggests that by assessing taxes on activities with negative externalities and making subsidies available to those with positive externalities, the market can achieve a more efficient allocation of resources. Furthermore, the effectiveness of Pigouvian tax and subsidy policies is affected by factors such as product characteristics, market structures, and targeted results (Wang et al., 2014).

The underlying assumptions of the Pigouvian theory include the existence of economic externalities that are unaccounted for in market transactions; hence the market's inefficient allocation of resources. The theory also assumes that the tax imposed is equal to the marginal cost

of the negative externalities. Furthermore, as criticized by Weitzman (2018), the theory assumes the existence of a single externality, though multiple externalities may be present, resulting to inaccurate measurement of the marginal external cost. Other critics (Edenhofer et al., 2021; Lockwood, 2017) have also highlighted that political and social oppositions and resistance can hinder the implementation of the theory. Stern and Stiglitz (2021) argue that the more complex negative externalities may not be as simplistic as Pigou's proposed model. On the other hand, there has been considerable support for the Pigouvian theory, due to its relevance and practical application in mitigating the increasing global environmental challenges (Edenhofer et al., 2021; Borochov & Boris, 2021). The Pigouvian theory was adopted as the foundational framework for this literature review due to its relevance, simplicity, and practical applicability within the context of developing countries.

Double Dividend Theory

The double dividend theory, initially proposed by Bovenberg and De Mooij in 1994, explains the environmental and economic benefits of green tax reform (Heerden et al., 2014). It suggests that environmental taxes such as carbon tax can lead to a "double dividend" by not only reducing environmental damage but also by improving economic efficiency (Lei, 2019) such as the generation of additional revenue. The double dividend concept has been researched extensively over the years focusing on the consequences of environmental tax reform (Heerden et al., 2014). Regueiro-Ferreira and Sampedro (2022) further explained that environmental policies may cause the generation of the "green dividend", environmental improvement obtained, and the "blue dividend" such as improvements in welfare as a result of environmental revenue. Therefore, it is possible, under certain conditions, to achieve both environmental and economic objectives through carbon taxes under the double dividend theory.

2.3 Empirical Review

This section provides empirical studies that support the claim that carbon taxes and renewable energy reduce carbon emissions. However, despite its ability to reduce carbon emissions, carbon taxation is not without challenges as discussed below.

2.3.1 Carbon Emission Reduction Using Carbon Tax

Carbon tax is a significant form of environmental taxation, characterized by the imposition of charges on the carbon content of fossil fuels, with the overarching objective of curtailing carbon dioxide emissions and combatting climate change (Stechemesser & Guenther, 2012); however, its impact is not uniform across countries as a result of the unique socio-economic contexts of different countries.

Finland was the first country to introduce a CO_2 tax in 1990, closely followed by Sweden, Norway and Denmark (Akerfeldt & Hammar, 2015). Martinsson et al. (2024) carried out a study to determine whether Swedish carbon tax scheme reduces CO_2 emission. Using firm level panel data from 4,000 Swedish manufacturing firms from 1990-2015, they found that aggregate emissions of

CO_2 decreased by 31% during that time period. This result suggested that carbon taxation can account for a major part of emissions reduction. In the same vein, Hu et al. (2021) had a similar result in their study that compared the effects of China's resource tax and carbon tax policies on energy consumption, air emissions, the macroeconomy, government tax revenue, household income, and enterprise net profit. Using China's input-output table, they constructed a Computable General Equilibrium (CGE) model with simulated combined reform of the two policies (as China had no carbon tax policy in place), then compared their environmental and economic effects. The study's findings showed that the carbon tax policy had a greater impact on environmental protection and drastically decreased emissions of CO_2 and air pollutants. Additionally, carbon tax caused a decrease in the use of various energy sources, including fuel oil and coal.

The effectiveness of carbon tax implementation depends largely on the political institution, socio-economic context of the country, and fiscal flexibility of the country. Wu et al., (2024) opined that carbon taxation reduces carbon emission, negatively affect Gross Domestic Product (GDP) due to the reduction of certain fossil-fuel intensive industries, and negatively affects international competitiveness of domestic companies due to its regressivity. Studies (Andersson & Atkinson, 2020; Sagar, 2019) have shown that the carbon taxes in developed countries such as Denmark, Sweden, Netherlands, and Ireland tend to be regressive due to its effect on the poor. They argue that the tax burden falls heavily on the poor compared to the rest of the population because they tend to spend a major portion of their income on energy intensive products to meet their basic need, for example on heating and electricity (Pearson & Smith, 1991). Based on studies and the countries' experiences, it is obvious that carbon tax system designs can vary from country to country depending on the level of industrial, political, and socio-economic nature of the country.

As Africa's leading emitter of greenhouse gases (GHG), South Africa has received global attention, particularly since 2005, when its per capita emissions significantly exceeded the global average of 9 tons CO2e per person compared to the global average of 5.8 tons and six times higher than the sub-Saharan African average of 1.4 tons (World Resources Institute, 2009). In response to mounting environmental concerns, the South African government introduced the Carbon Tax Act in 2019 with the objective achieving its emissions reduction targets of 33% by 2035 (Ntombela et al., 2019). As the world's 14th largest emitter of GHGs in the African continent, South Africa's heavy reliance on coal for electricity production has led to its electricity system being among the most carbon-intensive globally. Despite ranking 17th in primary energy consumption worldwide, South Africa's carbon tax has emerged as a pivotal tool in achieving its emissions reduction commitments, though it has faced several challenges. Notably, significant exemptions and allowances were granted to energy- and carbon-intensive institutions, which constitute the primary targets of the tax. During the first phase, these exemptions covered up to 95% of emissions for all liable polluters (Baker, 2022). Occhiali (2023) argued that despite the protracted implementation process in South Africa, the carbon tax has only managed to generate a negligible portion of total revenue, amounting to a mere 0.11% in the fiscal year 2021–2022. Moreover, while its impact on emissions remains uncertain, Occhiali suggests that it is unlikely to yield significant reductions

due to the country's overdependence on coal. These challenges underscore the complex interplay between environmental policy, economic interests, and political dynamics in South Africa's efforts to mitigate climate change and reduce carbon emissions.

As of today, South Africa is the only African country out of 6 developing countries (Argentina, Colombia, Chile, Mexico, South Africa and Uruguay) that that have implemented a carbon tax. Mexico introduced a carbon tax in 2014; however, the relatively low tax rates have had minimal impact on reducing fossil fuel consumption. In, 2018, Uruguay adopted a carbon tax with an emphasis on revenue recycling and reinvestment in renewable energy projects (Rabbia, 2022). In 2019, Argentina and South Africa implemented carbon tax regimes, while Colombia and Chile initiated similar measures in 2017 (Amigo, 2020; Ntombela et al., 2019). Despite these policy efforts, these developing countries have experienced common challenges, including tax rates that are insufficient to drive significant reductions in carbon emissions, sustained reliance on fossil fuels by industrial sectors, and adverse socio-economic effects, particularly rising energy costs, that disproportionately affect their vulnerable populations (Reich et al., 2022; Mardones & Flores, 2022).

Carbon taxation has been linked to the double dividend hypothesis, positing its potential to yield dual benefits by incentivizing behaviors conducive to greenhouse gas emission mitigation, while concurrently generating revenue for governments. Such generated revenue can be earmarked for the financing of renewable energy initiatives, particularly in regions such as Africa, where an estimated 900 million individuals rely on fossil fuels for cooking and 600 million lack access to electricity (International Energy Agency [IEA], 2022).

2.3.2 Challenges of Using Carbon Taxation in Carbon Emission Reduction

The various socio-economic and political contexts of developing countries, especially the low and middle-income nations, put them in precarious situations with regards to the implementation of carbon taxation while they face socio-economic and fiscal challenges such as economic losses, disproportional income allocation, aggravated poverty level and slow implementation.

Economic Losses - Wu et al. (2024) observed that levying a Carbon tax alone resulted to GDP losses ranging from 0.39% to 3.35% from economic losses. In their study, the GDP losses due to Carbon tax, was attributed to decline in the mining sector that was highly dependent on fossil fuel. However, they found that re-investing the carbon tax revenue into renewable energy development and reduce the GDP losses from -0.94 to -0.68.

Regressivity - Dorband et al. (2019) opined that research results on the regressivity of carbon tax in developed countries appeared to be inconsistent as a result of the differences in structure, study design and methodological approach. They analyzed 87 developing and emerging countries' household expenditure Multi Regional Input-Output (MRIO) tables, determined direct CO_2 emission from fossil fuel carbon foot print, and indirect CO_2 emission from products and services for consumption from different income groups, and assessed the carbon pricing on income levels

using micro-simulation cost of maintaining current consumption with a carbon price in place. According to their findings, there was a higher likelihood of regressivity as the lowest-income households would pay tax on a larger share of their income. Consequently, they opined that, implementing a carbon price in countries with a large proportion (50% or more) of the low income group (India, Egypt, Indonesia, Benin and Nicaragua from the sample) might be in conflict with their respective poverty eradication agenda. Hence policy makers in these countries should be particularly attentive when designing carbon pricing policies. The study concluded that carbon prices tend to be regressive in middle income economies and progressive in middle to low income economies (since the disposable income of the poorest group in low income economies was reduced by less than 2.5% while the income of the poorest group in middle income economies was reduced by 3.8% to 5.5%. Therefore, the study concluded that total impact depends not only on the size of income loss to the poorest, but on the size of the poorest group as well.

Political and Administrative Challenges– In South Africa, political resistance by Eskom, a state-owned electricity utility company the successful implementation of carbon tax policies due to the perceived threat on their economic interest (Baker, 2022; Kumba & Olanrewaju, 2024). According to Black (2017) despite the effectiveness of carbon taxation in reducing carbon emission, it may not be feasible for some countries, especially in low and middle income countries (LMICs), due to lack of political buy-in and poor administrative capacity. In his study to determine countries that should implement carbon tax, he constructed and used composite indicators, a policy analysis tool, to illustrate the complex, multi-dimensional issues of carbon tax implementation by comparing countries and ranking based on carbon taxation suitability. The result of this study showed that low and middle income countries (LMICs) varied widely across carbon taxation suitability matrix reflecting the notion that carbon taxation implementation is not a one-size-fits all process. For example, Sri Lanka and India, scored very high overall but have very low political feasibility scores. Gambia and Ukraine also ranked highly overall but had low administrative feasibility scores. Ghana and Mexico, on the other hand, had high administrative scores, but moderate political and economic desirability scores. Nigeria scored poorly overall, with a very low administrative score.

The potential challenges of implementing carbon tax in Nigeria is multifaceted. Nigeria faces several administrative, social, and economic challenges in considering efficient carbon emission reduction plans such as carbon tax. Furthermore, Nigeria's inefficient tax system, without enhancement, may hinder the efficiency of a carbon tax regime, may hinder compliance and enforcement, such as inefficiencies in its tax system, a poor taxpayer database, and high rates of corruption and tax evasion (Panle & Okpara, 2021; Onanuga & Onanuga, 2019). The efficient development and execution of a carbon taxing system that can make a substantial contribution to climate mitigation initiatives may be compromised by these fundamental flaws.

2.3.3 Carbon Reduction Using Renewable Energy Adoption

The economic benefits of embracing renewable energy include the diversification of a nation's energy portfolio or energy mix, enhanced energy security, reduced outflows of foreign currency, and increased employment opportunities, and elimination of energy poverty in some developing countries (Qadri et al., 2023). Also, researchers (Kafeel et al., 2023; Bashir et al., 2020; Cheng et al., 2019) have drawn attention to the significance of renewable energy as a major energy sources in the mitigation of environmental degradation. Cheng et al (2019) investigated the impact of renewable energy on carbon emission using panel data of CO2 emissions per capita and renewable energy supply in 35 OECD countries. Similarly, Kafeel et al. (2023) studied the impact of eco-innovation, environmental taxes, and renewable energy consumption on the environmental performance of 21 OECD countries for the period 2006 to 2020. This study adopted the generalized method of moments (GMM) and instrumental variables 2 stage least square (2SLS) methods and found that increased use of renewable energy resulted to a reduction of carbon emission.

While the adoption of renewable energy sources also reduces reliance on oil imports, particularly for countries that depend heavily on such imports, it provides opportunities for economic diversification for oil-exporting nations like those in the Organization of the Petroleum Exporting Countries (OPEC) (Feng & Yang, 2023). Renewable energy is also a cheaper source of energy for developing countries where most of the population lack access to reliable electricity.

Unlike in developed countries like Germany and Sweden, adoption of renewable energy in some developing countries such as India, Malaysia, and South Africa is still quite slow due to several challenges ranging from lack of funding, over-reliance on fossil fuel, lack of public awareness and political resistance. Wind energy policies in India can be traced back to the early 80's; however, it was not until the 2000's that a series of power sector reforms created the institutional framework for renewable energy (Chaudhary, 2016). At the time, the policy focus was driven by firms' need for reliable energy supply and an upsurge in industrial development due to the manufacturing boom. Furthermore, it was during this period that climate change was mentioned in India's policies as a concern, but second to the need for energy sufficiency. As a result of the effectiveness of these policies at the time, foreign firms grew and introduced better energy technologies, creating global opportunities for the local firms that worked with them. Despite these developments in renewable energy, adoption and generation efficiency have remained slow due to the supplier market that was more interested in the policy benefits such as tax credits and tax-free sale of electricity rather that the provision of adequate power supply, hence, challenges persisted. Consequently, solar power was not deployed in India until 2009 due its high cost in comparison to coal and wind energy. As of 2019, renewable energy represented 22% of India's total energy capacity (Elvasarasan et al., 2020). Furthermore, he attributed the slow development and adoption of renewable energy in India to lack of awareness, ineffective national policies, availability of land space for renewable energy plants, and financial challenges. India is still in the process of increasing its renewable energy

capacity and generation in order to meet its Paris Agreement (2019) commitment of meeting 40% of non-fossil fuel electricity by 2030.

Malaysia's energy policies with the objective of ensuring energy stability while limiting carbon emission reduction date back to 2009. However, similar to India, and despite its significant efforts to shape its energy landscape and optimize its renewable energy potential, Malaysia's goal of 20% renewable energy-mix by 2025 appears to be unrealistic since, it had achieved only 2% of its target as of 2022 (Abd-Aziz et al., 2024). According to Lau et al. (2022), the slow pace of renewable energy development and adoption was attributed to lack of government financial support, modern renewable energy technology, low-level of public awareness, financial constraints and lack of human capacity with regards to the renewable energy processes and equipment operation. South Africa's renewable energy transition and implementation has remained slow, even after significant policy developments (Kumba & Olanrewaju, 2024). As of 2023, renewable energy accounted for only 7.3% of South Africa's total energy mix, largely due to its over-reliance on coal and other challenges such as high initial capital cost, and lack of appropriate infrastructure (Anekwe et al., 2024).

Over the last 20 years, Kenya has taken various measures including efficient energy policies and incentives and taking advantage of its geothermal energy abundance. Kenya's energy reforms from 2006 to 2019 accelerated the growth of its renewable energy technologies. As a result, while relying on external sources of funding, renewable energy increased to 88% of Kenya's energy mix in 2021 (Fields et al., 2023). The success of Kenya's renewable energy plans and policies is attributable to several factors including transparent and accessible renewable energy support schemes and policy frameworks. Kenya's vision 2030 includes achieving 100% renewable power generation.

Although Nigeria has one of the lowest GHG emission levels worldwide, it is susceptible to detrimental climate effect as it has experienced some negative effects in recent years such as increased occurrence of severe weather impacts, flooding, and high level of food insecurity (Umeh et al, 2024). In addition to this, Nigeria has been faced with the challenge of acute shortage of electricity; consequently, many households and businesses have resorted to self-generation of off-grid electricity (International Renewable Energy Agency [IRENA], 2023). According to IRENA, Nigeria electricity generation consists of 85% natural gas which is a major source of carbon emission. In an effort to meet its net-zero target and reduce energy poverty, the Nigerian Electricity Act of 2023 (the Act) was enacted into law on June 8th, 2023. The Act, which repeals the Electric Power Sector Reform Act 2005 (EPSRA), aims to consolidate the laws relating to electricity in Nigeria across the entire value chain of the Nigerian Power Sector, including the incorporation of renewable energy into Nigeria's energy mix. In addition, the Act encourages participation of state governments in the power sector and increase in private sector investment. Furthermore, the Act mandates the Ministry of Finance to introduce tax incentives that may promote and facilitate the generation and consumption of electricity from renewable energy sources. Subsequently, the

Nigerian government, in collaboration with the International Renewable Energy Agency (IRENA) launched the Renewable Energy Roadmap (REMAP) Nigeria which issues guidelines to assist Nigeria in achieving its target of 60% renewable energy power generation by 2050 (IRENA, 2023). The success of Nigeria's renewable energy transition depends largely on the effectiveness of its policies and on the mitigation of the potential challenges as experienced by other countries.

2.3.4 Carbon Taxation and Renewable Energy Adoption

The implementation of carbon taxes has been shown to have a positive influence on a country's welfare, with the potential to encourage the adoption of renewable energy sources thereby contributing to environmental sustainability (Bashir et al., 2020; Brown, 2022; Suzuki & Ishiwata). Additionally, the adoption of renewable energy policies, such as setting power purchase agreements, providing incentives, and imposing carbon taxes, play a crucial role in promoting financing and investment in renewable energy among countries (Chang et al., 2016). Furthermore, the revenue from carbon taxes can also be used to finance renewable energy technologies and subsidies for renewable energy production potentially mitigating opposition to carbon taxation.
The relationship between carbon taxes and renewable energy adoption has been explored in the context of different economies (Wu et al., 2021; Suzuki & Ishiwata, 2022). The interplay between carbon taxation and renewable energy adoption is essential for the acceleration of GHG emission reduction and the achievement of the UNSDG, specifically "Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all" and "Goal 11: Make cities inclusive, safe, resilient and sustainable".

Furthermore, as a price-oriented policy instrument, the carbon tax exerts influence on consumer behavior and spurs investment in renewable energy technologies, thereby driving environmental sustainability (Zhang, 2018). It is also important to consider the potential trade-offs and synergies between carbon tax policies and renewable energy policies because while carbon taxes and renewable subsidies are capable of reducing carbon emissions and promoting renewable energy adoption, the effect of the optimal combination of these policy instruments may vary geographically and depend on the specific characteristics of each country (Aleti, 2020; He et al., 2012).

Yin et al. (2024) in their study to examine the effect of a carbon tax on the adoption of renewable energy consumption sampled 39 economies from 1991-2019. The study considered country-specific features that do not considerably change over time and common shocks that heterogeneously influence all economies, in order to arrive at more general conclusions holding in different economies. A panel CS-ARDL (Cross-Sectional Auto Regressive Distributed Lag) model was utilized and estimated using PMG (Pooled Mean Group) methodology. The result of this study showed that relationship between carbon tax and renewable energy adoption was positively significant for the developed economies in the sample. However, for the few developing countries included in the sample, there was no impact in the short-run, and the relationship in the long run was insignificant. The study attributed this to the inefficient tax administration and corruption

control in the developing economies. In order to alleviate this challenge, Yin et al. suggested that governments may create awareness on the long-term benefits of the transition and the objectives of the carbon tax. A major shortcoming of this study is the use of unequal number of developed and developing economies in the sample. Consequently, developing countries that are seeking to promote renewable energy adoption through carbon taxation should exercise caution in adhering to the study's recommendation by taking into consideration additional country-specific factors.

Using a simulation model, Wu et al. (2024) investigated the effect of carbon tax and renewable energy investment on China's energy mix in order to ascertain whether combined carbon tax and renewable energy policies accelerated the de-carbonization of energy systems and the extent to which their implementation ultimately achieved co-benefits in terms of pollution and carbon reduction. Using a general equilibrium model (GEM), the researchers analyzed the impacts of these policies on energy transition, air pollution, and CO_2 emissions in China, and the findings revealed that complementing carbon taxation with renewable energy policies significantly reduced coal-fired power generation and fossil fuel consumption while increasing renewable energy technologies. Additionally, regional variations in the effectiveness of carbon pricing and renewable energy investments were observed, with certain regions requiring more aggressive carbon tax policies and renewable energy deployment in order to achieve substantial de-carbonization.

In their study to determine cost effective renewable energy delivery options in Sub-Saharan Africa (using Nigeria as a case study), Daggash and Mac Dowell (2021) argued that penalising GHG emissions via carbon tax did not reduce fossil fuel use, but instead increased firm operating costs. Hence they opined that by the year 2050, 77% of annual electricity generation in Nigeria would be from fossil fuels. This is contrary to the findings of the previous studies that found that carbon tax reduced the use of fossil fuel based energy. It appears that Daggash and Mac Dowell may not have considered integrating carbon tax and renewable energy policies as their conclusion was based on the independent impact of each policy.

Bhat and Mishra (2019) conducted a study focusing on the efficacy of carbon taxation in promoting the development of clean energy-intensive technologies in India. Unlike in developed countries where carbon tax proceeds are primarily directed towards environmental initiatives, in India, these funds are predominantly allocated to research and development (R&D) in energy-efficient technologies. Using the Difference-in-Difference approach, the study sought to evaluate whether the revenue generated from carbon taxation has indeed been channeled into R&D expenditures, thereby testing the validity of the "double dividend hypothesis" for carbon tax in the Indian context. The study empirically examined the actual impact of carbon taxation on research and development of energy-efficient technologies. The result confirmed that carbon tax as a policy instrument was successful in encouraging research and development in India's renewable energy sector.

Suzuki and Ishiwata (2022) concluded that carbon tax promotes the adoption of renewable energy by investigating the effect of carbon tax on the renewable energy transition in a deregulated market.

Due to the social conflicts (for example selection between fossil fuel and renewable energy) and price competition (for example, reducing selling price to gain market share) among energy companies, the study used an online experimental approach with a multi-player game. The game participants for the online experiment included 56 students from the University of Tsukuba. Using In-game and post-game surveys, the experiences of participants were examined and the result showed that carbon taxation encouraged usage of renewable energy in the second half of the game unlike the first half of the game that showed no impact. This suggested that although the assessment of carbon tax ultimately affected the behavior of market players, the carbon tax information that they received initially did not change their behavior. Consistent with the findings of Yin et al. (2024), the impact of carbon tax implementation may be negligible in the short term but is likely to become more pronounced over time.

Existing literature (Dorband et al., 2019; Wang et al., 2016; Shang, 2023) has predominantly focused on projecting the potential impact of climate policies, with limited attention to the actual socio-economic effects of carbon taxation, particularly in developing low-income economies. Discussion notes of the Committee of Experts on International corporation in Tax Matters (2019) reported that carbon tax implementation is still scarce and limited in developing countries as it still faces considerable public and political resistance, and there are various ways of designing carbon taxation and revenue recycling schemes based on the country's emission profile, energy and tax policy objectives, capacity of tax administration and climate risk profile. Prize (2020) argues that carbon tax can be challenging to implement because it has the potential to aggravate poverty by increasing prices of basic goods and services, for example food, energy, and transportation. Furthermore, he was unable to determine wether international mandates or revenue potential were driving the adoption of carbon tax in low-income economies. Due to the paucity of studies, as mentioned earlier, it is difficult to assess the true impact of carbon tax on developing economies as the few countries that have adopted it have had it in operation for less than ten years. In concordance with Roz (2020), Occhiali (2023), maintains that Sub-Saharan African economies are not economically or administratively prepared for carbon tax implementation as these countries are still struggling with issues of poverty and unemployment, although the issue of environmental degradation has become an increasingly salient political issue worldwide.

In order to promote renewable energy adoption in low-income developing countries, a comprehensive approach that considers the interaction between carbon taxation policies, renewable energy subsidies, and other policy instruments is essential. This approach should consider the unique economic, social, and environmental contexts of low-income countries in order to ensure that the policies are effective, equitable, and conducive to sustainable development. It is important to note that the impact of carbon taxes on energy consumption and sustainable development has not been extensively studied in developing countries (Hartono et al., 2023), though it is evident that the design and implementation of effective climate policy mixes, including carbon taxes and renewable energy subsidies, are crucial for achieving effective and sustainable energy transitions (Bergh et al., 2021). However, the distributional effect of a carbon tax on income

and its implications for sustainable development should be carefully evaluated to ensure that it does not disproportionately affect vulnerable populations in developing countries (Feng et al., 2020).

3.0 BALANCING CARBON TAXATION, RENEWABLE ENERGY ADOPTION AND SOCIO-ECONOMIC DEVELOPMENT

Historically, developing countries have viewed environmental concerns as a lower priority compared to economic development, maintaining that mitigating efforts should not hinder economic development (De Guevello et al., 2019). However, some of these developing countries such as China, South Africa, Mexico, and Nigeria have adopted, or are considering adopting carbon pricing due to the increasing adverse effects of climate change. The devastating impact of climate change has prompted Nigeria and other developing nations to embark on the path to GHG emission reduction by committing to net-zero by mid-century. Notwithstanding, Occhialli (2023) argues that environmental concerns, though a salient issue, are not considered priority over socio-economic issues such as poverty and unemployment in developing countries.

Nigeria recently committed to a net zero emissions target by 2060 at the Conference of Parties (COP26) in Glasgow in 2021. As a result of this commitment, the Nigerian Climate Change Act was enacted in October 2021, followed by the Electricity Act of 2023 which was enacted on June 8th, 2023. Section 164 of the Electricity Act provides for the development of renewable energy while Section 166, subsection 1, provides for a fiscal policy framework to foster its implementation. In February 2023, the Nigeria National Council on Climate Change (NCCC) announced its plans to develop a carbon pricing mechanism for carbon tax and carbon trading, in line with the Climate Change Act 2021.

Balancing carbon taxation, renewable energy adoption, and socio-economic development in developing countries requires a harmonious and inclusive approach that addresses the unique challenges and opportunities within their socio-economic landscape. Research shows that some of the measures adopted to ensure effective implementation of carbon tax and renewable energy without compromising socio-economic development include

designing effective and efficient policy design to mitigate the negative impacts of carbon taxation. This requires a thorough understanding of how carbon taxation affects the households, workers and their communities (De Guevello, 2020).

Nigeria remains one of the world's largest gas-flaring nations that is heavily reliant on oil and gas revenues, which poses a significant barrier to effective decarbonization (Okoroafor et al., 2024). That notwithstanding, carbon taxation may offer a dual opportunity by serving as both a climate mitigation tool and a revenue source for financing investments in renewable energy infrastructure and energy-efficient technologies. Concurrently, renewable energy development can promote greater energy access and stimulate socio-economic development, particularly in low-income countries.

Revenue Re-cylcling

A common theme across studies conducted on developing countries was the adverse impact of carbon taxation on the poor (Wang et al., 2016; Gutierrez, 2017; Vogt-Schilb et al., 2019; Dorband et al., 2019; Steckel et al., 2021; Martinsson et al., 2024). In 2019, Vogt-Schilb et al. sought to find out how governments of 16 Latin America and Caribbean countries could mitigate the negative consequences of carbon tax and found that recycling the revenues back to households had a progressive income effect and reduced inequality. Shang (2023) added that carbon tax may affect poverty and inequality through other channels such as consumption, income, and health. Based on the findings of Vogt-Schilb, Bhat and Mishra (2019) it is recommended that developing economies recycle carbon tax revenues through lump-sum pay-outs, or reductions in other distortionary taxes such as labour and capital to mitigate the adverse effects. However, in countries with weak institutional frameworks, alternative forms of credits may be preferable, as lump-sum payments could be vulnerable to corruption.

Policy Integration

Integrating carbon taxation and renewable energy policies ensures coherence and alignment with socio-economic development goals, and prevents duplication and overlapping of policies that could lead to multiple taxation and further exacerbation of poverty (Gutierrez, 2020). Such areas of integration include policy incentives such as tax incentives and subsidies that encourage renewable energy adoption, and make renewable energy accessible and affordable.

Policy Mapping and Analysis

According to De Guevello (2020), mapping of country specific policy objectives is necessary to design efficient and effective policies and instruments in order to identify existing and potential synergies and conflicts. Additionally, analyzing interactions between carbon tax and renewable energy policies based on international experiences to help identify potential conflicts, and developing respective integration policies.

Ex-Ante Simulation Modelling

Furthermore, using Computed General Equilibrium (CGE) models to identify economy-wide impacts of the policies help to provide macro-economic feed-back on potential impacts of carbon tax and renewable energy policies. Gutierrez (2020) investigated the interaction between carbon tax policies and renewable energy policies and concluded that the policies were complementary and not overlapping. The study concluded that since the objectives of both policies differed, though with carbon emission reduction as the ultimate impact. The goal of carbon taxation in Columbia was GHG reduction while the goal of renewable energy was energy security (as a result of extreme climate events such as El Nino); furthermore, he argued that even if both policy instruments had the primary goal of reducing GHG emission, their interaction would be overlapping, hence

implementation of carbon tax and adoption of renewable energy requires more caution and nuance during policy design.

4.0 CONCLUSION AND WAY FORWARD

The relationship between carbon taxation and renewable energy adoption underscores the pivotal role of fiscal policies in promoting sustainable development. While empirical evidence suggests the effectiveness of carbon taxes in reducing carbon emissions and fostering renewable energy adoption, challenges persist, particularly in economically challenged nations. A balanced policy framework that addresses environmental concerns while considering socio-economic realities is imperative for achieving sustainable outcomes in developing countries. Furthermore, a comprehensive policy approach that integrates environmental taxes with other supportive measures such as tax and renewable energy incentives may be necessary to effectively engender renewable energy adoption without compromising economic development in developing countries. It is important to note that limitations of the simulation models used in the studies reviewed include lack of data from developing countries, the models' inability to accurately mimic the real life systems, high level of assumptions, and the potential to generate incorrect results if not thoroughly validated and verified. Thus, reliance on the results may require some level of validation with comparable real-world data.

Developed countries should expedite funding to developing economies to support in strengthening institutional capacity and technological capabilities for effective implementation of carbon taxation policies and the adoption of renewable energy. Additionally, developing countries should ensure political commitment towards initiating and maintaining carbon tax and renewable energy policies, fostering of public trust, and continuous monitoring and evaluation of policy effectiveness. This will enable the identification of areas of improvement and adjustment, necessary adjustments, ensuring the efficient and effective implementation of carbon taxation and renewable energy initiatives.

5.0 RECOMMENDATION

In order to mitigate the negative effects of climate change while considering the implementation of carbon tax and transition to renewable energy, governments of developing countries should design carbon tax policies that are sensitive to the socio-economic conditions of their respective countries while exercising caution during policy design. Policy designs should support specific groups that may be adversely impacted by the new tax. Also, some proceeds from carbon taxes should be earmarked for research and development in renewable energy technologies in order to further encourage adoption, and some should be re-distributed to poor households in the form of cash transfers, social welfare, or subsidies in order to alleviate the adverse income effect. Governments should incentivize investment in clean energy infrastructure by providing tax incentives and tax exemptions to encourage transition away from fossil fuels. In While these

incentives are often employed to attract investment, they can lead to significant revenue losses if not properly managed (James, 2013). The key challenge lies in balancing tax revenue with tax expenditures to ensure sustainable economic growth.

Nigeria has struggled to optimize its tax revenue potential due to extremely low tax compliance and an over-reliance on oil revenue (OECD, 2021). Additionally, the country has a large informal economy that remains largely untaxed, further exacerbating revenue shortfalls (Medina & Schneider, 2018). To mitigate the issue of excessive tax incentives, Nigeria must focus on increasing tax compliance through improved enforcement mechanisms, digitalization, and taxpayer education (IMF, 2022).

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