

UNIVERSITY OF GHANA

COLLEGE OF HUMANITIES



UNIVERSITY OF GHANA

**PROMOTING SUSTAINABLE ENERGY TRANSITION: ASSESSING THE
INTERPLAY OF ENVIRONMENTAL TAXES, ENERGY AID, AND GOVERNANCE
QUALITY**

BY
ENUSAH ABDULAI
(10599125)

THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON, IN PARTIAL
FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF DOCTOR OF PhD IN

ACCOUNTING DEGREE

AUGUST 2023

DECLARATION

I, Enusah Abdulai, hereby declare that this work is an independent account of my research conducted under the supervision of Dr. Francis Aboagye-Otchere and Dr. Cletus Agyenim-Boateng of the Department of Accounting, University of Ghana Business School. This thesis has not been submitted wholly or partly for any award at any other institution. I confirm that all references cited and ideas taken from other people's works have been fully acknowledged. I, therefore, accept personal responsibility for any mistakes that may be included in this report.



October 23, 2023

ENUSAH ABDULAI

(10599125)

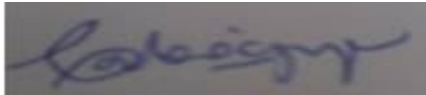
(STUDENT)

DATE



CERTIFICATION

We certify that this thesis was supervised under procedures laid down by the University of Ghana.



.....
PROF. FRANCIS ABOAGYE-OTCHERE
(LEAD SUPERVISOR)

October 23, 2023

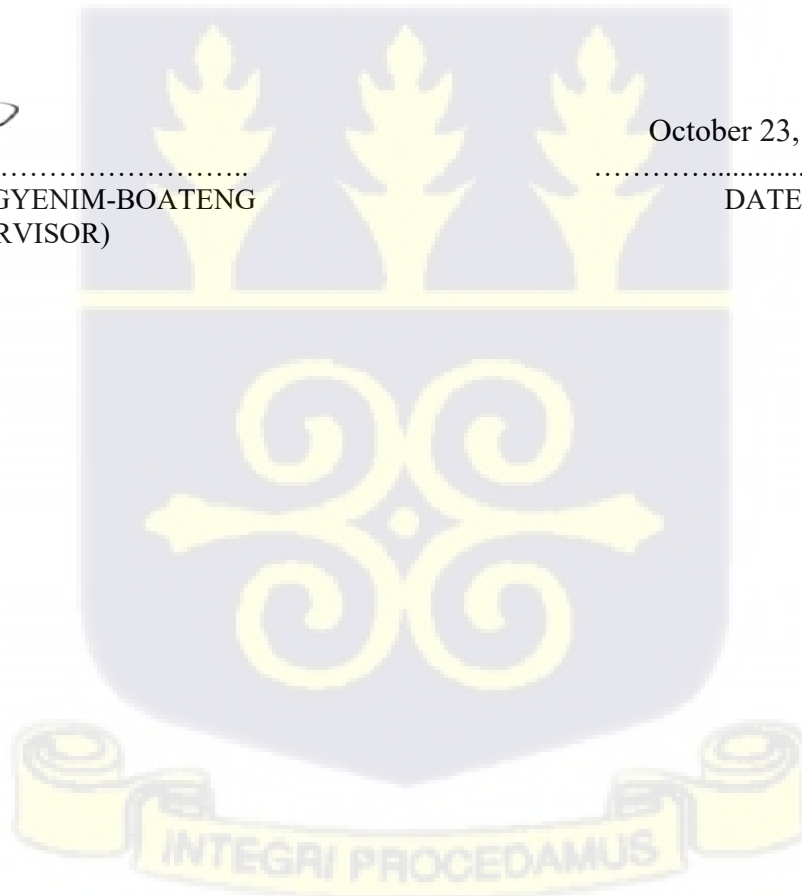
.....
DATE



.....
DR. CLETUS AGYENIM-BOATENG
(SUPERVISOR)

October 23, 2023

.....
DATE



DEDICATION

I dedicate this thesis to the author and finisher of my faith, the Lord Jesus Christ, my Lord and Savior. I also dedicate this work to my mother, Salamatu Enusah, my late father, Bienle Enusah, and the Enusah family.



ACKNOWLEDGEMENT

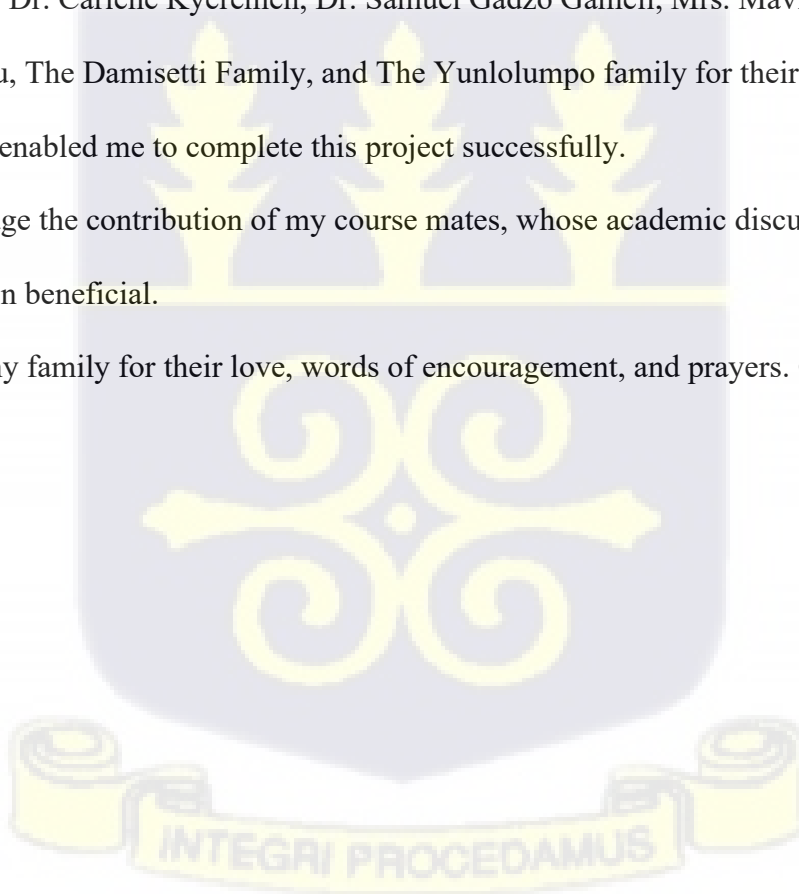
I would like to express my deep gratitude to my supervisors, Dr. Francis Aboagye-Otchere and Dr. Cletus Agyenim Boateng, for their invaluable mentorship, time, and support throughout the study.

I also thank all the lecturers and staff of the Department of Accounting, University of Ghana Business School, for their assistance. I appreciate the help of Ms. Alice Anima Aboagye, Dr. Ekoa Aryee, Mrs. Rhoda Atitsogbui, and Mr. Isaac Elton

I am indebted to Dr. Mark Boadu, Rev. Dr. Samuel Donkor, Mrs. Cynthia Aboagye-Otchere, Dr. George Sarpong, Dr. Carlene Kyeremeh, Dr. Samuel Gadzo Gameli, Mrs. Mavis Pobi, and Mr. Sulemana Iddrisu, The Damisetti Family, and The Yunlolumpo family for their encouragement and support that enabled me to complete this project successfully.

I also acknowledge the contribution of my course mates, whose academic discussions and other support have been beneficial.

Lastly, I thank my family for their love, words of encouragement, and prayers. God richly bless you all.



ABSTRACT

Fossil fuel consumption, a leading cause of climate change and environmental degradation, necessitates a shift towards cleaner and more sustainable energy sources. However, energy transition is not without its challenges, including financial constraints, policy design, and governance deficiencies. To address these issues, nations have adopted environmental fiscal policies such as environmental taxes and energy development assistance, while also concentrating on enhancing the robustness of governance structures. This thesis explores the impact of these measures on the energy transition process through three related research papers. The first paper assesses the effects of carbon tax policy on energy transition-related environmental and socio-economic outcomes using a quasi-experimental design. The second paper investigates the impact of energy development assistance and governance quality on environmental tax efforts in Sub-Saharan Africa using instrumental variable regression techniques. The third paper examines the threshold effects of energy development assistance on energy transition efficiency, with a focus on the role of accounting and governance quality. Key findings include that carbon tax policy can promote energy transition by reducing emissions from energy consumption, improving energy intensity, increasing renewable energy adoption, and enhancing welfare. Additionally, findings suggest that energy development assistance should be context-specific, complementary, and coherent to support environmental taxation and the energy transition of aid recipient countries. Similarly, the findings reveal that energy development assistance can be effective if used in moderation and in conjunction with good accounting and governance practices. These findings have important policy implications for countries seeking to transition to cleaner and more sustainable energy sources.

TABLE OF CONTENTS

CERTIFICATION	ii
DEDICATION	iii
ACKNOWLEDGEMENT	iv
TABLE OF CONTENTS	vi
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF ABBREVIATIONS	xii
CHAPTER ONE	1
INTRODUCTION	1
1.1 Background of the Study	2
1.2 Environmental Fiscal Policies	8
1.3 Governance Effectiveness	9
1.4 Environmental Fiscal Policies and Socio-Economic Welfare	10
1.5 Environmental Fiscal Policies and Energy Transition in Developed Countries	11
1.6 Environmental Fiscal Policies, Governance, and Energy Transition in Developing Countries	13
1.7 Problem Statement	17
1.7.1 Carbon Tax Policy and Energy Transition Pathways	17
1.7.2 Energy Development Assistance, Governance, ERT, and Energy Transition	20
1.7.3 Theoretical tensions in energy transition	24
1.8 Research Purpose and Objectives	26
1.9 Significance of the Study	27
1.9.1 Significance to Theory	27
1.9.2 Significance to Policymaking	28
1.9.3 Significance to Practice	30
1.10 Overview of Research Methodology	31
1.10 Structure of this Thesis	33
CHAPTER TWO	35
CARBON TAX POLICY ADOPTION AND ENERGY TRANSITION IN THE EU: A QUASI-EXPERIMENTAL ASSESSMENT	35
Abstract	36
1.0 Background	37
2.1 Carbon Tax Policy in the EU Context	40
2.2 Environmental Double Dividends and a Just Energy Transition	42

2.3 Carbon Tax Policy and Energy Intensity of GDP	44
2.4 Carbon Tax Policy and CO2 Emissions Per Energy Use.....	45
2.5 Carbon Tax Policy and Renewable Energy Adoption	45
2.6 Carbon Taxes and Socio-Economic Welfare	46
3. Methodology	48
3.1 Variable Definitions.....	49
3.1.1 Independent variable	49
3.1.2 Dependent variables.....	49
3.1.3 Covariates	49
3.2 Empirical Strategy	50
3.2.1 Robustness Checks.....	52
4. Preliminary Analysis.....	53
4.1 Parallel Trend Analysis.....	56
5. Empirical Results	57
5.1 CO2 per Energy Use	59
5.2 Energy Use per GDP.....	60
5.3 Installed Renewable Capacity.....	60
5.4 Human Development Index	61
6. Robustness Checks.....	62
7.1 Conclusions and Implications	64
7.1.1 The Special Case of Developing Countries	67
7.2 Research Limitations	68
CHAPTER THREE	69
THE EFFECT OF ENERGY DEVELOPMENT ASSISTANCE AND GOVERNANCE QUALITY ON ENVIRONMENTAL TAX EFFORT IN SUB-SAHARAN AFRICA.....	69
Abstract.....	70
1. Background.....	71
2. Literature Review.....	74
2.1 Energy Aid and Environmental Tax Effort.....	74
2.2 Governance Quality and Environmental Tax Effort	76
2.3 Control Variables and Environmental Tax Effort.....	77
3. Methodology	79
3.1 Definition of Variables.....	80
3.2 Model Specification and Estimation	81
3.2.1 Robustness Checks.....	84
3.3 Diagnostic Tests.....	85
4. Empirical Results and Discussion.....	89

4.1 Descriptive Statistics.....	89
4.2 Baseline Regression Results: IV-GMM.....	96
4.2.1 EDA and Climate Change Tax Effort.....	96
4.2.2 EDA and Air Pollution Tax Effort.....	97
4.2.3 EDA and Aggregate Environmental Tax Effort.....	98
4.2.4 Governance Quality and Environmental Tax Effort.....	99
4.2.5 Control Variables and Environmental Tax Effort.....	100
4.3 Asymmetric Analysis and Time-Varying Granger Non-Causality.....	102
5. Conclusion and Policy Implication.....	105
5.1 Low Income SSA Countries.....	106
5.2 Middle Income SSA Countries.....	107
6. Research Limitations.....	109
CHAPTER FOUR.....	110
THRESHOLD EFFECTS OF ENERGY DEVELOPMENT ASSISTANCE ON ENERGY TRANSITION EFFICIENCY: THE ROLE OF GOVERNANCE EFFECTIVENESS.....	110
Abstract.....	111
1.1 Introduction.....	112
1.2 Nonlinear Effects of EDA on RETEF: Theoretical Perspectives.....	115
1.3 Accounting and Governance Effectiveness and Foreign Aid.....	116
1.4 Absorptive Capacity and the Interacting Role of AGE.....	117
1.5 Conceptual Model.....	119
2.0 Methodology.....	120
2.1 Data.....	120
2.2 Measurements and Preliminary Analysis.....	121
2.2.1 Measurement of Renewable Energy Transition (RET) Progress.....	121
2.2.3 Measurement of Renewable Energy Transition Efficiency (RETEF).....	127
3. Regression Analysis.....	131
3.1 Regression Model Specification and Estimation.....	132
3.1.1 MTNARDL Model Specification.....	134
4. Preliminary Analysis.....	136
3.2 Unit Root Test.....	137
4. Empirical Results and Discussion.....	139
4.1 The Relationship between EDA Regimes and RETEF (Model I).....	139
4.2 The Interaction Effect of AGE and Higher EDA Levels (Model II).....	144
5.0 Conclusions.....	147
CHAPTER FIVE.....	154
CONCLUSION.....	154

5.1 Overview.....	155
5.2 Summary of Policy Implications.....	157
5.2.1 Chapter Two (Paper 1) Policy Implications.....	157
5.2.2 Chapter Three (Paper 2) Policy Implications.....	161
5.2.3 Chapter Four (Paper 3) Policy Implications.....	162
5.3 Key theoretical contributions of the study	163
5.4 Limitations of the Thesis.....	165
5.5 Directions for Further Studies.....	165
REFERENCES	167



LIST OF TABLES

Table 2. 1: EU Carbon Tax Status as of 2019.....	41
Table 2. 2: Descriptive Statistics.....	53
Table 2. 3: Pairwise correlations.....	55
Table 2. 4: CS-DiD: Panel A: CS-NT Result Panel B: CS-YT Result	58
Table 2. 5 Bacon Decomposition.....	62
Table 3. 1: General Diagnostics Tests	85
Table 3. 2: Instrumental Variable Diagnostic Tests.....	86
Table 3. 3: Stationarity and Cointegration Tests.....	88
Table 3. 4: Descriptive Statistics.....	90
Table 3. 5: Pairwise Correlation	92
Table 3. 6: Regression Estimates (IV-GMM).....	96
Table 3. 7: Smoothed Instrumental Variable Quantile Regression Estimates	104
Table 3. 8: Time-Varying Granger Non-Causality Test	105
Table 4. 1 :RET Progress.....	124
Table 4. 2: Renewable Energy Transition Efficiency Index (2000-2019).....	130
Table 4. 3: Descriptive Statistics of Regression Sample.....	136
Table 4. 4: Unit Root Test.....	138
Table 4. 5 Model I Results.....	140
Table 4. 6: Model II Results	145

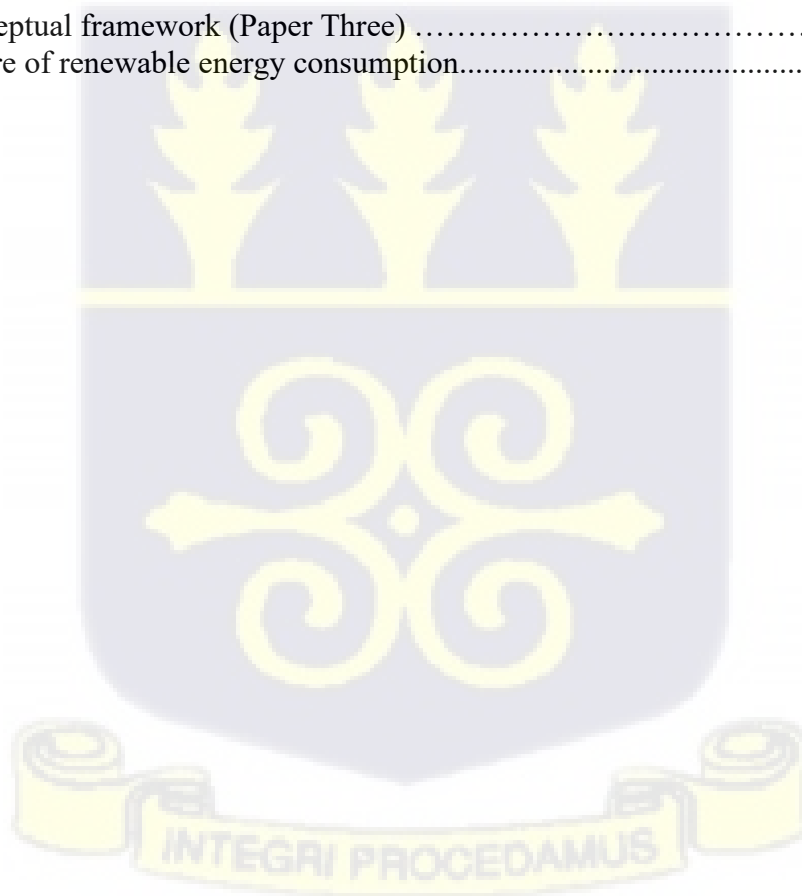
LIST OF FIGURES

Figure 1. 1: Global Trend in Energy-Related Greenhouse Gas Emissions (GHGe) 3
Figure 1. 2: OECD Decoupling Trend..... 5
Figure 1. 3: Flow of Energy Development Assistance by Renewable Technology-Africa..... 14

Figure 2. 1: Research Framework..... 47
Figure 2. 2: Visual Inspection of Parallel Trends 57
Figure 2. 3: Goodman-Bacon Decomposition Results 64

Figure 3. 1 Visualization of Mean values of Key Variables 95

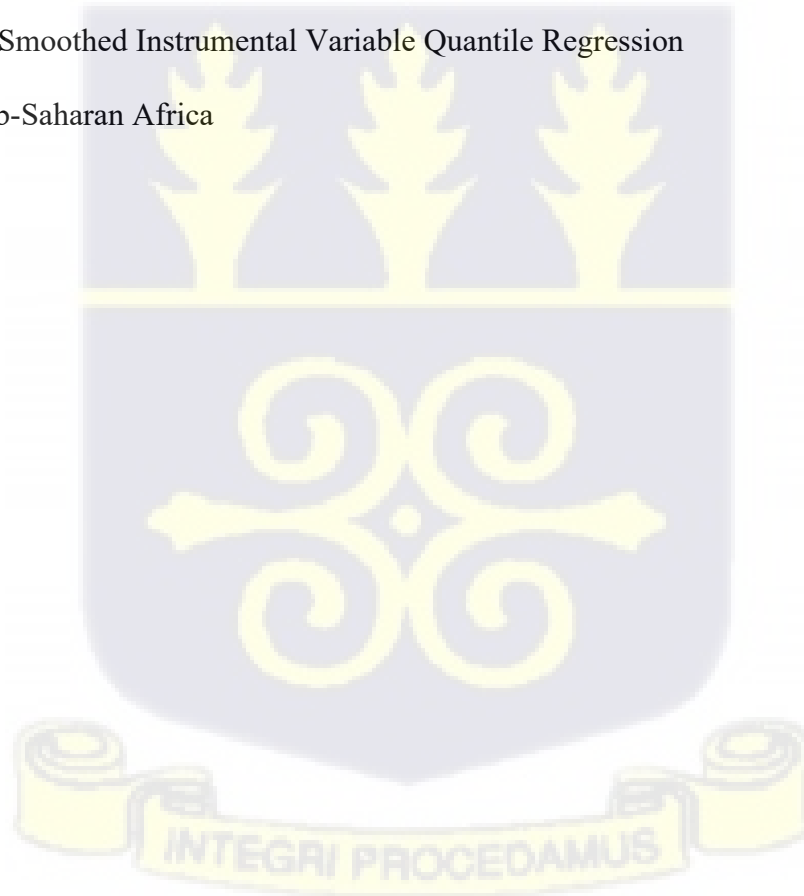
Figure 4.2 Conceptual framework (Paper Three)119
Figure 4. 1: Share of renewable energy consumption..... 126



LIST OF ABBREVIATIONS

1. AETE: Aggregate Environmental Tax Effort
2. AGE: Accounting and Governance Effectiveness
3. AI: Artificial Intelligence
4. APTE: Air Pollution Tax Effort
5. ATT: Average Treatment Effect on the Treated
6. CCTE: Climate Change Tax Effort
7. CO₂: Carbon Dioxide
8. CO₂e: Carbon Dioxide Emissions
9. CSDiD: Callaway and Sant'Anna Difference in Difference
10. DA: Development Assistance
11. DEA: Data Envelopment Analysis
12. DiD: Difference in Difference
13. EDA: Energy Development Assistance
14. ERT: Environmentally Related Taxes
15. ETS: Emissions Trading System
16. EU: European Union
17. GHG: Greenhouse Gass
18. GHGe: Greenhouse Gas Emissions
19. GDP: Gross Domestic Product
20. IEA: International Energy Agency
21. IMF: International Monetary Fund
22. IRENA: International Renewable Energy Agency (IRENA)

23. IV-GMM: Instrumental Variable Generalized Method of Moments
24. LIC: Low Income Countries
25. LMIC: Lower Middle-Income Countries
26. MDG: Millennium Development Goal
27. MTNARDL: Multiple Threshold Nonlinear Autoregressive Distributed Lag
28. OECD: Organization for Economic Co-operation and Development
29. RET: Renewable Energy Transition
30. RETEF: Renewable Energy Transition Efficiency
31. SDG: Sustainable Development Goal
32. SIVQR: Smoothed Instrumental Variable Quantile Regression
33. SSA: Sub-Saharan Africa



CHAPTER ONE

INTRODUCTION



1.1 Background of the Study

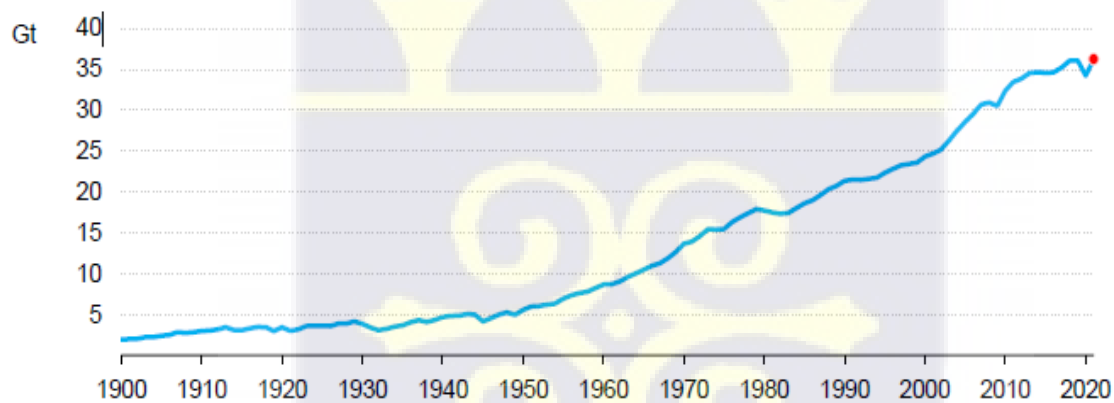
The call for a sustainable energy transition has never been louder in the face of the environmental threats posed by carbon-intensive energy consumption. However, the high costs associated with energy transition and governance challenges are significant barriers. This study delves into the role of environmental taxation, governance, and Energy Development Assistance (EDA) in facilitating energy transition pathways. In this regard, the study explores two key energy transition pathways: (1) the environmental pathway, focusing on energy efficiency and renewable energy adoption; and (2) the socio-economic pathway, which considers the human welfare implications of energy transition, often referred to as just energy transition. Furthermore, the study scrutinises the interplay between these three variables by examining how EDA and governance quality influence the environmental tax efforts of countries that receive EDA. Environmental tax effort is the ratio of environmental tax revenues to GDP.

Energy issues are prominent in the Sustainable Development Goals (SDGs), as SDG 7 aims to ensure access to affordable and clean energy for all. This goal reflects the urgent need to reduce energy-related pollution, which contributes more than two-thirds of global greenhouse gas emissions (see Figure 1.1) and causes climate change, food insecurity, and health risks (Cheng et al., 2021a; Ge et al., 2020; International Renewable Energy Agency, 2021). For example, statistical estimates suggest that greenhouse gas emissions (GHGe) from fossil energy consumption were linked to about one in five deaths worldwide in 2018 (Green, 2021; Jackson et al., 2022; Milman, 2021; Vohra et al., 2021). Besides, numerous studies have demonstrated the direct link between air pollution from fossil fuel combustion and a range of health issues, including respiratory diseases, cardiovascular problems, and increased mortality rates (Green, 2021; Jackson

et al., 2022; Milman, 2021; Vohra et al., 2021). Beyond the immediate public health concerns, the long-term environmental impact of fossil energy-related emissions is equally alarming. The accumulation of greenhouse gases in the atmosphere is driving climate change, leading to more frequent and severe weather events, rising sea levels, and ecosystem disruption (Green, 2021; Jackson et al., 2022; Milman, 2021; Vohra et al., 2021). These changes threaten food and water security, biodiversity, and the overall sustainability of our planet, with far-reaching consequences for both current and future generations. To make matters worse, the adverse effects disproportionately impact vulnerable populations, further exacerbating global inequities.

Regardless of these harmful effects fossil energy, the World Energy Outlook Report (2017) projects that its consumption will grow by 50% between 2016 and 2050.

Figure 1. 1: Global Trend in Energy-Related Greenhouse Gas Emissions (GHGe)



Source: IEA (2021)

The escalating consumption of fossil fuels and their associated GHGe is primarily due to the coupling of economic activities with fossil energy consumption (Girouard, 2021; Krane, 2017; Olson & Lenzmann, 2016; Vohra et al., 2021). The term “coupling” means that the growth and operations of economic activities are directly linked to, or dependent on, fossil energy

consumption. As economic activities increase, so does fossil energy consumption, leading to increased GHGe (Chen et al., 2017; Khan et al., 2023; Wei et al., 2020).

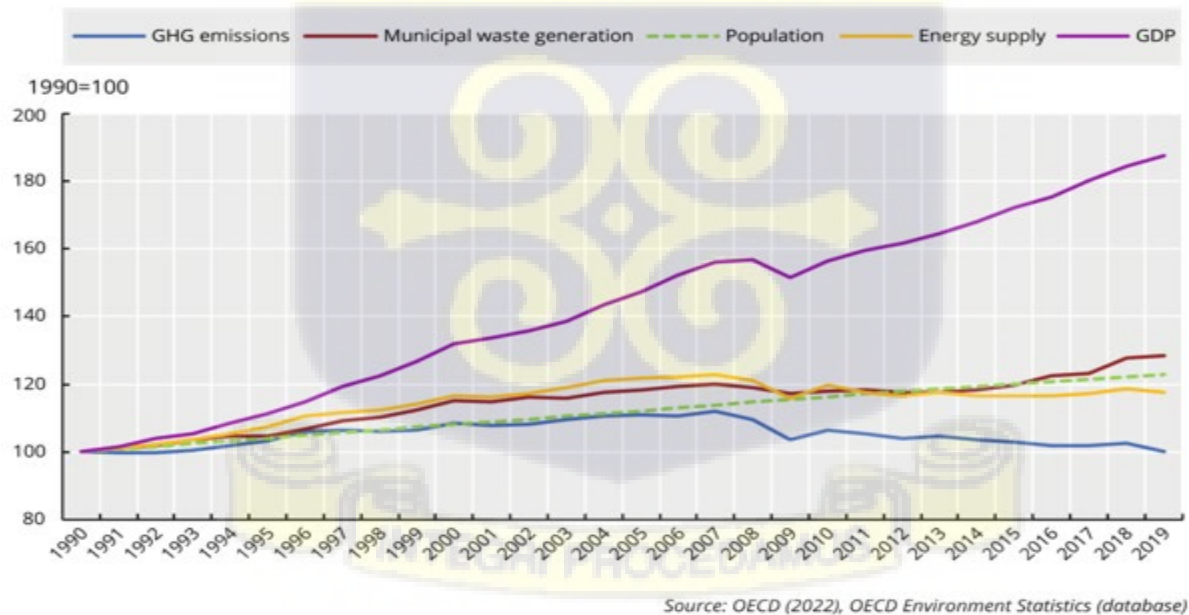
In recent decades, developing nations that experienced significant economic growth and poverty reduction have concurrently experienced increased carbon emissions from fossil energy consumption (Davey, 2022; Khan et al., 2023; Wei et al., 2020). In East Asia and the Pacific region, an 85% decrease in extreme poverty from 1981 to 2011 coincided with an 185% surge in carbon dioxide emissions (CO₂e) related to fossil fuels (Davey, 2022; Goldstein & Goldstein, 2015; Skipper, 2022). Similarly, in South Asia, a reduction of extreme poverty by 30% was accompanied by a 204% increase in CO₂e (Davey, 2022; Skipper, 2022). In stark contrast, Sub-Saharan Africa witnessed a 98% increase in impoverished individuals, while fossil energy-related CO₂e declined by 17% (Davey, 2022; Goldstein & Goldstein, 2015; Skipper, 2022). Following this trend, developing countries must increase energy-related CO₂e to escape extreme poverty and improve their economies. However, this approach is not sustainable for the environment or long-term economic development. Therefore, the challenge is to answer the golden question, "How can we achieve economic development while reducing negative energy-related environmental impacts?". This question draws a lot of skepticism for several reasons.

Historically, economic development has been closely tied to the availability and utilization of cheap and abundant fossil fuels, such as coal, oil, and natural gas. These energy sources have enabled industrialization, transportation, and the expansion of various economic activities that have driven economic growth. Replacing this deeply entrenched fossil energy-based infrastructure and economic model with more sustainable alternatives requires substantial investments, technological advancements, and profound structural changes, all of which can be politically,

economically, and socially challenging. Another key factor contributing to the difficulty in decoupling is the inertia and path dependence of existing energy systems and technologies. Fossil fuel-based infrastructure, such as power plants, transportation networks, and industrial facilities, often have long operational lifespans, making it challenging to rapidly transition to alternative energy sources. The significant sunk costs and vested interests in the fossil fuel industry create strong incentives to maintain the status quo, further hindering the adoption of low-carbon technologies.

Notwithstanding the challenges, the Organisation for Economic Co-operation and Development (OECD) has proven over the past 30 years that promoting renewable energy sources and improving energy efficiency can help decouple the interdependencies between carbon emissions and economic growth (Khan et al., 2023; Luo et al., 2020; Zhang et al., 2021; Girouard, 2021).

Figure 1. 2: OECD Decoupling Trend



The graph in Figure 1.2 elucidates the OECDs decoupling of economic growth (Gross Domestic Product- GDP) from environmental impact (GHG emissions and energy supply). From 1990 to 2008, the trend lines for GDP growth, energy supply, and GHGe exhibit a trend called relative decoupling (Girouard, 2021). Thus, during this period, both GDP and environmental impact indicators increased, but the GDP growth rate surpassed that of the environmental impact indicators. For instance, when we compare the rising purple line of GDP alongside the blue line that denotes GHGe, it is clear that the increase in GDP was more pronounced than the increase in emissions. This suggests a relative decoupling, a trend that was observed until 2008.

Post-2008, the graph shifts towards absolute decoupling (Girouard, 2021). This is characterised by continued GDP growth while environmental impact indicators decrease. This trend signifies that economic growth was achieved alongside a reduction in environmental impact. Therefore, it is possible to increase productivity while simultaneously minimising energy consumption and energy-related emissions.

The Head of the OECD's environmental division, Nathalie Girouard, stated that increasing energy efficiency and the share of renewable energy in the total energy supply were crucial for achieving decoupling in the OECD region (Girouard, 2021). Thus, the OECD attained decoupling through energy transition, which is the shift from traditional energy sources (i.e., fossil fuels) to more efficient and low-carbon alternatives (IEA, 2021; Wang & Wang, 2020; Yang et al., 2022). Energy efficiency refers to using less energy to provide the same amount of useful output from a service, while renewable energy adoption is the shift from fossil-based systems to renewable energy sources like wind, solar, lithium-ion batteries, and hydropower (Mahi et al., 2021; Patterson, 1996; Shove, 2018). Both pathways are relevant in achieving sustainable energy transition and reducing

energy-related environmental harm, such as GHGe, air pollution, and the degradation of natural resources (Girouard, 2021; Mahi et al., 2021; Patterson, 1996; Shove, 2018).

Empirically, it is confirmed that renewable energy sources are more efficient and carbon-neutral relative to fossil-based energy systems (IEA, 2021; Li et al., 2022; Yang et al., 2022). For instance, the IEA (2021) suggests that every 1 Gigawatt (GW) of extra solar capacity can reduce CO₂e by 3.3 million tons a year. Similarly, hydropower is currently the most prevalent renewable source, constituting 78% of the world's renewable energy generation (Killingtveit, 2019; Shahsavari & Akbari, 2018). Statistical reports also suggest that the consumption of hydropower energy has helped the world avoid over 100 billion tons of CO₂e over the last 50 years (International Hydropower Association, 2022). From these discussions, energy transition offers the most promising pathway to achieve carbon neutrality (Girouard, 2021; IEA, 2021; Wang & Wang, 2020; Yang et al., 2022).

Notwithstanding the relevance of energy transition pathways in achieving carbon neutrality and sustainable development, the costs of implementing these pathways are prohibitive (IEA, 2021; International Renewable Energy Agency-IRENA, 2022; Olabi & Abdelkareem, 2022). Worse of all, nations that account for more than half of global CO₂e are those with severe funding gaps to implement the energy transition pathways (Pueyo, 2018; Schwerhoff & Sy, 2017; World Energy Outlook Report, 2021). These funding challenges are acknowledged in the World Energy Outlook Report (2021, p. 18), as it claims that lack of funding constitutes “the missing link to accelerate clean energy deployment.”

To this extent, the accounting discipline can play an essential role in addressing the funding gaps and promoting energy transition through governance and environmental fiscal policies in the form of environmental taxation and EDA (Ahonen et al., 2022; Andrew et al., 2010; Bebbington &

Unerman, 2018; Bebbington & Unerman, 2020).

1.2 Environmental Fiscal Policies

Environmental fiscal policy leverages government spending and taxation to influence the environmental impact of economic activities (Dafermos & Nikolaidi, 2019; Petrie & Petrie, 2021). Using environmental taxes to curb pollution and support energy transitions is grounded in the theory of environmental externalities. This theory posits that certain economic activities have costs (e.g., pollution) or benefits not accounted for in their market prices, known as externalities (Baumol & Oates, 1988; Meade, 1973; Pigou, 1920). These externalities impact third parties not directly involved in economic activity. For example, burning fossil energy creates greenhouse gas emissions that harm the environment and human health, but these costs are not paid by the producers or consumers of fossil fuels (Ediger, 2019; Xia et al., 2022). Therefore, environmental taxes internalise these externalities by making the polluters pay for the damage they cause (Ediger, 2019; Shahzad, 2020; Xia et al., 2022). Using taxes to internalise the externalities of unclean energy consumption can affect the energy transition pathways, which are discussed subsequently. EDA (i.e., hereafter used interchangeably with energy foreign aid or energy aid) also constitutes an important fiscal policy that can promote energy transition (Combes et al., 2016; Marineau, 2020). EDA provides financial, technical, or policy support to help developing countries improve access to modern and sustainable energy services while reducing greenhouse gas emissions (Combes et al., 2016; Marineau, 2020; Wang et al., 2023). Different actors, such as bilateral or multilateral donors, international organisations, development banks, foundations, or private sector entities, can provide EDA to support energy transition (Combes et al., 2016; Marineau, 2020; Wang et al., 2023). While EDA can facilitate energy transition, there are debates concerning its

implications on the environmental tax efforts of aid recipient countries as well as its implications for energy transition efficiency (Moolio & Kong, 2016; Sothan, 2018; Tang & Bundhoo, 2017).

These potential implications are discussed subsequently.

1.3 Governance Effectiveness

Governance plays a crucial role in the energy transition process. It involves establishing policies, regulations, and institutions that can facilitate the shift towards more sustainable energy systems (Blair & Roessler, 2021; Marineau, 2020). This includes setting clear and ambitious targets for renewable energy deployment, implementing effective regulatory frameworks to incentivise clean energy investments, and promoting transparency and accountability in the energy transition process (Feeny & De Silva, 2012; Maruta & Banerjee, 2021). Effective governance becomes paramount in developing regions like Africa, where governance structures may be less robust due to limited resources and weak institutional capacity (Findley et al., 2017; Ping et al., 2022). Therefore, implementing robust accounting and governance mechanisms (e.g., accountability and transparency) has implications for the environmental fiscal policies discussed above (i.e., environmental taxes and EDA).

Regarding environmental taxes, effective governance is required to establish administrative structures for tax collection, ensure compliance, and manage potential resistance from affected parties (Daude et al., 2013a; Gnanon & Brun, 2019). Good governance also involves regular monitoring and evaluation to assess the effectiveness of environmental taxes and make necessary adjustments (Daude et al., 2013a; Gnanon & Brun, 2019). Also, effective governance is crucial for enforcing environmental taxes, necessitating a robust legal framework and judicial system for dispute resolution and non-compliance penalties, as well as transparency and accountability to ensure the equitable and effective use of tax revenue (Daude et al., 2013a; Sebele-Mpofu, 2020).

Moreover, robust accounting and governance frameworks can facilitate monitoring and evaluation of the impact of environmental taxes on energy transition, allowing policymakers to make informed decisions about future policy interventions (Daude et al., 2013a; Sebele-Mpofu, 2020).

Similarly, governance effectiveness is vital for energy-related development assistance to support energy transition (Feeny et al., 2019; Gnanon & Brun, 2019; Maruta & Banerjee, 2021; Ogundipe et al., 2020). For instance, effective governance mechanisms can help reduce the risk of corruption and mismanagement of foreign aid, which can undermine the effectiveness of energy-related development assistance programs (Feeny et al., 2019; Ogundipe et al., 2020; Sovacool, 2021). Furthermore, transparent and accountable use of funds can foster trust among stakeholders, including donors, governments, and local communities, thereby increasing the likelihood of successful energy transition outcomes (Boly & Gillanders, 2018; Fazekas & King, 2019; Maruta et al., 2020). Therefore, accounting and governance practices ensure that energy-related development assistance effectively promotes sustainable energy transition.

1.4 Environmental Fiscal Policies and Socio-Economic Welfare

Potential injustices must be considered as the world seeks to achieve energy transition. The concept of a just energy transition implies that the shift from fossil fuels to renewable energy sources should not only be environmentally sound but also socially fair and economically viable (Baker, 2022b; Carley & Konisky, 2020; Heffron & McCauley, 2017). It recognises that the costs and benefits of the energy transition are not evenly distributed among different groups of people, regions, and countries, so some may face disproportionate burdens or risks of being left behind (Baker, 2022b; Carley & Konisky, 2020; Heffron & McCauley, 2017). Therefore, a just energy transition requires addressing the potential trade-offs and synergies between environmental, social, and economic objectives and ensuring that no one is adversely affected by the transformation of the energy

system (Baker, 2022b; Jenkins et al., 2018; Khastar et al., 2020; Sovacool & Dworkin, 2014). Environmental taxation and EDA are two policy instruments that can support the energy transition, but they may also have unintended consequences for socio-economic welfare.

Environmental taxes, such as carbon taxes, have the potential to generate revenue for public spending and encourage low-carbon behaviour. However, they may also be regressive, disproportionately affecting the poor (Jenkins et al., 2018; Timilsina, 2022; del Guayo & Cuesta, 2022). These taxes can also increase production costs for businesses dependent on fossil fuels, potentially leading to job losses and decreased production (Jenkins et al., 2018; Timilsina, 2022; del Guayo & Cuesta, 2022). Similarly, EDA can help broaden access to clean and affordable energy. Yet, it may also foster aid dependency in recipient countries. This dependency can hinder their ability to build local capacity for energy transition, resulting in inefficient transition outcomes in the long run (Jenkins et al., 2018). Therefore, it is crucial to design and implement environmental fiscal policies that minimise negative impacts and maximise positive outcomes for socio-economic welfare (del Guayo & Cuesta, 2022; Sovacool & Dworkin, 2014). This study considers not only the environmental implications of environmental fiscal policies but also their socio-economic implications.

1.5 Environmental Fiscal Policies and Energy Transition in Developed Countries

Governments in developed nations primarily address the financial challenges associated with energy transition by implementing carbon pricing mechanisms such as emissions trading systems (ETS) and carbon taxation (International Monetary Fund-IMF / OECD, 2021; Timilsina, 2022). These strategies serve a dual purpose: they not only generate environmental tax revenues that can be reinvested in the transition to cleaner energy sources but also discourage the use of carbon-

intensive energy sources by increasing their cost. This, in turn, encourages the adoption of energy-efficient practices and the use of renewable energy alternatives (IMF & OECD, 2021; Prasad, 2022; Qu & Sun, 2022). The European Union (EU) has established the most comprehensive carbon pricing mechanism to date (IMF/OECD, 2021). Its ETS, known as the EU-ETS, was instrumental in achieving a 21% reduction in regulated emissions in 2020 and is projected to enforce a 43% reduction by 2030 (Fahey, 2012; Galdi et al., 2021; d'Oultremont, 2010). In addition to the mandatory ETS that all EU member states must participate in, several countries within the EU have voluntarily implemented a carbon tax policy. This tax imposes a specific rate per ton of CO₂e, thereby incentivising a reduction in carbon emissions (OECD, 2021; Pigou, 1920; Xian-sen, 2015).

In the discourse on carbon taxes and ETS, scholarly consensus posits carbon taxes as the most economically efficient mechanism to internalise environmental costs into product pricing (García & Sterner, 2021; IMF/OECD, 2021; Kettner-Marx & Kletzan-Slamanig, 2018; Parry et al., 2022). However, the adoption of carbon taxes is not widespread, with only a select few nations implementing such measures (Stefan, 2022; The Tax Foundation, 2022; United Nations-UN, 2021). Furthermore, an OECD and IMF report from 2021 indicates that even among these few nations, the prevailing carbon tax rates are significantly lower than the threshold deemed necessary for facilitating a sustainable energy transition.

To illustrate, in 2018, the average effective carbon rate (ECR) across all sectors and EU countries was a mere 34 euros per tonne of CO₂e, markedly below the lower-end benchmark value of 60 euros. This observation precipitates an unresolved query: Do nations that have instituted a carbon tax policy witness any discernible environmental and socio-economic advantages in their energy transition journey compared to their counterparts without a carbon tax? (Ghazouani et al., 2020; Prasad, 2022; Skovgaard et al., 2019). This question is essential for policymakers and researchers,

as it can provide evidence of carbon taxation's effectiveness and its practical advantages over ETS. Therefore, the author's first research point is to experimentally examine the effects of carbon tax policy on the environmental (i.e., Energy Efficiency and Renewable Energy Adoption) and socio-economic (i.e., Human Development) outcomes of energy transition in the EU.

1.6 Environmental Fiscal Policies, Governance, and Energy Transition in Developing Countries

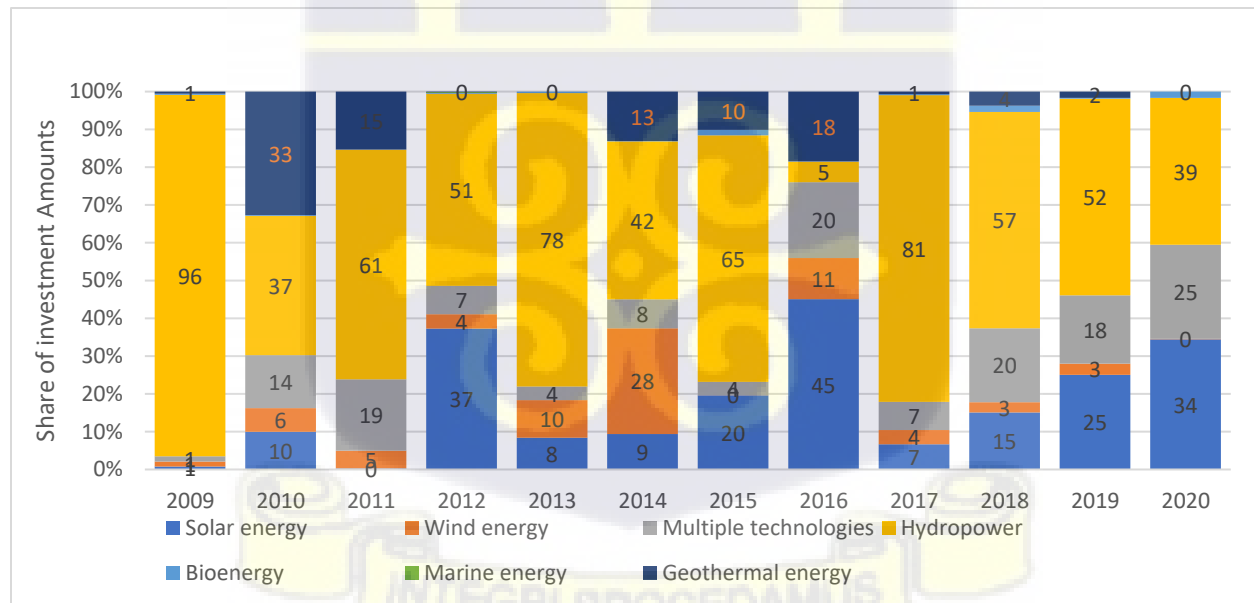
In contrast to their developed counterparts, most developing nations, particularly those in Africa, lack ETS or explicit carbon taxes (Alemu & Lee, 2015; IEA, 2021; IMF/OECD, 2021). South Africa is the sole African nation to have enacted an explicit carbon tax policy as of June 1, 2019, imposing a rate of R144 per ton of CO₂e resulting from fossil fuel consumption (Baker, 2022a; Deloitte, 2023; IMF, 2023; IMF/OECD, 2021; Steenkamp, 2017).

Despite the absence of ETS or carbon tax policies in most developing countries, nearly all nations worldwide, implement Environmentally Related Taxes (ERT) (OECD, 2023; Parry et al., 2022; Shahzad et al., 2020). These differ from carbon taxes in their design and scope. Specifically, a carbon tax targets the carbon content of fossil fuels and is quantified in terms of currency per ton of CO₂e (OECD, 2018; Parry et al., 2022). In contrast, ERTs are typically levied on activities or products contributing to environmental degradation or pollution (Dias Soares, 2011; Ghazouani et al., 2020; Shahzad et al., 2020). Consequently, ERTs represent the most prevalent form of environmental taxation employed to encourage energy transition in developing countries. Empirical research has substantiated the significance of ERTs in facilitating energy transition within these nations (Bashir et al., 2021; Doğan et al., 2022; Fang et al., 2022; Shahzad, 2020).

The role of Environmentally Related Taxes (ERT) in facilitating energy transitions in developing

nations is crucial, yet these taxes often fall short of amassing adequate resources for such endeavours (Carattini et al., 2018; IMF/OECD, 2021; Parry et al., 2022; Pomeranz, 2018). The 2021 policy document of the IMF and OEC indicates that the environmental tax effort in developing countries is significantly lower than what is needed for energy transition (IMF/OECD, 2021), with statistics showing an average environmental tax effort of 20% compared to 63% in developed countries. Consequently, developing countries depend on EDA to finance their energy transitions (IRENA & African Development Bank-AfDB, 2022; IRENA, 2022). Notably, developing countries in Arica depend on EDA to promote energy transition in diverse renewable energy sources (IRENA, 2022), as shown in Figure 1.3. However, the effectiveness of development assistance in these countries remains a topic of ongoing discussion (Moolio & Kong, 2016; Sothan, 2018; Tang & Bundhoo, 2017).

Figure 1. 3: Flow of Energy Development Assistance by Renewable Technology-Africa



Source: IRENA, 2020

Some research suggests that dependency on development assistance could undermine domestic tax efforts by reducing the necessity to mobilise domestic revenues, as captured by the fiscal

bargaining and aid dependency theories. For instance, studies indicate that when public services are provided through foreign aid, it can cause citizens to question the government's ability to meet their needs (Blair & Roessler, 2021; Marineau, 2020; Montinola et al., 2020). This can make citizens question the state's legitimacy to collect taxes, thereby reducing the state's ability to extract environmental taxes for energy transition (Blair & Roessler, 2021; Blair & Winters, 2020; Marineau, 2020). By implication, this suggests that EDA can undermine the environmental tax efforts of aid recipient countries, further exacerbating the existing funding gaps in energy transition.

While developing countries do implement Environmentally Related Taxes (ERT), the pivotal question that requires empirical scrutiny is not whether ERT influences energy transition, as numerous empirical studies have already corroborated the impact of ERT on energy transition (Ahmad et al., 2023; Bashir et al., 2022; Shamsi & Farzanegan, 2021). Instead, in light of the contentious discourse surrounding the interplay between foreign aid and tax effort, a fundamental question that merits exploration is: "What is the effect of EDA on the energy-related environmental tax effort of developing countries?". The nexus between EDA and environmental tax effort is a crucial area of investigation, given that these fiscal policies are instrumental in driving energy transition (Bashir et al., 2022; Gomez-Echeverri, 2018; Shamsi & Farzanegan, 2021). Addressing this question can enhance our understanding of how foreign aid and domestic environmental taxation interact, a critical component in energy transition. This insight can inform the development of more effective energy transition strategies, considering how foreign aid might impact domestic tax efforts.

Additionally, the theory of aid dependency contends that nations with excessive reliance on external assistance may forgo the development of domestic capabilities in domains such as

research and development, human resource education, and institutional fortification (Blair & Roessler, 2021; Combes et al., 2016; Marineau, 2020). This may engender persistent inefficiencies in the energy transition process (Blair & Roessler, 2021; Kretschmer et al., 2013; Marineau, 2020). Moreover, empirical evidence suggests that developing nations receiving considerable foreign aid display limited absorptive capacity in governance, accountability, budgeting, and social capacity, resulting in suboptimal aid outcomes (Dietrich, 2016; Feeny & De Silva, 2012; Knack, 2001; Svensson, 2000). Hence, recipient nations must establish robust and efficient governance and accountability systems to ensure EDA's efficacy. Otherwise, an influx of foreign aid may induce issues of transparency, corruption, and misallocation of aid funds, thereby creating inefficiencies in energy transition (Bräutigam & Knack, 2004; Findley et al., 2017; Kim, 2019; Ping et al., 2022).

Moreover, the absence of effective governance systems may hinder the evaluation of project effectiveness and stakeholder involvement in applying EDA (Boly & Gillanders, 2018; Fazekas & King, 2019; Kaufmann, 2009; Maruta et al., 2020). This may lead to implementing projects that are incongruent with the needs and priorities of aid recipient countries and cause inefficiencies in energy transition (Boudreau, 2023; Bowles, 1989; Kaur & Sitlhou, 2017; Kaur & Sitlhou, 2017; Maruta et al., 2020; Su et al., 2021).

Given the above, some scholars have advocated that developing nations should reduce or eliminate foreign aid; however, this can be detrimental given the prevailing funding gaps (Mahembe & Odhiambo, 2019, p. 2019; Szent-Iványi & Timofejevs, 2021). Consequently, the primary challenge lies in determining the optimal thresholds of development assistance that developing countries can effectively utilise without causing inefficiencies in energy transition. This gives rise to two pertinent research questions: What thresholds of EDA result in energy

transition (in)efficiency? Can the quality of governance condition EDA to achieve efficiency in energy transition within developing countries?

1.7 Problem Statement

Fossil fuels are the dominant source of energy in the world today, but they also come with severe environmental and social costs (Azam et al., 2021; Matejcek & Matejcek, 2017; Ritchie et al., 2022; Song & Zhang, 2019). The combustion of fossil fuels releases greenhouse gases that cause global warming and climate change, as well as air pollutants that harm human health and ecosystems (Azam et al., 2021; Girouard, 2021; Ritchie et al., 2022; Song & Zhang, 2019). Fossil fuels are also finite and non-renewable resources that will eventually run out or become too expensive to extract (Holechek et al., 2022; Kwakwa, 2021; Shafiee & Topal, 2009). To address these problems, the world needs to embrace energy efficiency and renewable energy sources (Beuermann et al., 2014; Cheng et al., 2021b; Girouard, 2021; Yang et al., 2022). However, energy transition is not an easy or cheap task. It requires massive investments in infrastructure, technology, innovation, human capital, and supportive policies (Akrofi, 2021; IMF/OECD, 2021; Li et al., 2023). These come at a significant cost, and according to a report by McKinsey Global Institute (2022), achieving a worldwide energy transition by 2050 will require about \$275 trillion in spending by the world economy. Therefore, how nations have responded to these practical challenges of energy transition creates critical research gaps worthy of consideration, as presented below.

1.7.1 Carbon Tax Policy and Energy Transition Pathways

Different countries employ various strategies to promote the shift towards cleaner energy. Developed nations often rely on market-based mechanisms such as emissions trading systems

(ETS) and carbon taxes to promote energy transition (Hájek et al., 2019; IMF/OECD, 2021; Mariotti, 2015). Carbon taxes, in particular, have been recognised as an effective means to account for the adverse effects of non-renewable energy consumption (IMF/OECD, 2021; Parry et al., 2022; Wolde-Rufael & Mulat-Weldemeskel, 2021). However, their adoption remains limited, prompting questions about their efficacy in facilitating energy transition in terms of environmental and socio-economic pathways. For instance, a 2024 report by the Institute for Security Studies indicates that while carbon taxation is a direct and transparent method to deter pollution, only 38 carbon tax schemes have been put into action worldwide, accounting for a scant 6% of global greenhouse gas emissions. Furthermore, among the top 10 global emitters, only Japan has embraced a carbon tax. Major emitters such as the US, Russia, India, Iran, and Saudi Arabia have yet to implement the policy, maintaining a cautious approach towards carbon taxation.

Prior research has attempted to address the question mainly by investigating the effect of environmentally related taxes (ERT) on energy-related greenhouse gas emissions (Doğan et al., 2022; Ghazouani et al., 2021; Ulucak et al., 2020; Wolde-Rufael & Mulat-Weldemeskel, 2021; Wolde-Rufael & Mulat-Weldemeskel, 2022; Yunzhao, 2022). For example, both Yunzhao (2022) and Wolde-Rufael and Mulat-Weldemeskel (2021) evaluated the efficacy of environmental taxes in mitigating energy-related CO_{2e} using a panel of e-7 emerging economies. Their findings consistently indicate a negative association between ERT and CO_{2e}, with a unidirectional causality flowing from ERT to CO_{2e}. In a similar vein, within the context of European countries, Khan et al. (2023), Ghazouani et al. (2021), and Aydin and Esen (2018) established a negative association between environmentally related taxes and overall CO_{2e}. This relationship is also observed in Africa (Degirmenci & Aydin, 2023; Van Heerden et al., 2006), Asia (Wolde-Rufael

& Mulat-weldemeskel, 2021; Yu et al., 2023), and OECD countries (Al Shammre et al., 2023; Hashmi & Alam, 2019).

From the literature above, two issues are noteworthy. Firstly, prior studies do not specifically examine carbon taxes or provide empirical evidence on whether countries implementing carbon tax policies have seen improved environmental and socio-economic outcomes. This study uses a difference-in-difference quasi-experimental design to fill this gap by assessing the post-adoption effects of carbon tax policy on environmental and socio-economic aspects of the energy transition in the EU. Secondly, the prior literature primarily focuses on the impact of environmental taxes on CO₂e, overlooking other environmental and socio-economic pathways to sustainable energy transition (Faccioli et al., 2022; Silva et al., 2021). Meanwhile, CO₂e reductions constitute only one of the pathways to energy transition (Faccioli et al., 2022; Silva et al., 2021).

This study addresses such research gaps by selecting three key variables to measure different dimensions of environmental pathways of energy transition (i.e., CO₂e per energy consumption, energy consumption per GDP output, and renewable energy capacity). It also uses the human development index to assess the socio-economic implications of carbon tax policy adoption, providing a comprehensive analysis of the effect of carbon tax policy on energy transition pathways.

The EU is an appropriate context to address the question of carbon tax's post-adoption impacts on environmental and socio-economic energy transition outcomes. Firstly, the EU's pioneering role in carbon tax policy, with Finland introducing the first carbon tax in 1990 (Fullerton & Metcalf, 1997; Ghazouani et al., 2020; Hájek et al., 2019), positions it as a global leader in this area. The diverse carbon tax policies adopted by various EU member states, each with different rates and scopes, provide a natural experimental environment for evaluating the impact of these policies on

energy transition outcomes (Andersson, 2019; IMF/OECD, 2021; Metcalf & Stock, 2020; Schratzenstaller & Köppl, 2021).

Moreover, the EU's ambitious sustainability and inclusivity goals for energy transition by 2050, as outlined in initiatives like the European Green Deal and the 2030 Climate Target Plan (Eurostat, 2020), make it crucial to assess the influence of carbon tax policies on environmental and socio-economic aspects of energy transition. Such an evaluation can offer valuable insights and policy implications for achieving these objectives. Lastly, the EU's extensive and varied data on carbon taxes, environmental metrics, and socio-economic indicators enable a thorough and rigorous analysis of the after-effects of carbon tax policy implementation (Faccioli et al., 2022). This wealth of data enhances our understanding of how these policies influence energy transition outcomes.

1.7.2 Energy Development Assistance, Governance, ERT, and Energy Transition

Considering that most developing countries depend on EDA to fund energy transition, it is imperative to examine the fiscal (dis)incentive they create as far as environmental tax efforts are concerned (Combes et al., 2016; Kim & Gray, 2016; Mahalik et al., 2021; Marineau, 2020). Previous studies in this area have mainly focused on the impact of aggregate development assistance on aggregate tax effort without considering the specific role of environmental aid and taxation (Benedek et al., 2014; Combes et al., 2016; Marineau, 2020; Maruta & Banerjee, 2021). For example, Benedek et al. (2014) investigated the effect of foreign aid on the aggregate tax effort of 118 aid-recipient countries from 1980-2009. They reported a negative effect of aggregate development assistance on domestic aggregate tax revenues. This finding aligns with Marineau (2020), who provides evidence that foreign aid reduces the enforcement of taxation by recipient states, hence lowering tax efforts. Similarly, Combes et al. (2016) also showed that large foreign

aid inflows undermine tax capacity and public investment in developing countries, while large reductions in aid inflows tend to preserve recipients' fiscal behaviour.

From the foregoing, most studies on the relationship between development assistance and tax effort have used aggregate measures, which may obscure the effects of specific types of development assistance and tax effort (Benedek et al., 2014; Combes et al., 2016; Marineau, 2020; Maruta & Banerjee, 2021). This study addresses such a research gap by focusing on the effect of EDA on environmental tax efforts in Sub-Saharan Africa, a region that relies heavily on this form of aid (IRENA & AfDB, 2022). Also, the study further disaggregates environmental tax efforts into climate change tax efforts and air pollution tax efforts to capture the different dimensions of environmental taxation. By doing this, the study can provide specific policy insights for tackling environmental challenges. Besides, Benedek et al. (2014) and Findley et al. (2011) suggest that disaggregating development assistance and tax effort into various components can address the problem of inconsistent findings in the aid and tax effort literature.

The Sub-Saharan African region is a suitable case study for examining the effect of EDA on environmental tax efforts for several reasons. First, this region is one of the largest recipients of EDA, accounting for about 30% of the total energy aid flows to developing countries in 2020 (IRENA & AfDB, 2022). This implies that EDA plays a significant role in financing the energy transition and enhancing energy access in this region. However, it needs to be clarified whether this form of aid also affects the environmental tax efforts of the Sub-Saharan African countries, which can have implications for their fiscal sustainability and environmental performance.

Second, this region exhibits a high degree of heterogeneity in terms of its environmental tax effort, ranging from 0.1% to 3.6% of GDP in 2019 (IMF/OECD, 2021). This variation provides an

opportunity to explore the factors that explain the differences in environmental tax efforts across Sub-Saharan African countries, especially the role of EDA. By disaggregating environmental tax efforts into climate change and air pollution tax efforts, the study can also capture the different dimensions of environmental taxation and provide specific policy insights for tackling different environmental problems. Also, the Sub-Saharan African region is one of the most vulnerable to the adverse impacts of climate change and air pollution, which pose serious threats to human health, food security, and economic development (Fisher et al., 2021; Intergovernmental Panel on Climate Change, 2022; Kemoe et al., 2022; Maino & Emrullahu, 2022; Taalas, 2021). Therefore, it is crucial to understand how EDA can influence the environmental tax policies of Sub-Saharan African countries, which can help mitigate these environmental challenges.

Apart from examining the effect of EDA on environmental tax efforts, the study also investigates the threshold effect of EDA on energy transition efficiency and the role of governance quality in this relationship. The aid dependency theory posits that countries reliant on foreign aid for development may achieve undesirable outcomes (Combes et al., 2016; Marineau, 2020; Maruta & Banerjee, 2021). On the other hand, the theory of absorptive capacity suggests that the institutions of aid-recipient countries can effectively manage certain levels of foreign aid inflows, beyond which they may lack the capacity for effective management (Aluko, 2020; Feeny et al., 2019; Maruta & Banerjee, 2021). This implies that the ability of aid-recipient countries to use foreign inflows to achieve desirable results may be contingent upon institutional effectiveness, particularly the quality of governance and accountability (Adedokun, 2017; Fon & Alon, 2022). Therefore, the study narrows the discourse to the context of EDA, where the research examines how accounting and governance effectiveness can condition EDA to achieve energy transition efficiency.

While there are existing studies in this area, energy transition has yet to be the focus (Combes et al., 2016; Kim, 2019; Maruta & Banerjee, 2021). Instead, the current literature is replete with studies that examine whether foreign aid promotes or diminishes economic outcomes, such as GDP growth (Abou-Zaid et al., 2023; Kurihara, 2014; Moreira, 2005; Yiew & Lau, 2018). There is a dearth of studies examining the effect of energy aid on energy transition efficiency (Maruta & Banerjee, 2021); hence, this study is a novel attempt to bridge such a gap. Additionally, even the few existing studies on foreign aid have examined the relationship from a linear functional form specification, leading to non-converging results (Alia & Anago, 2014; Combes et al., 2016; Maruta & Banerjee, 2021). According to Combes et al. (2016) and McMillan (2011), the empirical evidence on the impact of foreign aid remains inconclusive, partly due to such methodological challenges. This study uses the novel Multiple Thresholds Non-Linear Autoregressive Distributed Lag (MTNARDL) to examine the potential threshold effects between EDA and energy transition efficiency, and the role of governance quality in this relationship. This offers the opportunity to determine the optimal thresholds of EDA that aid recipient countries can take and show how accounting and governance effectiveness can condition foreign aid inflows to promote energy transition efficiency.

The Sub-Saharan African region and the East Asian region are suitable regional contexts to examine the threshold effect of energy aid and governance quality on energy transition efficiency. Both regions rely on EDA for sustainable energy transitions (IRENA & AfDB, 2022; Ileri & Shirley, 2021). However, the Sub-Saharan African region exhibits lower fossil fuel consumption rates than the East Asian region (IEA, 2021; IRENA & AfDB, 2022; Ileri & Shirley, 2021). Furthermore, the East Asian region contributes significantly to global energy-related CO₂

emissions, accounting for more than 20% of the total in 2018, a stark contrast to the Sub-Saharan African region's 3%.

These factors can potentially influence the effectiveness of these regions in utilising EDA to facilitate their energy transitions. For instance, in regions with high fossil fuel dependence, influential stakeholders in the fossil fuel industry may resist transitioning to renewable energy (Goldthau & Sitter, 2019; Hamann et al., 2023; Healy & Barry, 2017; Perkins, 2021). Such resistance could result in the misuse or misallocation of EDA, thereby undermining the efficiency of the energy transition (Acht et al., 2015; Goldthau & Sitter, 2019). A comparative analysis of these two regions can yield valuable insights into how energy aid and governance quality interact to affect the efficiency of energy transition in developing regions with varying degrees of energy-related environmental impact. This comparison could further enrich the existing literature on this topic.

1.7.3 Theoretical tensions in energy transition

The complex challenge of sustainable energy transition demands a multifaceted theoretical framework, integrating concepts from environmental economics, development economics, and institutional theories. However, there exist some tensions between these theoretical perspectives as they relate to environmental taxation, energy development assistance, and governance quality in promoting sustainable energy transitions. At the core of this lies the tension between market-based instruments and external assistance to developing countries. Pigou's (1920) theory of environmental externalities and the environmental double dividends theory (Pearce, 1991; Tullock, 1967) support the use of environmental taxes to internalize environmental externalities and potentially yield additional economic benefits. This market-based approach assumes that price

signals can drive the behavioral changes and technological innovations necessary for energy transition.

However, the notion of a just energy transition introduces an important equity consideration. A just energy transition seeks to ensure that the benefits and burdens of transitioning to sustainable energy are distributed fairly, especially for vulnerable and marginalized communities (McCauley & Heffron, 2018; Jasanoff, 2018). This perspective challenges the assumption that market-based instruments alone can effectively drive an equitable energy transition, as they may disproportionately impact lower-income households. Incorporating the principles of a just energy transition into the theoretical framework is crucial to addressing the social and distributional implications of environmental taxation and other policy instruments.

The aid dependency theory introduces a further contrasting perspective, suggesting that external assistance, such as energy development aid, can create perverse incentives that potentially undermine recipient countries' efforts towards sustainable development and energy transition (Asongu & Jellal, 2016; Combes et al., 2016; Crivelli & Gupta, 2017; Marineau, 2020). Accordingly, the fiscal contract theory also complicates this picture by emphasizing the relationship between taxation and governance. It posits that taxation can strengthen the social contract between governments and citizens, promoting accountability and better public service provision. However, the influx of external aid may disrupt this relationship, potentially weakening the impetus for robust environmental fiscal policies and energy transition efforts (Huemer, 2013; Lenton et al., 2017; Mangoting & Sukoharsono, 2015; Timmons, 2005). This tension is exacerbated by the Samaritan's dilemma theory, which highlights the potential for well-intentioned aid to create moral hazard, discouraging recipient countries from taking necessary but difficult policy actions in pursuit of energy transition (Blair & Roessler, 2021; Marineau, 2020).

A significant tension also arises between domestic policy initiatives and international support mechanisms. Environmental taxation represents a domestically driven approach to energy transition, while energy development assistance introduces an element of international influence. This tension is particularly salient in developing countries, where domestic fiscal capacity may be limited, and reliance on external support is often higher. The challenge lies in balancing the need for international support with the imperative of fostering domestic ownership and capacity for sustainable energy policies, including the principles of a just energy transition. Even more revealing, governance quality emerges as a critical mediating factor in these theoretical tensions. The institutional absorptive capacity theory suggests that the effectiveness of aid is contingent upon the recipient country's ability to productively utilize external resources (Feeny et al., 2019; Maruta & Banerjee, 2021; Ogundipe et al., 2020). In the context of energy transition, this implies that governance quality plays a crucial role in determining whether energy development assistance translates into improved energy transition efficiency. Similarly, strong governance can enhance the impact of carbon taxes by ensuring effective implementation and revenue utilization.

Given these complex theoretical interactions, there is a clear need for empirical research to elucidate how these factors play out in real-world contexts (Enusah et al., 2024; Marineau, 2020; Combes et al., 2016). Therefore, this study is theoretically justified by the need to test and refine our understanding of how environmental taxes, energy development assistance, and governance quality interact in promoting sustainable and just energy transitions.

1.8 Research Purpose and Objectives

This research investigates the role of environmental fiscal policy and governance quality in facilitating energy transition. This research purpose is composed of three research objectives:

1. to assess the effectiveness of carbon tax policy in promoting energy transition within the European Union through a quasi-experimental design.
2. to investigate the impact of energy aid and governance quality on environmental tax efforts in Sub-Saharan Africa.
3. to examine the effect of energy aid on energy transition efficiency in developing nations, focusing on the interacting role of accounting and governance quality.

1.9 Significance of the Study

The significance of the study is threefold: (1) significance to theory, (2) significance to policymaking, and (3) significance to practice.

1.9.1 Significance to Theory

The study enhances the environmental double dividends theory by presenting a more thorough measurement framework that includes both economic and social dimensions, addressing scholars' calls for a holistic approach that goes beyond economic indicators. Moreover, the research significantly contributes to aid dependency theory by proposing and testing a more detailed model that breaks down aid into different thresholds, challenging the linear relationship assumption and offering new insights into how varying levels of aid can lead to different outcomes. Finally, the study advances aid dependency theory by examining the interaction between higher levels of aid inflows and institutional capacity on governance. This adjustment marks a significant theoretical progress, recognizing the complex interplay between external aid and domestic governance structures, and providing new perspectives on the conditions under which aid might be more or less effective in fostering development outcomes.

Furthermore, Chapter 4 (Paper 3) proposes a novel metric for measuring countries' progress in

renewable energy transitions. Existing measures, such as energy intensity and the share of renewable energy in final consumption, do not adequately capture the extent to which non-renewable energy has been replaced by renewable sources. The new metric developed in this study addresses this theoretical shortcoming and represents an important contribution to the accounting discipline and other fields interested in sustainable development.

Finally, the investigation in Chapter 3 (Paper 2) bridges another gap in the accounting literature by shifting the focus from the effects of environmental taxes to the factors that influence environmental tax efforts. This new perspective sets the stage for further theoretical exploration and development in this area, which has been underdeveloped compared to the substantial body of work on the impacts of environmental taxes.

1.9.2 Significance to Policymaking

The study is also significant, as its findings can guide policy decisions. Some examples of how this study can contribute to policymaking are presented below.

In chapter 2, the analysis reveals a significant differential impact of carbon taxes on environmental outcomes in EU countries. Specifically, countries with carbon taxes (the treatment group) show superior environmental metrics—such as lower CO₂ emissions per unit of energy consumed and reduced energy intensity—compared to those without such taxes (the control group). Interestingly, the impact is more pronounced for energy efficiency measures than for renewable energy adoption. This suggests that while carbon taxes are effective tools for enhancing energy efficiency, they may be less influential in driving renewable energy adoption. Policymakers should, therefore, consider implementing carbon taxes to improve energy efficiency but recognize that additional measures might be necessary to promote renewable energy sources.

Accordingly, the results of the third chapter present a complex picture of renewable energy aid (EDA) in Sub-Saharan Africa (SSA). In middle-income SSA countries, renewable EDA reduces efforts to impose climate change taxes but increases efforts to address air pollution and overall environmental taxation. Conversely, in low-income SSA countries, renewable energy aid negatively affects all categories of environmental tax efforts. This indicates that energy assistance needs to be highly context-specific and integrated with the recipient countries' environmental strategies. Policymakers should aim for aid that is complementary, coherent, and effective, ensuring that it aligns with the strategic priorities of the recipient countries.

Moreover, chapter four explores the threshold effects of EDA on energy transition efficiency, contingent upon accounting and governance effectiveness. The findings suggest that low to moderate inflows of EDA (0-70%) enhance energy transition efficiency, but inflows beyond this threshold lead to inefficiencies unless counterbalanced by strong accounting and governance practices. This highlights the delicate balance required in aid allocation: excessive aid can be counterproductive without robust institutional frameworks. Policymakers should thus calibrate the level of assistance carefully and ensure that governance and accounting systems are sufficiently developed to handle higher levels of aid effectively.

Overall, the study underscores the importance of context, moderation, and institutional quality in the effective deployment of policy measures related to environmental taxes and energy aid. Policymakers are urged to adopt a nuanced approach, recognizing that one-size-fits-all solutions are inadequate. Instead, policies should be tailored to the specific economic, social, and institutional contexts of the recipient regions to maximize their effectiveness and sustainability.

1.9.3 Significance to Practice

The study's findings offer valuable insights across multiple sectors, providing a comprehensive understanding of the impact of carbon taxes and environmental disclosure and assurance (EDA) on environmental and socio-economic outcomes. This knowledge is crucial for various stakeholders in their pursuit of sustainable practices and policies.

For investors, the study serves as a guide for making informed decisions about capital allocation. By understanding how carbon taxes and EDA influence environmental and socio-economic outcomes, investors can align their portfolios with sustainable practices, potentially mitigating risks and capitalizing on opportunities in the evolving landscape of environmental regulation and corporate responsibility. Managers and auditors can leverage the study's insights to enhance their organizations' environmental performance and reporting practices. Managers gain valuable knowledge about the determinants of environmental tax initiatives and the role of accounting and governance in improving energy transition efficiency. This understanding enables them to develop more effective strategies for achieving sustainability objectives. Auditors, in turn, can use these insights to evaluate and assure the accuracy of sustainability disclosures, thereby enhancing the credibility of environmental reporting. The study also holds significant relevance for regulators and civil society organizations. By providing a deeper understanding of the effects of carbon taxes and EDA, it equips these stakeholders with the knowledge needed to develop and advocate for policies that promote a fair and equitable energy transition. This information is crucial for shaping a sustainable energy future that balances environmental concerns with socio-economic factors.

In academia, the study's findings contribute to both research and teaching activities. It informs the

development of academic curricula on energy transition, helping to prepare future professionals to address the complex challenges in this field. By elucidating the factors driving environmental tax initiatives and the role of accounting and governance in achieving energy transition efficiency, the study enriches scholarly discourse and supports the education of the next generation of sustainability leaders. In conclusion, this study provides critical insights that span various sectors, contributing significantly to the broader discourse on sustainable energy practices and policies. Its comprehensive approach offers valuable guidance for stakeholders across the spectrum, from investors and managers to regulators and academics, fostering a more informed and effective approach to addressing the challenges of energy transition and environmental sustainability.

1.10 Overview of Research Methodology

This study adopts a positivist research paradigm, which assumes that reality is objective and can be measured through empirical observation and quantitative analysis (Saunders et al., 2015). In this study, we have measured several variables of interest (e.g., energy efficiency and environmental tax effort) with the aim of establishing cause-and-effect relationships among the variables, making the positivism paradigm appropriate. The study employs a deductive reasoning approach, where hypotheses are derived from existing theories and tested using empirical data (Creswell & Creswell, 2017; Saunders et al., 2015; Saunders et al., 2019). Within the study, propositions by theories such as the environmental double dividend theory, aid dependency theory, fiscal bargaining theory, theory of absorptive capacity, and institutional legitimacy theory were tested empirically using measurable variables. The empirical test results, therefore, served as a basis to deduce whether the propositions were valid or rejected.

Axiologically, the research adopts value-free axiology by minimising the influence of personal values on the research process. This is particularly important in studying complex and contentious issues such as energy transition and taxation, where stakeholders may have different perspectives and interests (Saunders et al., 2019; Sekaran & Bougie, 2016). Value-free axiology has been ensured by clearly defining research questions and hypotheses, using rigorous and transparent methods, considering alternative perspectives, and being transparent about potential sources of bias (Park et al., 2020; Saunders et al., 2019; Saunders et al., 2015).

The research approach adopted is the quantitative research approach. Quantitative design is consistent with the positivism paradigm and is a research approach that uses numerical data and statistical analysis to understand phenomena (Bloomfield & Fisher, 2019; Gephart & Saylor, 2020; Mukhopadhyay & Gupta, 2014).

Accordingly, the explanatory research design is adopted in this study. "Traditionally, the research denoted by the term explanatory research has been quantitative in nature and has typically tested prior hypotheses by measuring relationships between variables; the data are analysed using statistical techniques" (Denzin & Lincoln, 2011, p. 134). Therefore, the explanatory design is appropriate, considering this study aims to establish statistical relationships among variables. For instance, paper one uses a quasi-experimental design to assess the treatment effect of carbon taxes on energy-related environmental and socio-economic outcomes. Such a study aims to establish causal relationships between the variables of interest; hence, the explanatory design is appropriate.

The level of analysis undertaken is country-level analysis, using a population set of countries within the European Union to address research objective 1, Sub-Saharan African countries to address objective 2, and Sub-Saharan and East Asian countries to address research objective 3. A country-level analysis was appropriate since energy transition and its related antecedents, such as

climate change, are global phenomena addressed at the international and country levels. Also, energy policies and regulations are often determined at the national level; therefore, country-level data can provide insights into the effectiveness of these policies in driving the transition to cleaner energy sources. Additionally, country-level data can help researchers understand differences in energy transition progress between countries and identify factors that may contribute to these differences.

This study mainly uses secondary data from the World Bank's Databank, the OECD Database, the IRENA Database, and the Tax Foundation. These credible and reliable databases have been used consistently in similar studies. Several statistical analytical techniques are deployed to assist data analysis. Paper 1 deploys the difference-in-difference (DiD) quasi-experimental technique to analyse the treatment effect of carbon tax adoption on energy transition. Paper 2 uses instrumental variable techniques to examine the effect of energy aid on environmental tax efforts because it can address the endogeneity challenges in prior literature. Additionally, Paper 3 implements the Multiple Thresholds Non-Linear Autoregressive Distributed Lag Model Technique (MTNARDL) to examine how different levels of EDA affect energy transition efficiency.

1.10 Structure of this Thesis

Understanding the structure and sequence of this thesis is essential for making sense of it. This thesis takes the paper-based approach to writing, where the chapters are organised into distinct but related research articles.

In this regard, Chapter One introduces the general background underpinning all the papers and the research problem motivating them. Chapter One also presents the research purpose and objectives, as well as the research significance and structure.

Chapter Two is the first research paper devoted to examining whether EU countries that implement carbon tax policy have better energy-related environmental and socio-economic benefits than those that do not. The paper uses panel data from 23 EU countries, including eight that had implemented carbon tax policy by 2019. The quasi-experimental difference-in-difference analysis of Callaway and Sant'Anna (2021) and Goodman-Bacon's (2021) difference-in-difference decomposition analysis strategy were implemented.

Chapter Three presents the second paper, devoted to examining the effects of renewable energy aid and governance quality on climate change tax effort, air pollution tax effort, and aggregate environmental tax effort in Sub-Saharan Africa (SSA). It implements the Instrumental Variable Generalized Method of Moments (IV-GMM) and Smoothed Instrumental Variable Quantile Regression (SIVQR) analysis techniques.

Chapter Four presents a third paper that examines the threshold effects of EDA on energy transition efficiency and how accounting and governance effectiveness (AGE) condition this relationship. The study emphasises a sample of 17 Sub-Saharan African countries and implements Malmquist Data Envelopment Analysis (DEA) and Multiple Threshold Non-linear Autoregressive Distributed Lag (MTNARDL) statistical techniques.

Chapter Five concludes the overall study. It provides specific recommendations while pointing out areas for further study.



CHAPTER TWO

CARBON TAX POLICY ADOPTION AND ENERGY TRANSITION IN THE EU: A QUASI-EXPERIMENTAL ASSESSMENT



Abstract

Carbon tax policy is crucial for reducing energy-related greenhouse gas emissions and promoting a low-carbon economy. However, only a few countries have adopted it; hence, its effects on energy transition-related environmental and socio-economic outcomes are not well understood. This study applies a generalized difference-in-difference approach to examine the effects of carbon tax policy adoption on four outcomes: CO₂ emissions per energy consumption, energy consumption per GDP output, renewable energy capacity, and human development index. The study uses panel data from 23 EU countries, including eight that have adopted carbon tax policy by 2019. The results indicate that carbon tax policy has a negative average treatment effect on CO₂ emissions per energy consumption and energy consumption per GDP output, and a positive effect on renewable energy capacity and human development index. The results also show that the effects are stronger in the post-treatment period and for the group that has consistently implemented carbon taxes. The study contributes to the accounting literature on the effect of countries' environmental fiscal policies on energy transition.

Keywords: carbon tax policy; energy transition; environmental dividend; socio-economic dividend; quasi-experimental design.

-
1. This chapter is currently undergoing review with the *Journal of International Accounting, Auditing and Taxation (JIAAT)*.

1.0 Background

This study applies the quasi-experimental method of Callaway and Sant'Anna (2021) to examine how carbon tax policy adoption affects energy-related environmental and socio-economic outcomes in the EU. Global warming is now an established fact, and its deleterious effects on humanity are one of our world's greatest threats (Green, 2021; Jackson et al., 2022; Milman, 2021; Porter et al., 2020; Salter & Wilkinson, 2023; Vohra et al., 2021). The primary anthropogenic greenhouse gas is carbon dioxide (CO₂), mainly produced by burning fossil fuels (Godin et al., 2021; Salter & Wilkinson, 2023; Vohra et al., 2021). To address this issue, carbon reduction has been a focus of global climate summits such as COP 27 and the Paris Climate Change Conference (Chen & Lin, 2021; Pedersen & Andersen, 2023; Stanczyk, 2022). At these summits, countries make voluntary pledges, called "nationally determined contributions," to help limit global warming (Böhringer et al., 2021; Chen et al., 2021). A key part of these national policies is putting a price on greenhouse gas emissions, often through a carbon tax on fossil energy consumption.

A carbon tax is a way of internalizing the negative externalities of carbon emissions, thereby promoting the adoption of energy-efficient technologies and clean energy sources (Bhat & Mishra, 2020; Cheng et al., 2021b; Sarpong et al., 2023). By making fossil fuels more expensive, carbon taxes incentivise consumers and producers to reduce their use and switch to cleaner and more efficient alternatives (Cheng et al., 2021b; He et al., 2022; Qadir et al., 2021; Thisted & Thisted, 2020). For instance, a carbon tax can motivate people to drive less, use public transportation, purchase more fuel-efficient vehicles, or invest in energy efficiency. Carbon taxes can also promote innovation and investment in renewable energy sources such as solar, wind, and hydropower, which produce lower or no emissions (Cheng et al., 2021b; Ghazouani et al., 2020; He et al., 2022; Qadir et al., 2021). A carbon tax can make renewable energy more competitive

with fossil fuels, attract more funding for research and development, or increase demand for green products and services.

Notwithstanding the potential benefits of carbon taxes, only a few countries have adopted them (see Table 2.1). This raises the question of whether countries exposed to carbon tax policy experience environmental and socio-economic advantages compared to those without carbon taxes (Ghazouani et al., 2020; Prasad, 2022; Skovgaard et al., 2019). Studies have attempted to answer this question by using standard regression analysis to examine the relationship between environmentally related taxes and environmental outcomes, such as CO₂ reductions (e.g., Ulucak et al., 2020; Wolde-Rufael & Mulat-Weldemeskel, 2022). However, these analyses do not specifically focus on carbon taxes and do not provide information on whether countries with carbon tax policies perform better environmentally and socio-economically as far as energy transition is concerned. They also do not indicate whether countries with carbon tax policies have higher post-adoption benefits than the pre-adoption period.

Andersson (2019) and Ghazouani et al. (2020) conducted some of the closest studies to address these research gaps. However, Andersson's (2019) study only examined the effect of Sweden's carbon tax policy on the transportation sector's CO₂ emissions, not providing a holistic country-level experimental analysis. Besides, both studies only emphasize how carbon tax policy can reduce CO₂ emissions, which constitute only one of the pathways to energy transition. Thus, as Silva et al. (2021) suggested, other environmental and socio-economic pathways required for a just energy transition should be addressed. To address these limitations, we carefully selected three energy transition-related variables (CO₂ emissions per energy consumption, energy consumption per GDP output, and renewable energy capacity), which holistically represent the environmental pathways to energy transition (i.e., energy efficiency and renewable energy adoption). Using the

human development index, we also assess the socio-economic welfare implications of carbon tax policy adoption.

Therefore, our study answers four key research questions:

- i. What is the effect of carbon tax policy adoption on CO₂ emissions per energy consumption in the EU?
- ii. What is the effect of carbon tax policy adoption on energy consumption per GDP output in the EU?
- iii. What is the effect of carbon tax policy adoption on renewable energy adoption in the EU?
- iv. Do EU countries that adopt carbon tax policy have better Human Development than those that do not?

We examined the research questions using data from 23 EU countries, including eight that had implemented a carbon tax policy by 2019, also known as the treatment group (refer to Table 2.1). Our analysis employed Callaway and Sant'Anna's (2021) generalized difference-in-difference approach (DiD), which accounts for staggered treatment over varying periods. Our findings indicate that the average treatment effect on the treated (ATT) for carbon tax policy implementation is significant and negative for CO₂ emissions per energy consumption and energy consumption per GDP output. However, the ATT is positive for installed renewable capacity and the human development index. The event study analysis reveals that the ATT's magnitude is stronger in the post-treatment period. Similarly, Goodman-Bacon's (2021) difference in difference (DiD) decomposition also shows that the ATT is stronger for the group that has consistently implemented carbon taxes than those that never implemented them, emphasizing the long-term impact of carbon tax adoption.

The rest of the study is organised into six main sections. The second section reviews relevant literature, the third section presents the research methodology and estimation strategies, the fourth presents the preliminary analysis, the fifth discusses the estimated results, and the sixth presents robustness analysis. Section seven concludes the study.

2.1 Carbon Tax Policy in the EU Context

While many countries implement environmentally related taxes (ERT), only a few have adopted carbon taxes (CT) (Haites, 2018; Köppl & Schratzenstaller, 2022; OECD, 2018). The key difference between these two taxes is that a carbon tax is levied per ton of the carbon content of fossil fuels, while environmentally related taxes are generally imposed on activities that cause environmental harm or pollution (Ghazouani et al., 2020; Shahzad et al., 2020; World Bank, 2023). The primary goal of a carbon tax is to internalize the negative externalities associated with carbon emissions, such as climate change (Ghazouani et al., 2020; Köppl & Schratzenstaller, 2022). Carbon taxes are typically structured in terms of currency per ton of CO₂ emissions, providing incentives to reduce carbon emissions in a Pigouvian sense (Pigou, 1920).

In Table 2.1, Finland was the first country in the world to adopt a carbon tax in 1990. Since then, more EU countries have joined. Table 2.1 shows that 12 of the 28 EU countries had explicit carbon taxes as of 2019. The tax rates vary across countries, from \$0.08 per ton of CO₂e in Poland to \$137 per ton of CO₂e in Sweden. The average tax rate among the 12 countries is \$39.59 per ton of CO₂e, which is lower than the minimum of \$47.11 per ton of CO₂e suggested by the High-Level Commission on Carbon Prices to meet the Paris Agreement goals (Stiglitz et al., 2017). The High-Level Commission on Carbon Prices also advises that to reach the Paris climate goals, the

price should be at least \$40-80 per ton of CO₂ emissions by 2020 and increase to \$50-100 per ton of CO₂ emissions by 2030 (Stiglitz et al., 2017).

Table 2. 1: EU Carbon Tax Status as of 2019

Country	Carbon Tax Policy Implementation?	Carbon Tax Rate (per ton of CO ₂ e) Euros	Carbon Tax Rate (per ton of CO ₂ e) Dollars	Share of Jurisdiction's GHG Covered (%)	Year of Implementation
Austria	No				
Belgium	No				
Bulgaria	No				
Croatia	No				
Cyprus	No				
Czech Republic	No				
Denmark	Yes	€23.78	\$28.00	0.35	1992
Estonia	Yes	€ 2.00	\$2.36	0.06	2000
Finland	Yes	€62.00	\$73.02	0.36	1990
France	Yes	€45.00	\$53.00	0.35	2014
Germany	No				
Greece	No				
Hungary	No				
Ireland	Yes	€33.50	\$39.45	0.49	2010
Italy	No				
Latvia	Yes	€12.00	\$14.13	0.03	2004
Lithuania	No				
Luxembourg	No				
Malta	No				
Netherlands	No				
Poland	Yes	€0.07	\$0.08	0.04	1990
Portugal	Yes	€24.00	\$28.26	0.29	2015
Romania	No				
Slovakia	No				
Slovenia	Yes	€17.30	\$20.37	0.5	1996
Spain	Yes	€15.00	\$17.67	0.03	2014
Sweden	Yes	€116.33	\$137.00	0.4	1991
United Kingdom	Yes	€21.23	\$25.00	0.23	2013

Source: The Tax Foundation (2022)

The carbon tax covers different amounts of GHG emissions in different countries (Table 2.1), from 0.03% in Latvia and Spain to 0.5% in Slovenia. The average coverage among the 12 countries is 0.25%, much lower than the ideal coverage of all GHG emissions from all sectors.

Table 2.1 shows that carbon tax is not widely adopted or harmonised in the EU despite the potential benefits of reducing GHG emissions and generating revenue for climate action and social welfare. This suggests that there is an opportunity for EU countries to adopt or increase their carbon taxes and coordinate their tax policies with other EU members and international partners to create a consistent and credible carbon price signal to drive the transition to a low-carbon economy (IMF/OECD, 2021; James, 1999). This aligns with the recommendations of the IMF/OECD report for the G20 Finance Ministers and Central Bank Governors in September 2021, which calls for a global explicit carbon price or equivalent measures rising to around USD 75 per ton of CO₂ or more by 2030 (IMF/OECD, 2021).

2.2 Environmental Double Dividends and a Just Energy Transition

The environmental double dividend theory, also known as the “double dividend hypothesis,” is an economic theory that suggests that environmental policies can lead to both environmental and economic benefits, thus creating a “double dividend” (Pearce, 1991; Tullock, 1967). It proposes that well-designed environmental taxes can not only improve environmental quality but also stimulate economic benefits (Becattini et al., 2022; Cheng et al., 2021b; Wesseh Jr & Lin, 2019).

From the perspective of the first dividend, carbon taxes can reduce pollution or resource consumption, thereby mitigating environmental issues such as air pollution and climate change (Bartolomeo et al., 2000; Becattini et al., 2022; Cheng et al., 2021b; Lilliestam et al., 2021). For example, carbon taxes increase the cost of using carbon-intensive energy sources (e.g., fossil fuels), incentivizing consumers and producers to switch to cleaner and more efficient energy sources such as solar, wind, hydro, or nuclear power (Bashir et al., 2021; Zhang et al., 2021). Additionally, carbon taxes can generate government revenue, which can be invested in renewable

energy projects (e.g., R&D), subsidize low-carbon technologies, and enhance a country's renewable energy capacity. As such, the environmental dividend of carbon taxes can manifest in (1) reductions in energy-related CO₂ emissions, (2) improvements in energy intensity, and (3) increased adoption of renewable energy.

The second dividend of environmental taxes proposes that the revenue generated from these taxes can be used to reduce other taxes, such as income taxes, thereby improving economic welfare (Domguia et al., 2022; Liu et al., 2023b; Yüksel & Mikhaylov, 2022). This aligns with the concept of a “just energy transition,” which is inspired by the environmental justice movement and emphasizes the fair distribution of both the benefits and burdens of transitioning to cleaner energy (García-Muros et al., 2022; Tomás et al., 2023). While carbon taxes have the potential to achieve environmental goals, it is crucial to consider their impact on welfare.

The implementation of carbon taxes can have significant distributional impacts, disproportionately burdening certain socioeconomic groups (Baker, 2022b; García-García et al., 2020; García-Muros et al., 2022). One key concern is the potential increase in costs of essential goods and services, such as electricity, heating, and transportation. These expenses typically make up a larger proportion of a low-income family's budget compared to higher-income households. As a result, carbon taxes can impose a heavier financial strain on the poor, exacerbating existing economic inequalities. Another vulnerable group affected by carbon taxes are workers and communities dependent on carbon-intensive industries (Baker, 2022b; García-García et al., 2020; García-Muros et al., 2022). In regions heavily reliant on coal mining or oil refining, for example, carbon taxes can lead to job losses and economic disruption. Without adequate support and transition assistance, these workers and their families may face significant hardship and struggle to adapt to the changing economic landscape.

It is, therefore, crucial that carbon taxes are designed to achieve a double dividend in the form of welfare benefits. We assess the second dividend of carbon taxes by examining its effects on Human Development Index (HDI). The following sections discuss the above-listed variables under the first and second dividends.

2.3 Carbon Tax Policy and Energy Intensity of GDP

Energy intensity of output, an indicator of an economy's energy efficiency, is calculated as the ratio of energy consumption to GDP (Azhgaliyeva et al., 2020; Bashir et al., 2021; OECD, 2018). A high value implies that a large amount of energy is required to produce a unit of GDP, while a low value indicates greater efficiency. High energy intensity is associated with high carbon emissions, as fossil fuel consumption is a significant contributor to greenhouse gas emissions (Al-Mulali et al., 2012; Nawaz et al., 2021; Waheed et al., 2019; Yang et al., 2016). Carbon taxation, a key policy instrument for meeting the Paris Agreement's emission targets, can reduce energy intensity through four main channels: incentivizing energy efficiency, promoting innovation, providing market flexibility, and enabling revenue recycling (Ahmed et al., 2022; Bashir et al., 2021; Zhang et al., 2021).

By imposing higher costs on carbon emissions, carbon taxation encourages investment in energy-efficient technologies and practices, leading to a decline in energy consumption relative to economic output (Bertoldi, 2022; Cheng et al., 2021b; Waheed et al., 2019). It also stimulates innovation in clean technologies and allows businesses to choose the most cost-effective methods for emission reduction (Chen et al., 2020; Cheng et al., 2021b; Karmaker et al., 2021). Besides, governments can recycle carbon tax revenues into initiatives such as energy efficiency programs and renewable energy projects (Köppl & Schratzenstaller, 2022; Lilliestam et al., 2021; Sun et al.,

2021). Thus, carbon tax policy adoption is expected to have a negative average treatment effect on energy intensity.

2.4 Carbon Tax Policy and CO₂ Emissions Per Energy Use

Similarly, carbon taxes can reduce CO₂ emissions per energy use by creating a price signal that reflects the environmental cost of emissions (Becattini et al., 2022; Cheng et al., 2021b; Lilliestam et al., 2021; Pretis, 2022). By increasing the cost of emitting CO₂, carbon taxes provide a financial disincentive for businesses and individuals to continue using high-emission energy sources (Prasad, 2022; Qu & Sun, 2022). This encourages the adoption of cleaner and more sustainable alternatives and stimulates investment in energy-efficient technologies. As mentioned earlier, the revenue generated from carbon taxes can be reinvested in renewable energy projects and initiatives that support the transition to a low-carbon economy (Köppl & Schratzenstaller, 2022; Lilliestam et al., 2021; Sun et al., 2021). Additionally, carbon taxes promote market-based efficiency, driving innovation and the development of low-carbon solutions (Prasad, 2022; Qu & Sun, 2022). Thus, the empirical literature raises the expectation that carbon tax adoption will have a negative average treatment effect on CO₂ emissions per energy consumption.

2.5 Carbon Tax Policy and Renewable Energy Adoption

Renewable energy sources, such as solar, wind, hydro, and geothermal, offer a sustainable and environmentally friendly alternative to fossil fuels (Adebayo et al., 2023; Jebli et al., 2020; Quang et al., 2023; Shafiei & Salim, 2014). Carbon taxes play a significant role in driving renewable energy adoption by creating a more favorable economic environment for clean energy technologies. By increasing the cost of carbon-intensive energy sources, carbon taxes make renewable energy sources relatively more cost-competitive (Mukherjee et al., 2023; Venmans et al., 2020; Yüksel & Mikhaylov, 2022). This economic signal encourages businesses, investors,

and individuals to invest in and adopt renewable energy technologies to reduce their carbon footprint and comply with the tax (Abbas et al., 2023; Mukherjee et al., 2023; Venmans et al., 2020). Besides, governments can allocate funds raised through carbon taxes to finance research and development initiatives, provide financial incentives and subsidies for renewable energy installations, and invest in the necessary infrastructure (Abbas et al., 2023; Yüksel & Mikhaylov, 2022). This financial support helps reduce the upfront costs associated with renewable energy projects and accelerates their adoption. Therefore, carbon tax policy adoption is expected to have a positive average treatment effect on renewable energy adoption.

2.6 Carbon Taxes and Socio-Economic Welfare

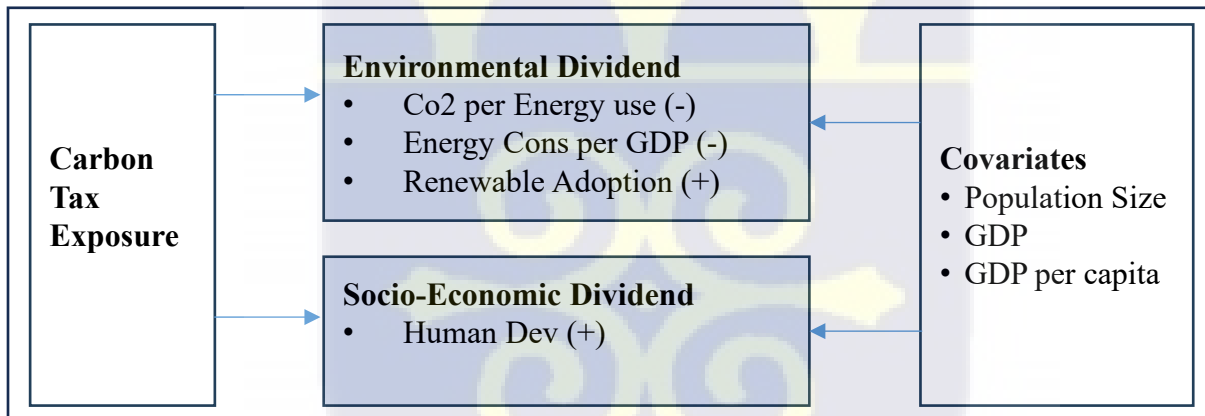
To ensure a just energy transition, carbon taxes should improve welfare and not deteriorate it. Some empirical research suggests that carbon tax revenues can be channeled to reduce unemployment (Degirmenci & Aydin, 2023; Domguia et al., 2022; Yang et al., 2020), improve household consumption (Fullerton & Metcalf, 1997; Heine & Black, 2019; Zhu et al., 2018), and achieve an overall positive effect on GDP (Aggarwal et al., 2021; Alola & Nwulu, 2022; Chen & Nie, 2016; Minlah & Zhang, 2021; Wesseh Jr & Lin, 2018). However, the validity of this hypothesis is not universally accepted. Some studies have argued that environmental taxes may have a negative effect on employment (Carraro et al., 1996; Degirmenci & Aydin, 2021; Fullerton & Metcalf, 1997; Wen et al., 2021; Zhou et al., 2020), household consumption (Freire-González, 2018; Zhou et al., 2020), and economic output (Hassan et al., 2020; Hongxing et al., 2021; Li & Masui, 2019). These studies show that environmental taxes may distort market prices, reduce competitiveness, affect income distribution, and hamper economic activity and development.

Therefore, the effect of carbon taxes on economic wellbeing can be positive or negative, depending on various factors such as the design of the tax, the use of the revenue, the structure of the economy,

and the interactions with other policies and market conditions. Hence, studies such as Faccioli et al. (2022) and Silva et al. (2021) have recommended using wellbeing measures that capture both economic and social dividends of carbon tax. To this extent, this study examines the socio-economic welfare effects of carbon tax implementation using the human development index, a composite index of life expectancy, education, and per capita income. Thus, life expectancy and education measure social wellbeing, while per capita income measures economic wellbeing. The expectation is that exposure to carbon tax policy will have a positive average treatment effect on human development index.

The above literature can be summarized into a simple conceptual framework, as shown in Figure 2.1.

Figure 2. 1: Research Framework



Source: Author's Construct, 2023

Note: The covariates in Figure 2.1 are partialled out when the DiD specification is estimated using Callaway and Sant'Anna's (2021) generalized difference in difference method. Thus, Callaway and Sant'Anna's (2021) generalized DiD estimate allows flexibility in the parallel trend assumption by conditioning on covariates. Hence, the final DiD estimates show the average treatment effects, not the covariates. It is also noteworthy that the negative and positive signs in Figure 2.1 are with respect to the treatment effects of carbon tax adoption, not the covariates.

3. Methodology

This study comprehensively examines whether EU countries that implement carbon tax policy (i.e., the treatment group) have better environmental and socio-economic impacts than those that do not. The EU is an appropriate context to address the question of carbon tax's post-adoption impacts on environmental and socio-economic energy transition outcomes. Firstly, the EU's pioneering role in carbon tax policy, with Finland introducing the first carbon tax in 1990 (Fullerton & Metcalf, 1997; Ghazouani et al., 2020; Hájek et al., 2019), positions it as a global leader in this area. The diverse carbon tax policies adopted by various EU member states, each with different rates and scopes, provide a natural experimental environment for evaluating the impact of these policies on energy transition outcomes (Andersson, 2019; IMF/OECD, 2021; Metcalf & Stock, 2020; Schratzenstaller & Köppl, 2021). The study draws on panel data from 23 EU countries from 1990-2019. The UK is not included in the sample as it is no longer a member of the EU as of January 31, 2020. Malta is eliminated from the sample due to the large amount of missing data.

Additionally, considering that the study implements a difference in difference analysis (DiD), there was a need to ensure that countries in the sample show a similar trend as far as the dependent variables of interest are concerned. However, visual inspection of trend graphs (see Figure 2.2) revealed that the trend lines of France, Portugal, and Spain often deviated from the rest of the countries; hence, they were eliminated from the sample to ensure that only comparable groups were used. This is not to suggest that the other countries followed exactly the same trend path, but the observed deviations were minimal. Of the 23 countries retained, eight had implemented carbon tax policy as of 2019, including Denmark, Estonia, Finland, Ireland, Latvia, Poland, Slovenia, and Sweden (refer to Table 2.1). These countries make up the treatment group in the quasi-

experimental design. The remaining countries had not implemented carbon taxes as of 2019, and they constitute the control group.

3.1 Variable Definitions

3.1.1 Independent variable

The independent variable of interest is carbon tax policy adoption status. This dummy variable turns one if a country is in the treatment group and zero if a country is in the control group. The data on the carbon tax policy status of countries were derived from taxfoundation.org and confirmed from the World Bank's "Carbon Pricing Dashboard," last updated on April 1, 2022.

3.1.2 Dependent variables

The study has two categories of dependent variables, which are informed by the environmental double dividend theory and the notion of just energy transition. The first category relates to the environmental dividend of carbon tax policy implementation, measured by (1) CO₂ per energy consumption, (2) energy consumption per unit of GDP output (energy intensity), and (3) installed renewable capacity. The second category concerns the socio-economic dividend of carbon tax policy, measured by the human development index. Our decomposition of the environmental dividends followed the path of Kaya identification (Kaya & Yokobori, 1997). Data on the variables was obtained from the World Bank's World Development Indicators database.

3.1.3 Covariates

We implemented Callaway and Sant'Anna's (2021) difference-in-difference technique (CS-DiD), which relaxes the parallel trend assumption by conditioning on covariates. To this extent, we

carefully select covariates suitable for each of our DiD estimations. The first estimate considers the treatment effect of carbon taxes on CO₂ emissions per energy consumption; the second looks at the treatment effect of carbon taxes on energy intensity (i.e., energy consumption per GDP output); the third focuses on installed renewable capacity; and the fourth considers the treatment effect on human development index. Following Kaya's identification (Kaya & Yokobori, 1997) and other relevant literature (Mavromatidis et al., 2016; Ortega-Ruiz et al., 2020; Pui & Othman, 2019), we selected population size, GDP per capita, and GDP as covariates for the DiD estimates. These are presented as:

$$CO2eEnergy = f(TreatmentStatus, GDPPC, Population) \quad (1)$$

$$EnIntenity = f(TreatmentStatus, GDPPC, Population) \quad (2)$$

$$RenCap = f(TreatmentStatus, GDP, Population) \quad (3)$$

$$HDI = f(TreatmentStatus, GDP, Population) \quad (4)$$

CO₂energy is CO₂ emission per energy consumption, EnIntensity is energy intensity or energy consumption per GDP output, RenCap is installed renewable capacity, HDI is human development index, GDPPC is gross domestic product per capita, and GDP is gross domestic product.

3.2 Empirical Strategy

We use a modified version of the difference-in-difference (DiD) method to account for the fact that different countries implemented the carbon tax policy at different times. Thus, carbon tax policy adoption in the EU is staggered over three cohorts or groups: (1) some countries are never treated; (2) some countries are treated at an earlier date; (3) some countries are treated at a later date. A common method for estimating treatment effects in such panel data settings is the two-way fixed effects difference in difference estimator (TWFE-DiD), which includes fixed effects for each

group and period. Thus, the baseline TWFE-DiD model is specified as follows:

$$Y_{it} = \beta_0 + \beta_1 G_i D_t + \gamma X_{it} + \lambda_i + \mu_t + \epsilon_{it} \quad (5)$$

Where i and t are country and year indices, Y is the outcome variable, which can be any of the four dependent variables we mentioned before; G is a binary variable that indicates whether a country belongs to the treatment group; and D is a binary variable that indicates whether a year is a treatment year. The main variable of interest is the interaction term $\beta_1 G_i D_t$, which shows whether country i was exposed to the carbon tax policy in year t . Its coefficient β_1 is the difference-in-difference estimator, which captures the average treatment effect on the treated (ATT). X_{it} is a vector of covariates, and λ_i and μ_t are vectors of country and year fixed effects that control for unobserved heterogeneity.

If all the treatment groups are exposed to the policy at the same time, we could use equation (5) with a two-way fixed effects estimator (TWFE) to estimate the ATT. However, since our sample has a staggered treatment, the TWFE estimator is unsuitable. Recent research by Callaway and Sant'Anna (2021) and Goodman-Bacon (2021) has shown that the standard TWFE estimator may not be accurate in a staggered treatment setting because it assumes that the treatment effect is the same for all treated units and periods. Additionally, the TWFE estimator can be biased if the parallel trend assumption is not met before treatment.

To address these issues, we use the generalized DiD approach proposed by Callaway and Sant'Anna (2021), which allows for different treatment effects and adjusts for observed covariates to relax the parallel trend assumption. This approach estimates multiple ATTs for each cohort-time combination based on when the cohort was treated and how long we observe the outcome after (or before) the treatment. For a cohort treated at time g , we have $T-g$ ATT estimators, where

T is the last panel period. The ATT for outcome variable Y can be expressed in two ways, depending on which units are used for comparison. If we compare with units that never received treatment (group C), then the ATT for the cohort treated at time g observed at time t is:

$$ATE_{(g,t)} = E[Y_t - Y_{g-1} | G_g = 1] - E[Y_t - Y_{g-1} | C = 1] \quad (6)$$

The ATT for outcome variable Y at time t for the cohort treated at time g can be calculated using equation 6. This equation compares the change in Y for a treated cohort to the change in Y for units that never receive treatment. This is known as the CS-NT estimator. Callaway and Sant'Anna (2021) also propose an alternative estimator that uses units not yet treated at time t as controls. In this case, the ATT is expressed differently.

$$ATE_{(g,t)} = E[Y_t - Y_{g-1} | G_g = 1] - E[Y_t - Y_{g-1} | D_t = 0, G_g = 0] \quad (7)$$

The ATT for outcome variable Y at time t for the cohort treated at time g can be calculated using Equation 7. This equation compares the change in Y for this cohort to the change in Y for units that will be treated later but have not yet been treated at time t (so $D_t = 0$). This is known as the CS-YT estimator. We estimate both Equation 6 (CS-NT) and Equation 7 (CS-YT) to check the robustness of our results. To get a summary ATT from the different cohort-time combinations (CS-NT and CS-YT), we use the doubly robust DiD estimator option proposed by Sant'Anna and Zhao (2020). This option uses stabilized inverse probability weighting and ordinary least squares.

3.2.1 Robustness Checks

In addition to CS-DiD analysis, we also use the decomposition method of Goodman-Bacon (2021), which breaks down the two-way fixed effects DiD estimator into a weighted average of all possible two-group/two-period DiD estimators. This method enables us to understand the sources of the

treatment effect. It also enables us to assess the robustness of our results by comparing the estimates with those of the CS-NT and CS-YT.

4. Preliminary Analysis

Table 2.2 contains the summary descriptive statistics of the variables for each country. Table 2.2 shows the variables' mean values and standard deviation (SD).

Table 2. 2: Descriptive Statistics

Country	Statistics	CO2 per Energy Use	Renewable Capacity	Energy Intensity	HDI	GDPPC	Population
Austria	Mean	2.214	3.814	3.287	0.881	10.589	15.923
	SD	0.216	0.132	0.248	0.029	0.128	0.04
Belgium	Mean	2.029	1.898	4.995	0.893	10.505	16.176
	SD	0.241	0.664	0.736	0.032	0.122	0.046
Bulgaria	Mean	2.47	1.904	5.804	0.753	8.555	15.865
	SD	0.145	0.303	1.646	0.046	0.277	0.07
Croatia	Mean	2.139	2.259	4.036	0.81	9.466	15.291
	SD	0.184	0.167	0.586	0.048	0.454	0.042
Cyprus	Mean	3.157	1.135	3.53	0.822	10.032	13.827
	SD	0.445	0.056	0.526	0.051	0.156	0.143
Czechia	Mean	2.719	1.942	6.237	0.831	9.562	16.155
	SD	0.28	0.401	1.408	0.053	0.216	0.014
Denmark	Mean	2.753	2.359	2.991	0.898	10.799	15.509
	SD	0.348	0.612	0.577	0.035	0.11	0.037
Estonia	Mean	3.116	1.25	5.659	0.815	9.587	14.138
	SD	0.298	0.195	1.468	0.064	0.356	0.052
Finland	Mean	1.818	3.269	6.539	0.892	10.557	15.476
	SD	0.279	0.171	0.911	0.038	0.173	0.031
Germany	Mean	2.492	4.179	3.827	0.902	10.489	18.219
	SD	0.122	0.833	0.605	0.036	0.115	0.011
Greece	Mean	3.228	2.236	3.359	0.833	9.839	16.194
	SD	0.389	0.438	0.24	0.044	0.136	0.023
Hungary	Mean	2.127	1.475	4.99	0.792	9.261	16.128
	SD	0.189	0.31	1.008	0.047	0.26	0.02
Ireland	Mean	2.962	1.754	2.818	0.859	10.653	15.234
	SD	0.273	0.446	0.92	0.065	0.337	0.117
Italy	Mean	2.502	4.182	2.841	0.852	10.343	17.88
	SD	0.178	0.368	0.18	0.037	0.062	0.026
Latvia	Mean	1.964	1.821	5.206	0.787	9.412	14.624
	SD	0.257	0.109	1.943	0.059	0.589	0.103
Lithuania	Mean	1.696	1.333	5.256	0.798	9.319	15.004
	SD	0.379	0.169	2.065	0.063	0.486	0.096
Luxemburg	Mean	2.684	1.179	3.564	0.874	11.442	13.066
	SD	0.283	0.055	0.924	0.044	0.166	0.145
Netherlands	Mean	2.164	2.182	4.146	0.901	10.606	16.6

	SD	0.167	0.603	0.655	0.028	0.139	0.042
Poland	Mean	3.183	2.205	5.229	0.808	9.04	17.459
	SD	0.286	0.683	1.599	0.053	0.355	0.006
Romania	Mean	2.491	3.023	4.925	0.755	8.748	16.873
	SD	0.172	0.212	1.906	0.055	0.327	0.06
Slovakia	Mean	2.175	2.03	5.665	0.789	9.427	15.499
	SD	0.228	0.195	1.817	0.059	0.426	0.007
Slovenia	Mean	2.259	1.943	4.906	0.859	9.902	14.518
	SD	0.136	0.114	0.747	0.046	0.237	0.017
Sweden	Mean	1.207	4.396	5.414	0.897	10.671	16.033
	SD	0.473	0.145	1.15	0.038	0.166	0.052

We observe from Table 2.2 that Cyprus has the highest mean CO₂ per energy use among the countries and has a high SD of 0.445, indicating that its CO₂ emissions vary considerably. Also, Sweden has the lowest mean CO₂ per energy use among the countries, and this may suggest that Sweden has a low carbon intensity in its energy use. Sweden's record of low CO₂ intensity is not surprising, considering that it is the second country in the world to introduce a carbon tax policy in 1991 after Finland implemented it in 1990. Another finding from Table 2.2 suggests that Denmark has the highest mean human development index among the countries, with 0.898, and a low SD of 0.035, indicating that its human development is relatively consistent over time. This implies that Denmark has achieved a high level of wellbeing for its population in terms of life expectancy, education, and income per capita. The rest of Table 2.2 can be interpreted in a similar manner.

In Table 2.3, we also report the Pearson correlation table for the variables to show the strength of the linear association between variable pairs. A Pearson correlation table displays the linear relationship between two variables, with values ranging from -1 to 1. A value of -1 indicates a perfect negative linear relationship, 1 indicates a perfect positive linear relationship, and 0 indicates no linear relationship. In Table 2.3, six variables are being compared.

Table 2. 3: Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) CO2intensity	1.000					
(2) RenCap	-0.354	1.000				
(3) EnIntensity	-0.172	-0.210	1.000			
(4) HDI	-0.233	0.438	-0.466	1.000		
(5) GDPPC	-0.086	0.285	-0.420	0.743	1.000	
(6) Population	-0.047	0.624	-0.040	0.074	-0.138	1.000

The correlation matrix reveals several interesting relationships among the key variables related to energy transition and development in EU countries. Notably, CO2 intensity (CO2 emissions per energy use) shows a moderate negative correlation (-0.354) with renewable capacity (RenCap). This suggests that countries with higher renewable energy capacity tend to have lower CO2 emissions per unit of energy used, which aligns with the expected benefits of transitioning to cleaner energy sources.

Energy intensity (EnIntensity) displays negative correlations with several variables, most notably with the Human Development Index (HDI) (-0.466) and GDP per capita (GDPPC) (-0.420). These relationships suggest that more developed and wealthier countries tend to have lower energy intensity, possibly due to more efficient technologies, service-oriented economies, or better energy management practices. The negative correlation between energy intensity and renewable capacity (-0.210), although weak, hints at the potential role of renewable energy in improving overall energy efficiency.

The Human Development Index (HDI) shows strong positive correlation with GDP per capita (0.743), which is expected given that economic output is a component of the HDI. More interestingly, HDI has a moderate positive correlation with renewable capacity (0.438), suggesting

that countries with higher human development tend to have more installed renewable energy capacity. This could indicate that more developed countries have greater resources and possibly stronger policy frameworks to support renewable energy adoption.

Population size shows a surprisingly strong positive correlation with renewable capacity (0.624). This unexpected relationship might suggest that larger countries have more diverse geographical features suitable for various types of renewable energy, or that they have greater absolute energy needs driving investments in renewables. However, population shows very weak correlations with other variables, including CO2 intensity (-0.047) and energy intensity (-0.040), indicating that population size alone does not strongly influence these energy efficiency metrics.

Lastly, it's worth noting that CO2 intensity has weak to moderate negative correlations with most other variables, including HDI (-0.233) and GDPPC (-0.086). While these correlations are not strong, they suggest a general trend where higher development and wealth are associated with slightly lower CO2 emissions per unit of energy.

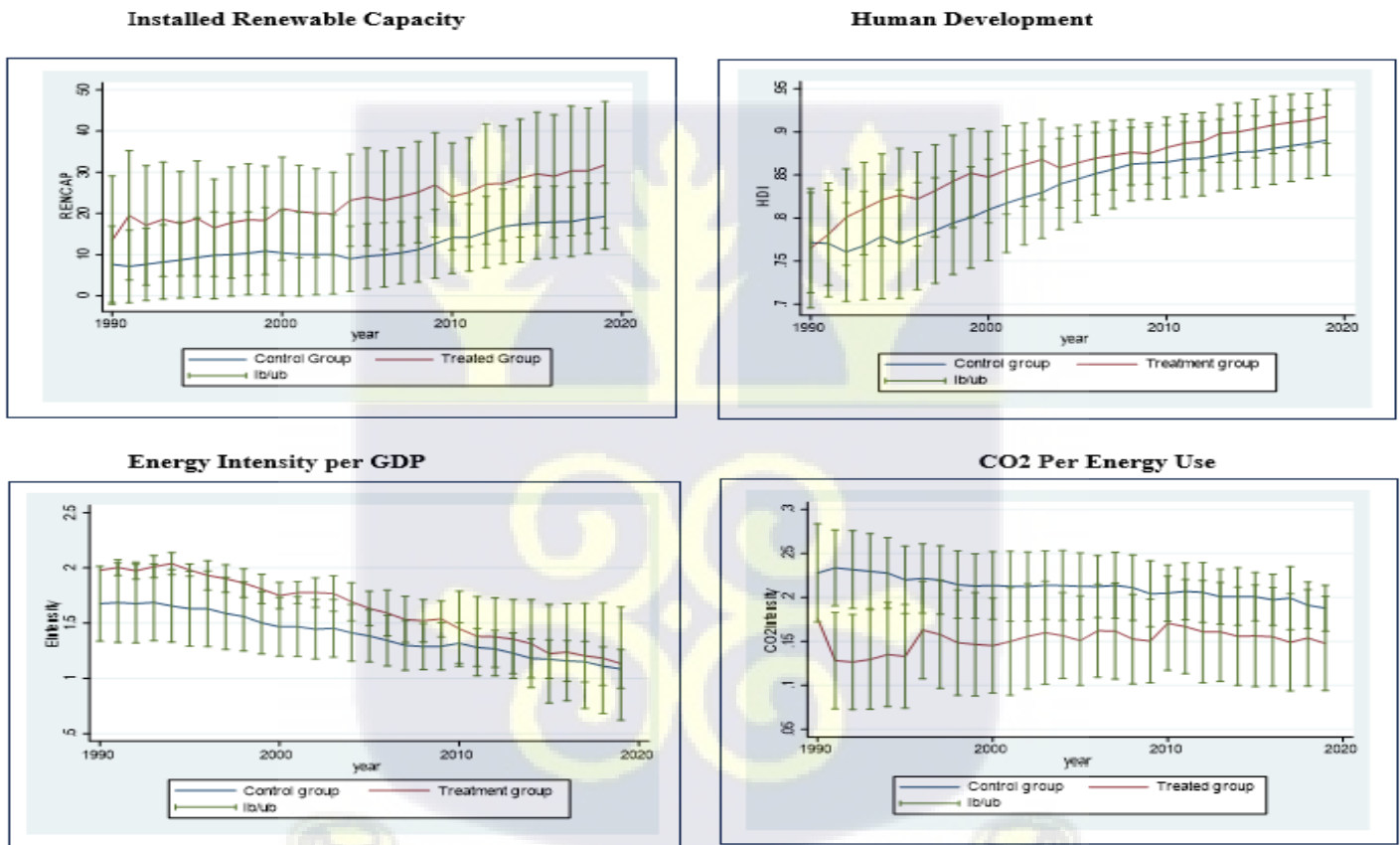
Notwithstanding, it is crucial to emphasize that while correlation analysis provides valuable insights into the relationships between variables, it is not sufficient to determine causality or the full complexity of these relationships. The correlations observed here suggest potential associations, but they do not explain the underlying mechanisms or account for confounding factors that may influence these relationships. Therefore, while these correlations offer a useful starting point for understanding, a difference in difference analysis is conducted to further establish the relationships among the variables.

4.1 Parallel Trend Analysis

The parallel trend assumption is an essential requirement for DiD estimation. It implies that, without a carbon tax, the outcome variable would have followed the same path for both the

treatment and control groups. This allows us to infer that any changes in the two groups after the treatment are due to the carbon tax adoption rather than other factors. This assumption is necessary for constructing a valid counterfactual scenario for the treated units but is hard to meet in most cases (Fredriksson & Oliveira, 2019; Ryan et al., 2019). The study plots the trend lines for the four dependent variables in Figure 2.2. The blue line shows the control group, while the red line shows the treatment group.

Figure 2. 2: Visual Inspection of Parallel Trends



Source: Author generated graph based on WDI and OECD Data (2023)

5. Empirical Results

The results of the CSDiD estimator are presented in Table 2.4. Panel A (CS-NT) shows the CSDiD estimator results when the never-treated group is used as the control group, while panel B (CS-

YT) presents the results when the not-yet-treated group is used as the control group.

Table 2. 4: CS-DiD:

Panel A: CS-NT Result
Panel B: CS-YT Result

	CO2 per Energy Use	Energy per GDP	Renewable Capacity	Human Dev. Index	CO2 per Energy Use	Energy per GDP	Renewable Capacity	Human Dev. Index
Overall ATT	-0.265*** (0.21)	-0.515*** (0.21)	0.308* (0.17)	0.026*** (0.01)	-0.314*** (0.08)	-0.529*** (0.21)	0.329** (0.17)	0.024*** (0.01)
ATT by group								
GAverage	-0.265*** (0.02)	-0.430*** (0.10)	0.256*** (0.02)	0.024*** (0.00)	-0.297*** (0.02)	-0.464*** (0.11)	0.272*** (0.02)	0.022*** (0.00)
G1991	NA (NA)	-0.753*** (0.28)	NA (NA)	0.017*** (0.01)	NA (NA)	-0.690** (0.26)	NA (NA)	0.017** (0.01)
G1992	-0.401*** (0.07)	(0.41) (0.38)	0.70 (0.06)	0.035*** (0.01)	-0.397*** (0.07)	(0.37) (0.35)	0.272*** (0.02)	0.032*** (0.01)
G1996	-0.186*** (0.05)	-1.041*** (0.22)	0.013*** (0.04)	0.036*** (0.00)	-0.150*** (0.04)	-0.839*** (0.25)	0.03 (0.04)	0.035*** (0.00)
G2000	-0.285*** (0.03)	(0.59) (0.55)	0.233*** (0.030)	0.019*** (0.00)	-0.520*** (0.03)	-0.851*** (0.39)	0.286*** (0.03)	0.019*** (0.00)
G2010	-0.187*** (0.03)	-0.215*** (0.04)	0.08 (0.06)	0.010*** (0.00)	-0.187*** (0.03)	-0.215*** (0.04)	0.08 (0.06)	0.010*** (0.00)
ATT by Calendar Period								
CAverage	-0.2311*** (0.06)	-0.493** (0.18)	0.271* (0.15)	0.025*** (0.01)	-0.262*** (0.07)	-0.512*** (0.18)	0.300* (0.17)	0.024*** (0.01)
ATT by Periods Before and After treatment (Event Study: Dynamic effects)								
Pre_avg	0.002 (0.01)	0.02 (0.05)	(0.01) (0.01)	0.001 (0.00)	0.01 (0.01)	(0.01) (0.04)	0.002 (0.01)	0.002 (0.00)
Post_avg	-0.353*** (0.06)	-0.571*** (0.22)	0.42*** (0.14)	0.025* (0.00)	-0.368*** (0.07)	-0.574*** (0.22)	0.425*** (0.14)	0.024*** (0.01)

Note: Robust Standard Errors in parentheses; ***, **, and * denote 0.01, 0.05, and 0.1 rejection level, respectively. CSDiD estimates are adjusted for the effects of covariates.

Regardless of the choice of a control group (i.e., whether CS-YT in panel A or CS-NT in panel B), we observe that the results are qualitatively identical, although the magnitude of the effect may slightly differ. The event study (i.e., dynamic effects-before and after) reveals that the pre-treatment average effect is insignificant for all the outcome variables, meaning that the groups had similar trends in the outcome before the treatment. By implication, the difference after the treatment can be attributed to the causal effect of the treatment. Therefore, the post-treatment period average being significant gives strong evidence that the treatment impacted the outcome

variables across all groups and periods. In the following subsections, we discuss the results. However, given that both CS-NT and CS-YT produced consistent results, we focus on interpreting only one (i.e., CS-NT) for brevity.

5.1 CO₂ per Energy Use

The results show that carbon tax policy adoption has a significant negative effect on CO₂ per energy use, meaning that it reduces the carbon intensity of the energy system. The overall average treatment effect on the treated (ATT) is -0.265, indicating that the EU countries that adopted carbon tax policy have 26.5% lower CO₂ per energy use than the EU countries that did not adopt carbon tax policy. The ATT by group shows that all treatment groups have significantly lower CO₂ per energy use than the control group. Also, the event study analysis indicates a negative and significant impact of carbon tax policy on carbon intensity in the post-treatment period, while no significant effect is observed in the pre-treatment period.

These results corroborate studies that call for the use of carbon taxes to support the transition to carbon-efficient energy systems. However, it is important to note that the magnitude of the effect (-26.5%) may seem substantial, but the actual impact on reducing emissions could be more modest, as the carbon intensity of the energy mix is just one factor influencing overall emissions. Other factors, such as total energy consumption levels, the fuel mix, and the broader economic and policy environment, also play crucial roles in determining a country's emission profile. Therefore, while carbon taxes appear effective in reducing the carbon intensity of energy use, their overall impact on total emissions may be more nuanced and dependent on the broader policy context.

5.2 Energy Use per GDP

The results show that carbon tax policy has a significant negative effect on energy consumption per GDP, meaning that it reduces the energy intensity of the economy. The overall ATT is -0.515, indicating that the EU countries that adopted carbon tax policy have 51.5% lower energy consumption per GDP than those that do not implement carbon tax policy. The ATT by group shows that most treated cohorts have significantly lower energy use per GDP than the control group. At the same time, the event study reveals that the treated group had a larger and more significant reduction in energy intensity during the post-treatment period relative to the pre-treatment period.

These findings suggest that carbon taxes can indeed incentivize businesses and households to improve energy efficiency, as discussed in the literature. However, it is crucial to consider that reductions in energy intensity per GDP do not necessarily translate into absolute reductions in energy use or emissions. In some cases, energy efficiency gains may lead to increased economic activity and, consequently, higher overall energy consumption and emissions (the "rebound effect"). Therefore, while carbon taxes appear effective in improving energy efficiency, their ultimate impact on total energy use and emissions may be moderated by other economic and behavioral factors.

5.3 Installed Renewable Capacity

The results show that carbon tax policy has a significant positive effect on installed renewable energy capacity, meaning that it increases the share of renewable energy sources in the energy mix. The overall ATT is 0.308, indicating that the EU countries that adopted carbon tax policy have 30.8% more renewable energy capacity than those that do not implement carbon tax policy.

The ATT by group shows that cohorts G1996 and G2000 have significantly higher renewable capacity than the control group, while the other cohorts failed to establish a significant effect. The ATT of the event study shows that the effect of carbon tax policy on renewable capacity is 0.025 units higher in the post-treatment period relative to the pre-treatment period. These results suggest that carbon tax policy effectively increases the share of renewable energy sources in the energy mix, especially in the long run.

While these findings align with the theoretical understanding that carbon taxes can incentivize the growth of renewable energy, it is important to note that the actual deployment of renewable energy is influenced by a complex interplay of factors, including technology costs, grid integration challenges, policy support, and market conditions. The observed increase in renewable capacity may not necessarily translate into a proportional reduction in fossil fuel use or emissions, as the integration of renewable energy into the grid and the overall energy system dynamics are crucial in determining the climate impact.

5.4 Human Development Index

The results show that carbon tax policy has a significant positive effect on human development index, meaning that it improves socio-economic wellbeing. The overall ATT is 0.026, indicating that the EU countries that adopted carbon tax policy have 2.6% higher human development index than the control group. The ATT by group shows that all cohorts have a significantly higher human development index than the control group, with G1992 having the largest positive effect (0.035) and G2010 having the smallest positive effect (0.01). The event study similarly suggests that the effect of carbon tax policy on the human development index is positive and significant in the post-

treatment period (0.025). These results suggest that carbon tax policy can ensure a just energy transition by improving the socio-economic wellbeing of the EU population, both in the short and long run.

While these findings are promising, it is important to recognize that the relationship between carbon taxes, environmental outcomes, and socio-economic wellbeing is complex and can be influenced by various factors, including the specific design and implementation of the carbon tax policy, the use of tax revenue, and the broader economic and social context. The positive effect on the human development index observed in this study may be mediated by factors such as improved public health, energy affordability, and environmental quality, but the causal pathways and the distributional impacts on different socio-economic groups within the population warrant further investigation.

6. Robustness Checks

We check the robustness of our estimates by running the Goodman-Bacon (2021) decomposition of the 2X2 DiD analysis. Table 2.5 contains the estimated results, while Figure 2.3 contains visual representations.

Table 2. 5 Bacon Decomposition

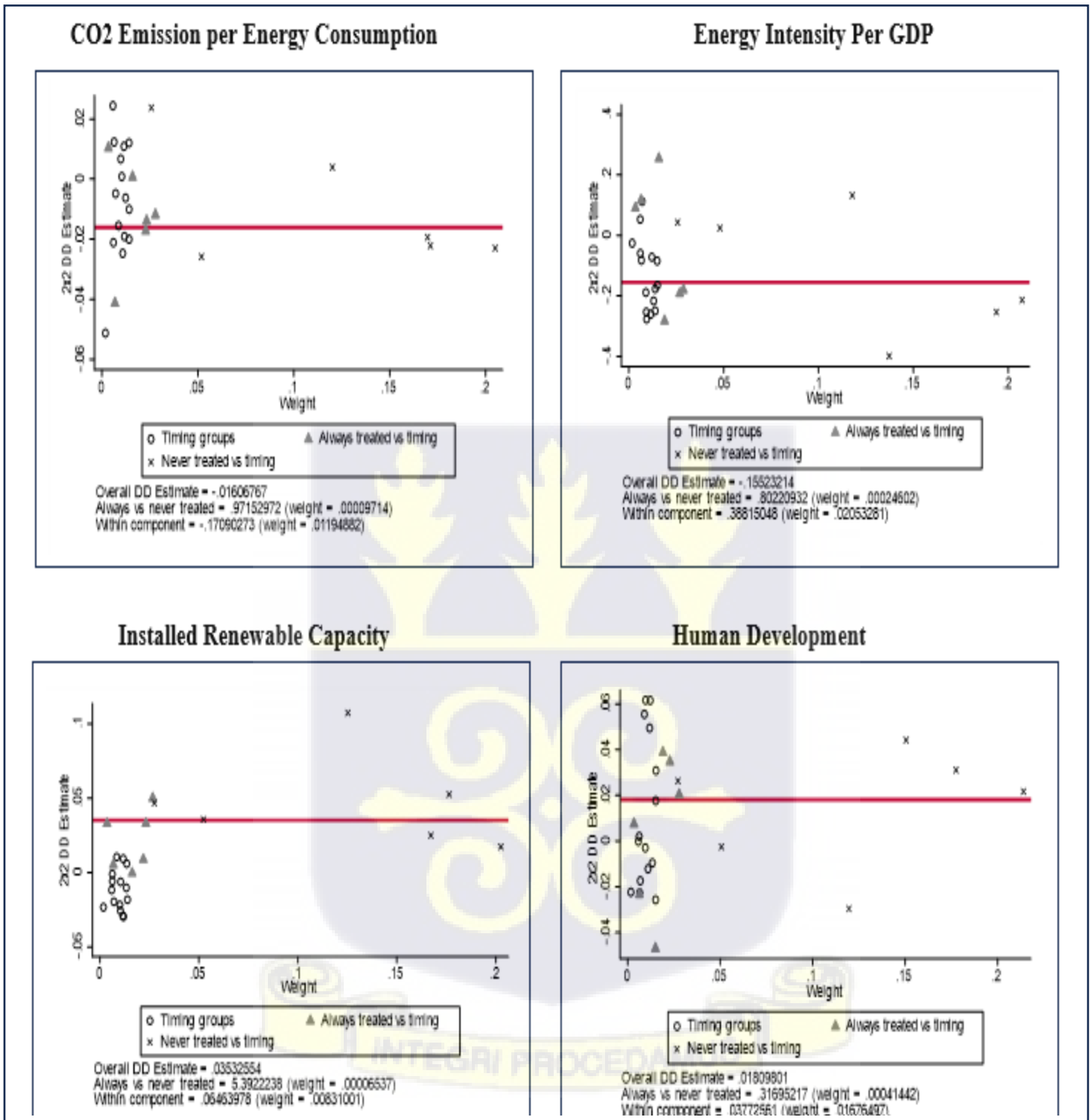
	ATT	Timing_ groups	Always vs timing	Never_ vs timing	Always_vs_ never	Within
CO2 per Energy Use	-0.016*** (0.006)	-0.005 0.144w	-0.013 0.100w	-0.016 0.743w	0.972 0.002w	-0.171 0.012w
Energy Use per GDP	-0.155*** (0.079)	-0.153 0.149w	-0.105 0.100w	-0.178 0.730w	0.802 0.000w	-0.388 0.021w
Renewable Capacity	0.035*** (0.011)	0.011w 0.142	0.025 0.098w	0.045 0.751w	5.392 0.002w	0.065 0.008w
HDI	0.018** (0.009)	0.015 0.149w	0.013 0.094w	0.019 0.740w	0.317 0.000w	0.038 0.017w

Note: Standard errors are in parentheses; w refers to weights; ***, **, and * denote 0.01, 0.05, and 0.1 rejection level, respectively.

The results of the Goodman-Bacon (2021) decomposition show consistency with those of the CS-NT and CS-YT in Table 2.4. From Goodman-Bacon's decomposition (Table 2.5), the ATT indicates that CO₂ emissions per unit of energy usage are lower in EU countries that have adopted carbon taxes, and these countries also have a reduced energy consumption per GDP output compared to those that have not adopted such taxes. Also, the results show that EU countries in the treatment group have more installed renewable capacity and human development relative to those that have not implemented carbon taxes. Noticeably, the results show that the greatest difference between the control and treatment groups emanates from the treatment group that has consistently implemented carbon taxes relative to those that have never implemented it, signifying the long-term effect of carbon tax policy adoption. The visual representations of the Goodman-Bacon decomposition are presented in Figure 2.3.

From the graph in Figure 2.3 below, the Goodman-Bacon decomposition graph can be interpreted such that the x-axis represents the weight of each 2x2 DiD estimate. The weight is the share of the overall DiD estimate that each 2x2 contributes. If a point is further to the right, it means that particular 2x2 DiD estimate contributes more to the overall DiD estimate. On the other hand, the y-axis represents the 2x2 DiD estimate itself. If a point is above zero, it means that the treatment had a positive effect in that particular 2x2 comparison. If it's below zero, the treatment had a negative effect. Moreover, the shape of each point represents the type of comparison being made. For example, in a staggered adoption setting, some comparisons might be between early-adopters and late-adopters, while others might be between adopters and never-adopters. Finally, the horizontal line at $Y = 0$ represents no effect. Points above this line indicate a positive effect of the treatment, and points below indicate a negative effect.

Figure 2. 3: Goodman-Bacon Decomposition Results



7.1 Conclusions and Implications

This quasi-experimental study evaluated the environmental and socio-economic impacts of carbon

taxation policies across EU countries. The results provide important contributions to both research and policymaking in this domain.

From a research perspective, the study adds to the growing body of empirical evidence on the effectiveness of carbon pricing instruments. By comparing outcomes between countries with and without carbon taxes, it demonstrates the tangible benefits of this policy approach. Specifically, the analysis found that carbon tax adoption significantly improved energy efficiency (reduced CO₂ emissions per energy use and energy consumption per GDP) and increased the uptake of renewable energy sources. Importantly, the environmental benefits were more pronounced for energy efficiency measures than for renewable energy adoption. This nuanced finding contributes to a better understanding of the multifaceted impacts of carbon taxation. The study also examined the socio-economic implications, revealing that carbon tax countries experienced greater improvements in human development outcomes. This reinforces the notion that well-designed carbon pricing can generate revenues to fund social welfare programs and support a just transition. However, the distributional effects warrant further investigation, as carbon taxes may differentially impact various regions, sectors, and income groups within a country.

From a policy perspective, these results provide strong evidence to support the wider adoption of carbon taxation within the European Union. The study's findings demonstrate that carbon pricing is an effective tool for reducing greenhouse gas emissions and promoting clean energy transitions. To create a fair and harmonized market across the EU and prevent carbon leakage, it is crucial for more member states to implement this instrument. The study highlights that a gradual, transparent, and credible approach to carbon tax implementation can be an effective strategy, as exemplified

by Sweden's experience. Thus, policymakers should consider gradually increasing the carbon tax rate over time, accompanied by clear communication on the policy's rationale, objectives, and expected outcomes. This approach can help build public acceptance and minimize potential backlash from affected industries and households. Additionally, transparency around the use of carbon tax revenues, such as investing in green infrastructure or providing income support for vulnerable groups, can further enhance the policy's credibility and legitimacy.

Policymakers should also consider complementary policies that foster clean energy innovation, investment, and public awareness to maximize the impact of carbon pricing. For instance, earmarking a portion of carbon tax revenues to fund research, development, and deployment of renewable energy technologies can stimulate further clean energy transitions. Pairing carbon taxation with incentives like subsidies, tax credits, or low-interest loans for green investments can also help drive private sector engagement and accelerate the shift to a low-carbon economy.

Effective communication and education strategies are also crucial to accompany carbon taxation policies. Engaging the public through awareness campaigns and participatory processes, as seen in France's national debate on ecological transition, can help build understanding and support for the policy. This, in turn, can encourage sustainable consumption and production patterns among businesses and households.

Additionally, the findings underscore the importance of coordinating carbon taxation with other international climate change mitigation efforts. Aligning carbon pricing with mechanisms like carbon markets, climate finance, and technology transfer can enhance the overall effectiveness of these policies in driving the global transition to a low-carbon economy. For example, linking

national or regional carbon trading systems, as demonstrated by the Switzerland-EU ETS link, can create larger, more efficient carbon markets and reduce abatement costs. Moreover, a cooperative, multilateral approach to carbon pricing can involve providing financial and technical assistance to support developing countries in transitioning to green economies. This can help ensure a more equitable and inclusive global climate change mitigation strategy, where developed countries support their less-developed counterparts in implementing effective carbon pricing policies.

By adopting these comprehensive and coordinated policy strategies, policymakers in the European Union can leverage the power of carbon taxation to drive meaningful environmental and socio-economic progress, ultimately contributing to the achievement of global climate goals.

7.1.1 The Special Case of Developing Countries

The results of this study show that carbon taxes have a stronger effect on energy efficiency than on renewable adoption in the EU. However, the implications of this finding may differ for developing countries, which face different challenges and opportunities in their energy transition. For instance, on average, African countries have lower energy intensity and higher renewable potential than the EU, meaning they can benefit more from renewable adoption than energy efficiency (IEA, 2021, 2019; World Bank, 2020). Moreover, developing countries have lower income levels and higher poverty rates than the EU, meaning they are more sensitive to carbon taxes' regressive distributional impacts and social costs (Parry et al., 2022). Therefore, developing countries may need to design carbon taxes that are more progressive and inclusive and that are accompanied by complementary policies such as subsidies, rebates, exemptions, or transfers to protect the poor and vulnerable groups from the adverse effects of higher energy prices

(IMF/OECD, 2021).

7.2 Research Limitations

One limitation is that the study only examines the effects of carbon tax policy in the EU and does not consider other regions or countries. Future research could expand the scope of the analysis to include other regions or countries and consider a broader range of environmental and socio-economic outcomes. Finally, future research could also consider the potential distributional impacts of carbon tax policy and explore ways to design carbon tax policy to achieve both environmental and socio-economic goals in a just and equitable manner.



CHAPTER THREE

THE EFFECT OF ENERGY DEVELOPMENT ASSISTANCE AND GOVERNANCE QUALITY ON ENVIRONMENTAL TAX EFFORT IN SUB-SAHARAN AFRICA



Abstract

The literature on foreign aid and tax efforts largely overlooks the specific role of environmental aid and taxation. To fill this gap, we examine the effects of energy development assistance (energy aid) and governance quality on climate change tax effort, air pollution tax effort, and aggregate environmental tax effort in Sub-Saharan Africa (SSA). Utilizing panel data from 15 SSA countries over 20 years (2000-2019), the sample is divided into two groups based on income levels: seven low-income countries (LIC) and eight middle-income countries (MIC). The instrumental variable generalized method of moments (IV-GMM) regression technique is employed to estimate the parameters of the baseline model specifications. The study also uses the Smoothed Instrumental Variable Quantile Regression (SIVQR) technique to test the robustness of the baseline model. Among middle-income SSA countries, the findings suggest that renewable energy aid inflows reduce climate change tax efforts but increase air pollution and aggregate environmental tax efforts. However, among low-income SSA countries, renewable energy aid negatively impacts all three categories of environmental tax efforts. Governance quality tends to enhance all three categories of environmental tax effort in both low-income and middle-income SSA countries. The implications of these results are discussed.

Keywords: Energy Aid; Governance Quality; Environmental Tax Effort; Sub-Saharan Africa

-
2. This chapter has undergone review with the *Energy Reports* Journal.

1. Background

Environmental taxes, imposed on activities like pollution, resource depletion, or waste generation (Abbas et al., 2023; Abokyi et al., 2019; Al Shammre et al., 2023; Bashir et al., 2022; Chien et al., 2023), play a pivotal role in promoting sustainable development by encouraging cleaner energy sources and discouraging carbon-intensive ones (Bashir et al., 2022; Sarpong et al., 2023). This study explores how energy development assistance (EDA) and governance quality (GOVQ) influence these environmental tax efforts in Sub-Saharan African countries (SSA). Understanding the fiscal implications of aid is important, as most of it is funneled through government spending (Combes et al., 2016; Marineau, 2020).

Aid can be a double-edged sword. It could lead to a moral hazard where governments depend on donors for environmental objectives instead of mobilizing domestic resources through taxes (Ammendola, 2010; Combes et al., 2016; Crivelli & Gupta, 2017; Pham & Pham, 2019). Conversely, it could boost tax efforts by improving tax administration (Benedek et al., 2014; Mascagni & Timmis, 2017; Müller & Claar, 2021; Müller et al., 2021). This study adds to the discourse by specifically examining the impact of energy aid and governance quality on environmental tax efforts (Maruta & Banerjee, 2021).

Climate change is a pressing global issue (Ivanova, 2020; Scott & Ku, 2018; Wunderling et al., 2023), and energy transition is a key strategy to combat it as energy-related emissions contribute over 89% of global greenhouse gases (International Energy Agency-IEA, 2022). However, the high costs of renewable energy technologies and integration challenges have hindered their adoption in SSA (IMF/OECD, 2021; Oyedepo & Adaramola, 2020). Governments often resort to environmental taxation to fund energy transition investments and enhance energy efficiency (Ahmad et al., 2023; Bashir et al., 2022; Shamsi & Farzanegan, 2021). But in SSA, these taxes fall

short in funding energy transition, making financing a significant hurdle to accelerating energy transition in the region (IMF/OECD, 2021; International Renewable Energy Agency-IRENA, 2021; Oyedepo & Adaramola, 2020).

Developed countries and international organizations have extended financial and technical assistance to SSAs through renewable energy aid to support this transition (Finan & Kanie, 2018; Maruta & Banerjee, 2021). Yet, debates persist about foreign aid's impact on recipient countries' tax efforts. Energy aid could either decrease environmental tax effort if seen as an easier source of revenue (Asongu & Jellal, 2016; Banerjee et al., 2021; Marineau, 2020; Thornton, 2014), or increase it if it enhances revenue administration or supports environmental tax policy reform (Benedek et al., 2014; Wen et al., 2023). The current understanding of this phenomenon is largely theoretical and anecdotal, underscoring the need for empirical study (Asongu & Jellal, 2016; Maruta & Banerjee, 2021; Thornton, 2014).

The current body of knowledge on the relationship between foreign aid and tax efforts has largely overlooked the specific impact of environmental aid and taxation (Maruta & Banerjee, 2021). This gap limits the potential for policy development to address environmental challenges. Our research aims to fill this void by examining the effect of renewable energy aid and governance quality on environmental tax efforts in Sub-Saharan Africa. We expand our research scope by categorizing energy-related environmental taxes into three categories: climate change tax, air pollution tax, and aggregate environmental tax, and investigating their interplay with energy aid and governance quality. This enables us to concentrate on the drivers of environmental tax effort, an aspect often neglected in favor of studying the consequences of environmental taxation (Chien et al., 2023; Maruta & Banerjee, 2021; Shahzad, 2020).

From the foregoing, the study answers four research questions:

1. What is the effect of EDA on the air pollution tax efforts of SSA countries?
2. What is the effect of EDA on the climate change tax efforts of SSA countries?
3. What is the effect of EDA on the aggregate environmental tax effort of SSA countries?
4. What is the effect of governance quality on the environmental tax efforts of SSA countries?

To address these research questions, we employ the Instrumental Variable Generalized Methods of Moments Regression (IVGMM), and the Smooth Instrumental Variable Quantile Regression (SIVQR) techniques, which can address the endogeneity challenges faced by prior studies (Combes et al., 2016; Papiés, 2017) and at the same time provide both linear and asymmetric estimates of the parameters. While some previous studies have tried to account for nonlinearity by including squared or interaction terms in their models (Benedek et al., 2014; Brun et al., 2008; Clist & Morrissey, 2011), these methods have been associated with heteroscedasticity, collinearity, and misspecification (Combes et al., 2016). Our study employs IV-GMM and SIVQR estimation techniques to address these issues.

Our results, based on panel data from 15 SSA countries (2000 - 2019), suggest that in middle-income SSA countries, EDA decreases climate change tax efforts but increases air pollution and aggregate environmental tax efforts. Conversely, in low-income SSA countries, EDA has a negative effect on all three categories of environmental tax efforts. Governance quality consistently improves all three categories of environmental tax effort in both low-income and middle-income SSA countries. The rest of our study is organized into five sections: a literature review, a description of our research methodology, a presentation and discussion of our empirical model estimates, a discussion on the policy implications of our findings, and a section addressing the limitations of our study.

2. Literature Review

2.1 Energy Aid and Environmental Tax Effort

The empirical evidence regarding the relationship between foreign aid and tax efforts is a subject of much debate. One school of thought, based on the aid dependency theory, posits that foreign aid can reduce tax effort (Asongu & Jellal, 2016; Combes et al., 2016; Crivelli & Gupta, 2017; Marineau, 2020; Pham & Pham, 2019). According to this paradigm, foreign aid may decrease the incentive and capacity of recipient governments to mobilize domestic resources as they become reliant on external sources of finance (Bräutigam & Knack, 2004; Cui & Hu, 2023; Remmer, 2004). The empirical literature suggests three ways foreign aid can negatively impact tax efforts. The first mechanism is the enforcement mechanism. This means that foreign aid allows recipients to avoid enforcing taxation while still being able to function and finance their operations. This is attractive to recipients because taxation is both operationally costly (e.g., funding the tax apparatus) and politically costly (i.e., taxing citizens makes them demand more representation and accountability) (Marineau, 2020; Morrison, 2015; Remmer, 2004).

The second mechanism is the substitution mechanism, based on the fiscal bargaining theory for tax compliance. According to this theory, tax compliance results from a bargaining process between the state and citizens in which the state provides services in exchange for taxes paid by citizens (Berenson, 2018; Marineau, 2020; Misra, 2019). However, the bargaining process breaks down if citizens can receive services from non-state actors without paying taxes. Thus, foreign aid can fund service delivery by non-state actors, substituting the state as a service provider. This reduces citizens' demands on the state, reducing the need to extract taxes (Bodea & LeBas, 2014; Combes et al., 2016; Deserranno et al., 2020; Dolan, 2020).

The third mechanism is the legitimacy mechanism. This means foreign aid can reduce citizens' perception of the state's legitimacy. When external resources are used to provide public services, citizens may doubt the government's ability to provide for their needs (Blair & Roessler, 2021; Marineau, 2020; Montinola et al., 2020). This can make the citizens question the state's legitimacy to tax, hence negatively impacting the tax effort of the state (Blair & Roessler, 2021; Bräutigam et al., 2008; Marineau, 2020; Prichard et al., 2014; Svensson, 2000).

Besides, Samaritan's Dilemma theory can explain the negative relationship between aid and tax. It explains that aid-recipient countries can strategically maintain suboptimal tax performance in order to continue receiving higher levels of foreign aid (Blair & Roessler, 2021; Marineau, 2020). This phenomenon is also referred to as the crowding-out effect of foreign aid.

The other school of thought suggests that foreign aid can increase tax efforts in recipient countries for several reasons. The fiscal capacity theory argues that the ability of a state to raise revenue from its citizens depends on its administrative and institutional capacity to enforce taxation and provide public goods and services (Besley & Persson, 2013; 2014; Ricciuti et al., 2019). According to this theory, foreign aid can increase tax efforts by enhancing the fiscal capacity of recipient countries through technical assistance, capacity building, and the improvement of tax administration (Bayale, 2020; Fjeldstad & Tungodden, 2003; Mascagni & Timmis, 2017; Moore et al., 2015; Morrison, 2015; Munyanyi et al., 2022). For instance, the aid can help the government train more tax officers, implement new tax reforms, and develop better information systems that stimulate tax efforts (Bayale, 2020; Fjeldstad & Tungodden, 2003; Moore et al., 2015; Morrison, 2015).

Additionally, other empirical studies have argued from the perspective of fiscal contract theory. Such studies have argued that taxation results from a social contract between the state and its

citizens, whereby the state provides public goods and services in exchange for taxes paid by citizens (Huemer, 2013; Lenton et al., 2017; Mangoting & Sukoharsono, 2015; Timmons, 2005). Therefore, foreign aid can increase tax efforts by strengthening the fiscal contract between the state and its citizens through improved service delivery, accountability, and responsiveness.

2.2 Governance Quality and Environmental Tax Effort

Governance quality encompasses various dimensions, such as voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, the rule of law, and control of corruption (Aluko, 2020; Benedek et al., 2014; Farooq, 2022; Kaufmann et al., 2010). Countries can collect higher taxes only if the tax collection process is efficient. Governance quality can affect environmental tax efforts through various channels, such as tax morale, public service delivery, fiscal transparency and accountability, and tax administration capacity (Benedek et al., 2014; Daude et al., 2013a; Damianos, 2021; Gnanngnon & Brun, 2019). For instance, the perceptions and attitudes of taxpayers towards the government, public institutions, and public goods and services can affect tax morale (Daude et al., 2013a; Koumpias et al., 2020; Leonardo et al., 2017; Torgler et al., 2007).

Importantly, the quality of governance is not just about efficiency, but also about accountability and transparency. Governments with high governance quality are more likely to be transparent in their decision-making processes, particularly when it comes to environmental taxation. They are more likely to disclose information about tax rate-setting, the use of tax revenues, and the overall impact of environmental taxes on the economy and the environment (Arif & Rawat, 2018; Timmons & Garfias, 2015). This transparency can enhance public trust and support for environmental tax policies, leading to higher tax compliance and a more effective tax system (Jones et al., 2017; Kubler et al., 2020)

A higher quality of governance can increase tax morale by enhancing the trust and legitimacy of the government, improving the responsiveness and accountability of public officials, reducing corruption and rent-seeking, and ensuring a fair and efficient allocation of public resources (Daude et al., 2013a; Sebele-Mpofu, 2020). Also, public service delivery can influence tax efforts by affecting the cost-benefit analysis of taxpayers on the use of tax revenues (Gnangnon & Brun, 2019; Koumpias et al., 2020; Leonardo et al., 2017). A higher quality of governance can improve public service delivery, increasing the willingness to pay taxes and contribute to the public good, leading to a higher tax effort (Daude et al., 2013a; Gnangnon & Brun, 2019; Sebele-Mpofu, 2020).

Additionally, studies by Arif and Rawat (2018) and Kubler et al. (2020) suggest that the resilience of a country's tax system and its revenue performance are heavily influenced by the administrative superiority of its governance institutions. In situations where governance is inferior, there can be a corrosive impact on tax collection. However, good governance can enhance tax revenue by mitigating tax evasion, properly composing tax rates, and ensuring the fair inclusion of taxable revenue in tax reporting (Ajaz & Ahmad, 2010; Jones et al., 2017; Timmons & Garfias, 2015). Overall, it is evident from the literature that governance quality positively influences tax efforts (Ajaz & Ahmad, 2010; Arif & Rawat, 2018; Jones et al., 2017).

2.3 Control Variables and Environmental Tax Effort

Prior literature has analyzed trade openness, the size of the agricultural sector, GDP per capita, and the size of the shadow economy as control variables while examining the effect of foreign aid on tax effort (Combes et al., 2016; Marineau, 2020; Mascagni & Timmis, 2017; Wen et al., 2023). To this extent, it is expected that these variables may impact energy tax efforts, although they have

not been empirically tested in the context of environmental taxation (Combes et al., 2016; Marineau, 2020; Mascagni & Timmis, 2017; Wen et al., 2023).

Trade openness can pressure governments to reduce energy related environmental taxes to maintain competitiveness (Ekins & Speck, 1999; Levinson, 2003). This argument is predicated on the notion that higher energy related environmental taxes can increase production costs and diminish a country's competitiveness in international markets, thereby reducing environmental tax efforts. Conversely, an alternative perspective posits that trade openness can enable governments to augment their environmental tax efforts (Barros et al., 2023; Gnanon, 2021; Ho et al., 2023). This perspective is based on the notion that trade openness can incentivize governments to safeguard the environment as environmental standards become increasingly important in contemporary international trade. For instance, a country that imposes high energy taxes may be perceived as more environmentally conscious, which can enhance its international reputation and attract investment (Bazillier et al., 2016; Bazillier et al., 2017; Le et al., 2012).

The size of the shadow economy, defined as the economic activities hidden from official authorities for monetary, regulatory, or institutional reasons, has significant implications for environmental tax efforts (Ajide, 2021; Alm et al., 2019). A large shadow economy reduces the tax base and undermines tax collections, while a smaller shadow economy is associated with higher tax effort and revenue (Alm et al., 2019; Awasthi & Engelschalk, 2018; Schneider et al., 2010). Additionally, a larger shadow economy reduces taxpayers' tax morale, negatively impacting tax effort (Dell'Anno & Davidescu, 2019; Horodnic & Williams, 2016; Luttmer & Singhal, 2014; Torgler et al., 2007). When taxpayers perceive that a large share of the economy is evading taxes, they may feel less obliged to pay their taxes or more resentful of the tax system. This can erode

tax morale and increase the incentives to join the shadow economy, hence reducing tax efforts (Dell'Anno & Davidescu, 2019; Luttmer & Singhal, 2014).

Additionally, the literature suggests that a large agricultural sector reduces tax efforts in developing countries since agriculture is relatively difficult to tax (Gupta et al., 2021; Khan, 2001; Morrissey et al., 2016; Rajaraman, 2003). The agricultural sector can include activities such as subsistence farming, which may not be taxed, or informal sales of agricultural products that are not subject to tax (Chakraborty & Dash, 2017; Gngangnon, 2022). Moreover, a large agricultural sector can also lead to political pressure to maintain low tax rates or exemptions for the industry since it is a politically sensitive industry (Chakraborty & Dash, 2017; Gngangnon, 2022).

Tax effort is also expected to depend largely on the income level of a country (Barros et al., 2023; Besley & Persson, 2014; Empirical & Langford, 2016; Pessino & Fenochietto, 2010). Countries with higher incomes tend to have higher tax-to-GDP ratios, mainly because they may have a broader and more diverse tax base due to increased economic activities, more formal sectors, and more consumption and savings (Akitoby et al., 2020; De Mooij, 2020; Empirical & Langford, 2016). Also, higher-income countries may have better institutional quality and governance, which can improve tax administration, compliance, and enforcement. On the contrary, some studies arguing from the perspective of the environmental Kuznets hypothesis suggest that GDP can have a negative association with tax effort (Demissew Beyene & Kotosz, 2020; Leal & Marques, 2022).

3. Methodology

This study utilizes panel data from 15 Sub-Saharan African countries over 20 years (2000-2019), with sample selection based on data availability. The sample is divided into two groups based on income levels: seven low-income countries (LIC) and eight middle-income countries (MIC).

Subdividing samples into homogeneous groups can help control for confounding factors specific to different income levels (Lin et al., 2018; Pourhoseingholi et al., 2012; Wang et al., 2017). Also, low- and middle-income countries often have distinct policy priorities and development challenges that may affect their environmental tax efforts. Dividing the sample allows for more specific results, targeted policy implications, and a more comprehensive understanding of the relationships between variables in different economic contexts (Lin et al., 2018; Pourhoseingholi et al., 2012; Wang et al., 2017).

3.1 Definition of Variables

Environmental tax effort is the dependent variable of interest in this study and is defined as the ratio of environmental tax revenues to GDP (Combes et al., 2016; Crivelli & Gupta, 2017; Diaz-Sanchez et al., 2022). Within the OECD database, environmental taxes are classified by their tax base (i.e., energy, transport, pollution, and resources) and the environmental domain they relate to (i.e., air pollution, climate change, biodiversity, and the ocean). This study focuses on energy-related environmental taxes to produce results and policy recommendations specific to the energy sector. To provide a detailed analysis of the dependent variable, we decompose it into three environmental domains and run separate regression estimations for each of them. Thus, the decomposed dependent variables entail energy taxes related to air pollution (APTE), climate change (CCTE), and aggregate energy-related environmental taxes (AETE). Aggregate environmental tax effort refers to the sum of energy related environmental tax effort from all energy tax domains, including the air pollution, climate change, biodiversity, and the ocean. This gives a holistic picture of the phenomena under study. For ease of interpretation, we use the terms climate change tax effort, air pollution tax effort, and aggregate environmental tax effort to represent the above-mentioned environmental tax categories. Due to the large amount of missing

data, the study did not emphasize the other environmental tax domains (i.e., biodiversity and ocean).

The independent variables of interest are renewable energy development assistance (EDA) and governance quality (GQ). Data on EDA is obtained from the International Renewable Energy Agency (IRENA, 2022), while data on governance quality is obtained from the World Bank's World Development Indicators (WDI). Additionally, the study uses four control variables, all obtained from the WDI databases. These include (1) the size of the agricultural sector (SAgric), measured as the value added of agriculture, forestry, and fishing as a percentage of GDP; (2) trade openness (TOpenness), measured as the sum of a country's exports and imports as a share of that country's GDP; (3) GDP per capita (GDPPC); (4) the size of the shadow economy (Sshadow), compiled by Elgin et al. (2021) for the World Bank's Prospects Group. The natural logs of these variables were used for the analysis. To this extent, the effect of the independent variables on the dependent variables (i.e., AETE, CCTE, and APTE) is such that:

$$\text{AETE} = f(\text{EDA}, \text{GovQ}, \text{Sshadow}, \text{TOpenness}, \text{SAgric}, \text{GDPPC}) \quad (1)$$

$$\text{CCTE} = f(\text{EDA}, \text{GovQ}, \text{Sshadow}, \text{TOpenness}, \text{SAgric}, \text{GDPPC}) \quad (2)$$

$$\text{APTE} = f(\text{EDA}, \text{GovQ}, \text{Sshadow}, \text{TOpenness}, \text{SAgric}, \text{GDPPC}) \quad (3)$$

3.2 Model Specification and Estimation

The relationship between foreign aid and tax efforts has been challenging to analyze using standard regression techniques due to endogeneity concerns (Diaz-Sanchez et al., 2022; Thornton, 2014; Wen et al., 2023). Endogeneity can arise in this context for several reasons. First, there may be a bidirectional relationship between foreign aid and tax efforts, where aid can influence a country's tax collection, but tax efforts can also impact a donor's decision to provide aid. This two-way causal relationship violates the exogeneity assumption required for unbiased regression estimates

(Muoneke et al., 2023; Papiés et al., 2017). Moreover, foreign aid data, especially for developing countries, may be subject to measurement errors due to challenges in accurately tracking and reporting aid flows, which can introduce measurement error bias in the regression estimates (Muoneke et al., 2023; Papiés et al., 2017). To address these endogeneity concerns, we have employed energy poverty and the share of renewable energy consumption as instrumental variables for foreign aid. Energy poverty is a relevant instrument as it is a crucial motivator for donors to provide energy aid to developing countries (Diaz-Sanchez et al., 2022; Thornton, 2014; Wen et al., 2023). Countries with high levels of energy poverty are more likely to receive foreign aid targeted at improving access to energy. However, energy poverty is unlikely to have a direct impact on a country's environmental tax efforts, as tax policy decisions are typically influenced by broader economic, political, and social factors.

Similarly, the share of renewable energy consumption is a relevant instrument as it reflects the recipient country's commitment to transitioning to renewable energy sources, which is a primary objective of foreign energy aid (Diaz-Sanchez et al., 2022; Thornton, 2014; Wen et al., 2023). Countries with a higher share of renewable energy are more likely to receive foreign aid targeted at supporting renewable energy development. However, the share of renewable energy is not expected to have a direct effect on environmental tax efforts, as tax policies are more broadly aimed at addressing environmental externalities and generating revenue.

In Section 3.3, we conducted tests to evaluate the validity of the selected instrumental variables. The Durbin-Wu-Hausman test was used to assess whether the endogenous regressor (foreign aid) is, in fact, exogenous. This test examines the statistical significance of the difference between the ordinary least squares (OLS) and two-stage least squares (2SLS) estimates of the coefficients. A

statistically significant difference would indicate the presence of endogeneity, and the use of an instrumental variable approach is warranted. Additionally, we reported Hansen's J statistic, which is a test of overidentifying restrictions. This test evaluates the overall validity of the instruments by examining whether they are uncorrelated with the error term in the structural equation. A failure to reject the null hypothesis of the Hansen's J test would suggest that the instruments are valid and that the overidentifying restrictions are satisfied.

The results of these tests are reported in Section 3.3 and provide evidence supporting the validity and appropriateness of the chosen instrumental variables (energy poverty and the share of renewable energy consumption) in addressing the endogeneity concerns in the relationship between foreign aid and environmental tax efforts. The data on energy poverty and the share of renewable energy is obtained from the WDI database.

Consequently, the instrumental variable generalized method of moments (IV-GMM) regression technique is employed to estimate the parameters of the baseline model specifications, as seen in equations (4), (5), (6), (7)

$$AETE = \beta_0 + \beta_1 \widehat{EDA}_{it} + \beta_2 GovQ_{it} + \beta_3 Sshadow_{it} + \beta_4 TOpenness_{it} + \beta_5 SAgric_{it} + \beta_6 GPPC_{it} + \mu_{it} \quad (4)$$

$$CCTE = \beta_0 + \beta_1 \widehat{EDA}_{it} + \beta_2 GovQ_{it} + \beta_3 Sshadow_{it} + \beta_4 TOpenness_{it} + \beta_5 SAgric_{it} + \beta_6 GPPC_{it} + \mu_{it} \quad (5)$$

$$APTE = \beta_0 + \beta_1 \widehat{EDA}_{it} + \beta_2 GovQ_{it} + \beta_3 Sshadow_{it} + \beta_4 TOpenness_{it} + \beta_5 SAgric_{it} + \beta_6 GPPC_{it} + \mu_{it} \quad (6)$$

$$\widehat{EDA}_{it} = \pi_0 + \pi_1 Energy_Poverty_{it} + \pi_2 Renewable\ Energy\ Consumption_{it} + V_{it} \dots\dots (7)$$

Equations (3), (4), and (5) specify the effect of the independent and control variables on climate change tax effort (CCTE), air pollution tax effort (APTE), and aggregate environmental tax effort (AETE), respectively. μ_{it} is the error term. In all the equations, \widehat{EDA}_{it} represents the predicted values of the endogenous variables, which is derived using equation (6), where the instruments (i.e., Energy poverty and share of renewable energy consumption) are the predictors and V_{it} is the error term in equation (6). In

equation 6, the coefficients π_0 , π_1 , and π_2 represent the parameters to be estimated in this first-stage regression. They capture the relationship between the endogenous variable $(EDA)_{it}$ and the instrumental variables.

To estimate the regression model, the study implements the instrumental variable generalized methods of moments technique (IVG-MM). The IV-GMM has robust options to avoid the endogeneity problems and give more reliable estimates. It also uses the orthogonality condition, which makes it robust to autocorrelation and heteroscedasticity (Muoneke et al., 2023). Besides, it has options that can produce consistent results amidst weak instruments.

3.2.1 Robustness Checks

Notwithstanding the strengths of IV-GMM, it does not capture heterogeneity and nonlinearity in the conditional distribution of the dependent variable. To address this, we also use the Smoothed Instrumental Variable Quantile Regression (SIVQR) technique to test the robustness of our baseline model. This allows us to estimate the asymmetric effect of independent variables at different quantiles of the dependent variable (Kaplan, 2022; Kaplan & Sun, 2017). SIVQR has the strengths of IV-GMM and captures heterogeneity and nonlinearity in the conditional distribution of the dependent variable. It estimates causal effects at different quantiles of the dependent variable, which may vary depending on unobserved heterogeneity.

Additionally, it relaxes the assumption that the error term is homoscedastic and uncorrelated with instruments, which may not always be true. Thus, the τ^{th} ($0 < \tau < 1$) quantile of the conditional distribution of the dependent variable is specified for a set of given independent variables X_{it} as follows: $Qy_{it}(\tau|X_{it}) = X'_{it}\beta_{\tau}$, where $X'_{it} = (EDA, GovQ, Sshadow, TOpeness, SAgric, GDPPC)$. SIVQR has several advantages over traditional instrumental variable quantile regression. It requires less computing time and does not impose a location scale that can result in inconsistent estimates if the model is misspecified (Balasubramaniam, 2023; Baum et al., 2007; Kaplan, 2022;

Kaplan & Sun, 2017).

3.3 Diagnostic Tests

The Pesaran CD test, Breusch-Pagan LM test, and Pesaran scaled LM are used to assess the variables for cross-sectional dependence. These tests have a null hypothesis of no cross-sectional dependence. The results in Table 3.1 suggest the presence of cross-sectional dependency in both the LIC and MIC samples since the P-values were significant at 1%. However, both IV-GMM and SIVQR are robust against cross-sectional dependence. By using moment conditions that exploit the instrument relevance and orthogonality to the error term, IV-GMM and SIVQR provide consistent estimates of the parameters of interest while addressing both endogeneity and cross-sectional dependence (Balasubramaniam, 2023; Baum et al., 2007; Kaplan, 2022; Kaplan & Sun, 2017).

Table 3. 1: General Diagnostics Tests

	LIC Sample			MIC Sample		
Test A: Cross-Sectional Dependence	Statistic	d.f.	Prob.	Statistic	d.f.	Prob.
Breusch-Pagan LM	56.499	21	0.000	71.28	28	0.000
Pesaran scaled LM	5.478		0.000	5.784		0.000
Pesaran CD	0.206		0.837	0.041		0.967
<i>H0: No cross-section dependence (correlation) in residuals</i>						
Test B: Heteroskedasticity LR Test						
	Value	df	Prob.	Value	df	Prob.
AETE	17.634	7	0.014	112.423	8	0.000
CCTE	25.937	7	0.000	85.48	8	0.000
APTE	37.845	7	0.000	2904.167	8	0.000
<i>H0: Residuals are homoskedastic</i>						
Test C: Jochman's portmanteau test for serial correlation						
		Chi-sq(189)	7	Chi-sq(189)		8
<i>H0: No serial correlation</i>		Prob > F	1.00	Prob > F		1.00
Test D: Slope heterogeneity (Pesaran, Yamagata)						
		Delta	P-Value	Delta	P-Value	
		-0.328	0.743	1.408	0.159	
		adj	0.695	1.178	0.239	
<i>H0: Slope coefficients are homogenous</i>						

Additionally, slope homogeneity was assessed using Pesaran and Yamagata's (2008) test for slope

homogeneity. The Pesaran and Yamagata (2008) tests failed to reject the null hypothesis of slope homogeneity for both LIC and MIC samples (see Table 3.1). By implication, the observed relationship between the dependent and independent variables is consistent (homogeneous) across all entities in the respective samples. Furthermore, Jochmans and Verardi's (2020) portmanteau test for serial correlation in panel models was used to examine the possibility of serial correlation. The tests follow the null hypothesis of no serial correlation (Table 3.1). For LIC and MIC samples, the chi-square statistic is 7 and 8 with corresponding P-values of 1 apiece, which means we cannot reject the null hypothesis at any conventional significance level. Therefore, there is no evidence of serial correlation in the panel data. Further, the LR test for heteroskedasticity rejected the null hypothesis of homoskedastic residuals. However, as elaborated earlier, both IV-GMM and SIVQR are robust against homoskedasticity problems.

In addition, two key post-estimation tests were used to assess the validity and reliability of instrumental variable analysis (Table 3.2).

Table 3. 2: Instrumental Variable Diagnostic Tests

Test A: Endogeneity (orthogonality conditions)			
		chi2(1)	P-Value
LIC Sample	GMM C statistic	4.42879	0.0353
MIC Sample	GMM C statistic	5.16921	0.023
<i>H0: Variables are exogenous</i>			
Test B: Overidentification restriction test			
		chi2(1)	P-Value
LIC Sample	Hansen's J	1.72964	0.1885
MIC Sample	Hansen's J	0.83485	0.3609
<i>H0: the instrument is valid</i>			

The Durbin-Wu-Hausman test was used to evaluate whether the endogenous regressor in the regression model is, in fact, exogenous (Table 3.2). The null hypothesis of this test is that the

specified endogenous regressors can be treated as exogenous. The test is based on the assumption that the instruments are valid and uncorrelated with the error term. The test statistic is the C(difference-in-Sargan) statistic, which is a chi-squared distribution with degrees of freedom equal to the number of overidentifying restrictions. For the LIC sample, the test result in Table 3.2 shows that the C statistic is 4.42879 with a p-value of 0.0353. We can reject the null hypothesis that the variables are exogenous at the 5% significance level. Therefore, there is evidence of endogeneity in the model, hence justifying the inclusion of instrumental variables.

For the MIC sample, the value of the test statistic is 5.16921, and the p-value is 0.0230; hence, we can reject the null hypothesis and conclude that there is evidence that the variables are endogenous. This justifies the use of instrumental variable analysis.

Additionally, Hansen's J statistic was reported, which is a test of overidentifying restrictions (refer to Table 3.2). This test checks whether the instruments are valid, meaning that they are uncorrelated with the error term. The null hypothesis is that the instruments are valid. For both LIC and MIC samples, results in Table 3.2 reveal p-values above conventional significance levels of 0.05 (i.e., 0.3609 and 0.1885, respectively), proving the validity of instruments used in both models.

Also, the stationarity test results are presented in Table 3.3. While stationarity is not a requirement to run IVGMM or SIVQR, it ensures that the statistical properties of the data remain constant over time. Therefore, the study employs three widely-used panel unit root tests: Im, Pesaran and Shin W-stat, ADF - Fisher Chi-square, and PP - Fisher Chi-square to test for stationarity at levels for variables entailing SAGRIC, APTE, CCTE, ETOT, EDA, GDPPC, SSHADOW, TOpenness, and REGQ.

Table 3. 3: Stationarity

<i>Variable</i>	<i>Method</i>	LIC Sample	MIC Sample
		<i>t-Statistic</i>	<i>t-Statistic</i>
<i>SAGRIC</i>	ADF – Fisher Chi-square	70.163***	65.469***
	PP – Fisher Chi-square	196.469***	159.055***
	Im, Pesaran and Shin W-stat	-3.867***	-3.815***
<i>APTE</i>	ADF – Fisher Chi-square	39.397***	38.923***
	PP – Fisher Chi-square	89.559***	88.573***
	Im, Pesaran and Shin W-stat	-4.727***	-4.737***
<i>CCTE</i>	ADF – Fisher Chi-square	47.833***	48.004***
	PP – Fisher Chi-square	86.576***	85.953***
	Im, Pesaran and Shin W-stat	-4.308***	-4.302***
<i>ETOT</i>	ADF – Fisher Chi-square	43.645***	43.672***
	PP – Fisher Chi-square	85.211***	85.504***
	Im, Pesaran and Shin W-stat	-5.358***	-9.551***
<i>EDA</i>	ADF – Fisher Chi-square	57.351***	96.734***
	PP – Fisher Chi-square	491.202***	506.067***
	Im, Pesaran and Shin W-stat	-4.441***	-5.483***
<i>GDPPC</i>	ADF – Fisher Chi-square	45.895***	56.735***
	PP – Fisher Chi-square	80.498***	95.907***
	Im, Pesaran and Shin W-stat	-3.667***	-3.586***
<i>SSHADOW</i>	ADF – Fisher Chi-square	39.436***	38.710***
	PP – Fisher Chi-square	61.132***	58.556***
	Im, Pesaran and Shin W-stat	-6.148***	-6.820***
<i>Topenness</i>	ADF – Fisher Chi-square	63.088***	69.718***
	PP – Fisher Chi-square	350.421***	361.617***
	Im, Pesaran and Shin W-stat	-5.954***	-5.968***
<i>REGQ</i>	ADF – Fisher Chi-square	60.343***	60.463***
	PP – Fisher Chi-square	199.938***	296.316***
	Im, Pesaran and Shin W-stat	-6.934***	-6.462***

Across all variables and for both country groups, the test statistics are consistently large (in absolute terms for the Im, Pesaran and Shin W-stat), with corresponding p-values of mostly 0.000.

This uniformity in results is observed across all three testing methodologies. The consistency of these findings, indicated by *** for 1% significance level, provides strong evidence against the null hypothesis of non-stationarity or the presence of a unit root in these first-differenced series.

The results of the stationarity tests have significant implications for the study. Firstly, the consistent large test statistics and the corresponding p-values of mostly 0.000 across all variables

and for both country groups provide strong evidence against the null hypothesis of non-stationarity. This implies that the variables under consideration, including SAGRIC, APTE, CCTE, ETOT, EDA, GDPPC, SSHADOW, Topenness, and REGQ, are stationary at their levels. Stationarity is a crucial assumption in time series analysis as it ensures the reliability of the statistical inferences drawn from the data.

Secondly, the uniformity of results across all three testing methodologies – Im, Pesaran and Shin W-stat, ADF – Fisher Chi-square, and PP – Fisher Chi-square – reinforces the robustness of these findings. This consistency suggests that the results are not an artifact of the specific unit root test employed, but rather a reflection of the underlying properties of the data. This robustness increases the confidence in the study's findings and their potential applicability to other similar contexts or datasets.

4. Empirical Results and Discussion

4.1 Descriptive Statistics

Table 3.4 presents the descriptive statistics of the sample data, and Figures 3.1 and 3.2 contain the visual depictions. The statistics presented include the mean and the standard deviations of the variables based on the countries in the panel.



Table 3. 4: Descriptive Statistics

Countries	Stats	Middle Income Sample (T= 20 n= 8, N=160)								
		SAgric	TOpenness	EDA	Sshadow	REGQ	CCTE	APTE	AETE	GDPPC
Cameroon	Mean	3.462	0.407	1.61	15.523	9.496	4.251	2.646	3.808	11.564
	SD	0.056	0.106	0.95	0.201	0.297	0.142	0.211	0.113	0.118
Ghana	Mean	3.999	0.951	1.496	16.486	11.146	3.374	4.659	5.003	11.676
	SD	0.332	0.199	0.896	0.181	0.374	0.506	1.119	1.019	0.368
Kenya	Mean	3.741	0.449	2.135	15.604	10.808	5.136	4.562	5.621	11.623
	SD	0.194	0.207	0.789	0.325	0.168	0.718	0.696	0.646	0.181
Lesotho	Mean	2.018	1.236	0.994	15.324	10.258	4.085	2.646	4.439	11.056
	SD	0.25	0.431	0.832	0.278	0.317	0.486	1.110	0.318	0.24
Namibia	Mean	2.608	1.121	0.763	15.264	11.691	3.692	3.227	3.468	13.402
	SD	0.175	0.127	0.659	0.288	0.403	0.499	0.452	0.76	0.263
Senegal	Mean	3.272	0.598	1.613	16.898	10.89	4.912	4.288	4.419	11.413
	SD	0.099	0.081	0.722	0.178	0.209	0.338	0.299	0.226	0.127
South Africa	Mean	1.022	0.543	2.129	14.915	12.194	5.865	4.248	5.52	13.971
	SD	0.153	0.097	1.17	0.338	0.616	0.475	0.471	0.357	0.157
Nigeria	Mean	3.886	0.163	1.94	17.937	9.401	3.029	2.646	3.636	12.398
	SD	0.201	0.266	1.083	0.374	0.537	0.433	0.411	0.968	0.307
		Lower Income Sample (T=20, n= 7, N=140)								
Burkina Faso	Mean	17.09	13.96	1.688	51.418	1.154	6.713	5.773	5.897	20.434
	SD	0.547	1.048	0.888	0.322	0.173	0.529	0.455	0.454	0.504
Congo DR	Mean	16.724	14.903	1.94	53.559	-1.472	6.159	4.947	6.126	19.355
	SD	0.916	1.393	1.115	0.664	1.017	0.556	0.904	1.185	0.49
Madagascar	Mean	18.037	14.809	1.488	52.108	0.834	7.86	5.499	6.836	19.838
	SD	0.58	0.699	0.759	0.558	0.281	0.609	1.034	0.53	0.13
Malawi	Mean	18.297	14.41	1.484	51.165	0.688	6.581	5.725	5.988	18.76
	SD	0.859	0.05	0.865	0.494	0.259	0.534	0.472	0.653	0.437
Mali	Mean	19.073	14.968	1.874	51.502	0.87	6.774	5.825	7.438	21.114
	SD	0.473	0.245	1.072	0.224	0.14	0.968	0.832	0.551	0.256
Rwanda	Mean	17.835	13.422	1.893	50.632	0.962	6.492	5.523	6.548	20.447
	SD	0.704	0.831	0.828	0.716	0.722	0.587	0.472	0.622	0.925
Uganda	Mean	17.426	13.478	2.327	51.825	1.234	4.952	7.418	7.98	21.271
	SD	0.681	0.506	1.255	0.462	0.144	0.252	0.615	0.638	0.644

Note: SD = standard deviation, T = number of time periods, n = number of panels, and N = number of observations.

Starting with the key independent variables, the table shows that the mean values for renewable energy development assistance (EDA) vary considerably between the two groups. The middle-income countries have mean EDA values ranging from 0.763 in Namibia to 2.135 in Kenya, while the lower-income countries exhibit much higher mean EDA, ranging from 1.484 in Malawi to 2.327 in Uganda. This suggests that the lower-income countries may be receiving greater external support for renewable energy initiatives compared to their middle-income counterparts.

Regarding governance quality (GQ), the middle-income countries display a wider range of mean values, from 9.401 in Nigeria to 12.194 in South Africa. The lower-income countries, on the other hand, have consistently lower mean GQ values, from 0.688 in Malawi to 1.234 in Uganda. This indicates that the middle-income group, on average, benefits from stronger institutions and better governance, which may be a contributing factor to their higher economic status.

The stark contrast in the size of the agricultural sector (SAgric) between the two groups is particularly noteworthy. The middle-income countries have significantly lower mean SAgric values, ranging from 1.022 in South Africa to 3.999 in Ghana, while the lower-income countries exhibit much higher mean SAgric, from 16.724 in the Congo DR to 19.073 in Mali. This suggests that the middle-income countries have successfully transitioned towards more diversified economic structures, with a smaller reliance on agriculture.

Trade openness (TOpenness) also shows divergent patterns, with the middle-income countries displaying a wider range of mean values, from 0.163 in Nigeria to 1.236 in Lesotho. The lower-income countries, in contrast, have consistently high mean TOpenness, from 13.422 in Rwanda to 14.968 in Mali. This may indicate that the lower-income group is generally more integrated into global trade networks, which may have implications for their economic development trajectories.

The standard deviations (SDs) for the variables also provide valuable insights. The middle-income

countries tend to have lower SDs, suggesting less variability within the group, while the lower-income countries exhibit higher SDs, pointing to greater heterogeneity. This highlights the need to consider the unique circumstances and challenges faced by different income groups when designing policies and interventions.

Additionally, Table 3.5 displays the correlation coefficients between multiple variables. Each entry in the table represents the correlation between two specific variables.

Table 3. 5: Pairwise Correlation

Variables	MIC Sample						LIC Sample					
	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
Aggregate Environmental Tax Effort Equation												
(1) AETE	1						1					
(2) EDA	-0.034	1					0.115	1				
(3) REGQ	0.345	-0.071	1				0.287	-0.006	1			
(4) SAgric	-0.028	-0.007	0.239	1			0.108	0.028	-0.417	1		
(5) Sshadow	-0.003	0.004	-0.492	-0.2	1		-0.204	0.067	-0.475	0.4202	1	
(6) GDPPC	-0.291	0.22	0.472	-0.096	-0.386	1	-0.074	0.102	0.472	-0.487	-0.223	1
(7) TOpenness	0.089	-0.073	-0.174	-0.142	0.175	0.031	0.019	-0.403	0.32	-0.293	-0.401	-0.074
Air Pollution Tax Effort Equation												
(1) AETE	1						1					
(2) EDA	-0.049	1					0.231	1				
(3) REGQ	0.328	-0.071	1				0.393	-0.006	1			
(4) SAgric	-0.018	-0.007	0.239	1			-0.487	0.028	-0.517	1		
(5) Sshadow	-0.104	0.004	-0.482	-0.2	1		-0.458	0.067	-0.475	0.502	1	
(6) GDPPC	-0.321	0.22	0.472	-0.096	-0.386	1	0.185	0.102	0.482	-0.554	-0.223	1
(7) TOpenness	0.231	-0.073	-0.174	-0.142	0.175	0.031	-0.138	-0.403	0.32	-0.293	-0.401	-0.074
Climate Change Tax Effort Equation												
(1) AETE	1						1					
(2) EDA	-0.184	1					0.04	1				
(3) REGQ	0.038	-0.071	1				0.5	-0.006	1			
(4) SAgric	-0.153	-0.007	0.239	1			0.113	0.028	-0.517	1		
(5) Sshadow	-0.072	0.004	-0.482	-0.2	1		-0.06	0.067	-0.482	0.502	1	
(6) GDPPC	-0.196	0.22	0.472	-0.096	-0.386	1	-0.005	0.102	0.562	-0.554	-0.223	1
(7) TOpenness	0.352	-0.073	-0.174	-0.142	0.175	0.031	0.045	-0.403	0.32	-0.293	-0.401	-0.074

The coefficients range from -1 to 1 and indicate the strength and direction of the relationship between variables. The correlation matrix offers valuable insights into the relationships between the key variables in the study. Starting with the Aggregate Environmental Tax Effort (AETE) variable, we can see that it has a positive correlation with Regulatory Quality (REGQ) in both the

MIC sample (0.345) and the LIC sample (0.287). This suggests that better governance quality is associated with higher environmental tax effort across the country groups. Also, the correlation between AETE and Renewable Energy Development Assistance (EDA) is negative in both the MIC (-0.034) and LIC (0.115) samples, though the magnitude is larger in the LIC group. This indicates that higher levels of EDA may not necessarily be directly linked to increased environmental tax effort, and other factors may be at play. Again, we find that AETE has a negative correlation with the size of the agricultural sector (SAgric) in both the MIC (-0.028) and LIC (0.108) samples. This implies that a larger agricultural sector is associated with lower environmental tax effort, potentially due to the political influence or economic importance of the agricultural lobby. Similar patterns and interpretations can be drawn for the correlations with the Air Pollution Tax Effort (APTE) and Climate Change Tax Effort (CCTE) variables among others. The differences in the magnitude and direction of the correlations between the MIC and LIC samples highlight the need to consider the unique contextual factors and development stages of the countries when analyzing the determinants of environmental tax policies.

However, it is noteworthy that while correlation analysis provides an initial understanding of the relationships between the variables, the regression analysis can uncover more nuanced and complex relationships, including the potential changes in the direction and significance of the effects.

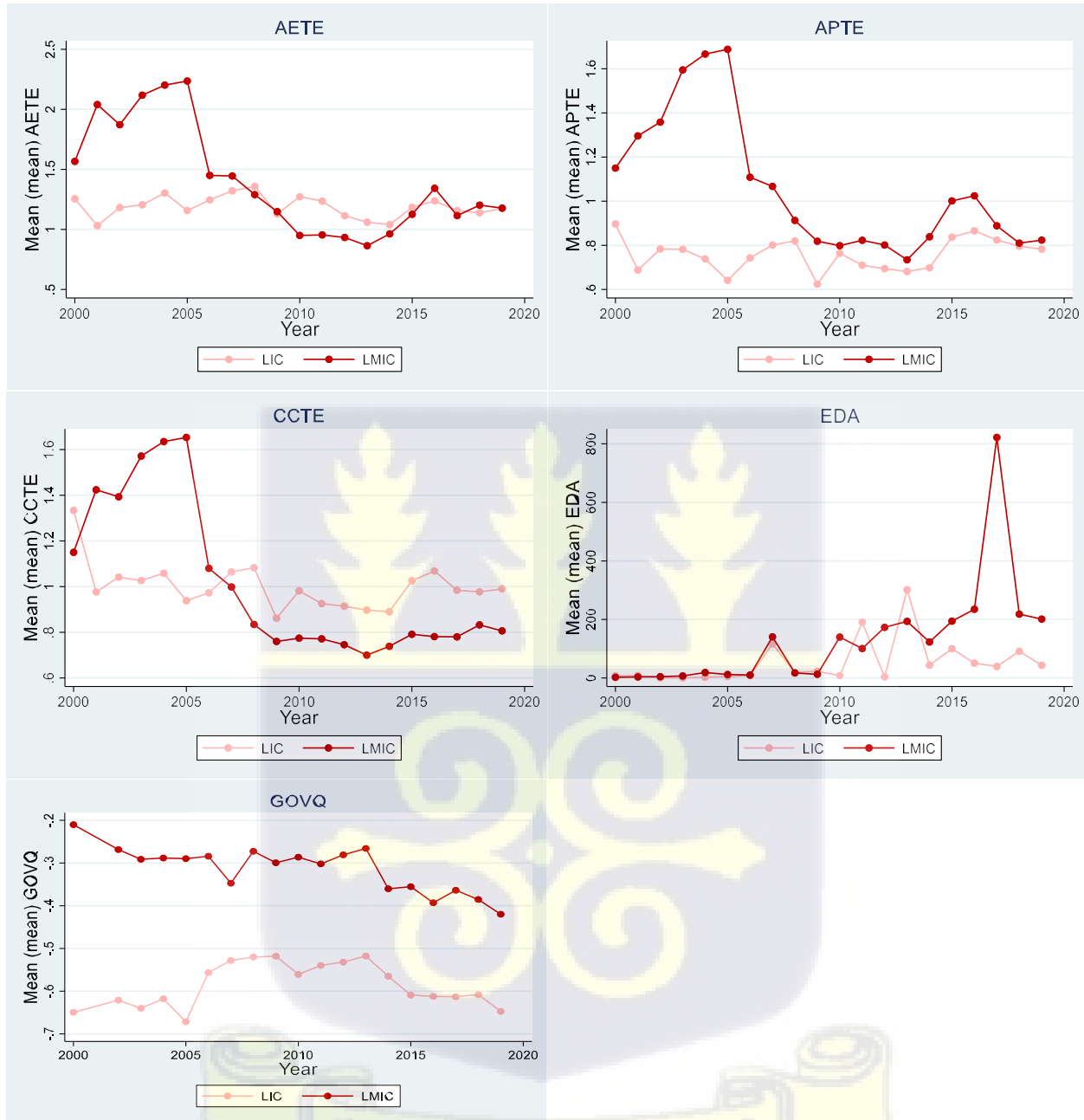
Figure 3.1 visually depicts the mean of the key variables used in the study, including AETE, CCTE, APTE, EDA, and GOVQ. The graph for each variable shows the mean trend line for the LMIC and LIC samples. The LMIC sample is represented by the red line, while the pink line represents the LIC sample. On average, the trend lines in Figure 1 shows that the LMIC sample generally has a greater environmental tax effort (i.e., AETE, APTE, and CCTE) compared to the LIC sample.

For example, regarding AETE, the trend line shows that the LMIC sample has an overall mean greater than that of the LIC sample, especially during periods ranging from 2000 to 2007. During the 2009 to 2015 period, the average AETE of the LMIC sample sharply fell below that of the LIC sample and the post 2015 to 2019 periods shows that both sample groups had similar average AETE. Similarly, the APTE graph shows a trend where LMIC's average APTE outpaces that of LIC by a wider gap during the 2000 to 2009 period. However, LMIC's APTE trend line sharply fell post 2009, closing the gap by which it outpaced the LIC sample. Contrary, the CCTE graph shows mixed trend lines. Thus, compared to LIC sample, the LMIC sample had higher average CCTE during 2001 to 2006 period. However, the LIC's average CCTE steadily rose by a small margin while that of LMIC sharply declined by a larger margin till it fell below the CCTE trend line of the LIC sample for periods ranging 2006 through to 2019.

Additionally, the graph shows that both LMIC and LIC samples received comparable amounts of EDA inflows during the 2000-2009 periods. Afterwards, the inflow of EDA to LICs became erratic, as EDA inflow could fell to zero in 2012 and rose in the next period to almost US\$300m. However, the EDA inflows to LMICs experienced a steady upward improvement post 2009, and continued steadily until 2016, where a sharp rise in EDA inflows occurred. Also, on the average, both samples reveal an adverse governance quality score. However, the LIC sample had the worst governance quality score, especially during the 2005 period.

These mean graphs of the variables reveal three key implications. First, countries' tax efforts may differ depending on the type of tax effort under consideration, justifying the need consider each tax effort before aggregating them in statistical analysis. Second, it suggests that governance quality remains poor in the SSA countries, calling for more improvements.

Figure 3. 1 Visualization of Mean values of Key Variables



Source: Author generated, 2023

Third, the graph shows how erratic the supply of EDA can be, hence amplifying calls for less dependence on foreign aid and need to develop local capacity. It is noteworthy that the mean of

the variables is descriptive and do not show statistical relationships. Therefore, the ensuing sections presents the statistical results obtained from estimating the empirical models in equation 3, 4, and 5.

4.2 Baseline Regression Results: IV-GMM

The results of the IV-GMM parameter estimates are presented in Table 3.6. The corresponding discussions are presented in 4.2.1 below.

Table 3. 6 Regression Estimates (IV-GMM)

	Middle Income Sample (MIC)			Low-Income Sample (LIC)		
	Climate Change Tax Effort	Air Pollution Tax Effort	Aggregate Environmental Tax Effort	Climate Change Tax Effort	Air Pollution Tax Effort	Aggregate Environmental Tax Effort
EDA	-0.213* (-2.09)	0.145* (-2.39)	0.431*** (-5.24)	-0.098*** (-3.70)	-0.023 (-1.75)	-0.099* (-2.42)
REGQ	0.403*** (-4.63)	0.542*** (-3.69)	0.772*** (-7.19)	0.293* (-2.39)	0.169*** (-3.66)	0.358*** (-4.46)
SAgric	0.044 (-0.11)	0.178 (-0.47)	0.557 (-0.98)	-0.719* (-2.06)	-0.473* (-2.24)	-0.470* (-2.15)
GDPPC	-0.324*** (-4.52)	-0.532*** (-10.91)	-0.330*** (-3.86)	-0.359** (-2.87)	-0.166* (-2.05)	-0.059 (-0.64)
TOpeness	0.720*** (-4.61)	0.667*** (-5.48)	0.500** (-2.84)	0.514*** (-4.4)	0.023 (-0.57)	0.167* (-2.34)
Sshadow	-0.437*** (-8.86)	-0.154*** (-3.8)	-0.208** (-3.13)	-0.066*** (-5.38)	-0.566** (-2.58)	- 0.637*** (-3.83)

Note: *t*-statistics in parentheses; ***, **, and * denote 0.01, 0.05, and 0.1 rejection level, respectively.

4.2.1 EDA and Climate Change Tax Effort

From the empirical results (Table 3.6), EDA has a significant negative influence on climate change tax efforts in both LIC and MIC, as established by prior studies (Combes et al., 2016; Diaz-Sanchez et al., 2022; Marineau, 2020; Thornton, 2014). This result can be explained from both positive and

negative perspectives. On a positive note, the result could suggest that renewable energy aid reduces the need for climate change taxes by providing alternative sources of energy that are less carbon-intensive (Bashir et al., 2022; Nchofoung et al., 2023; Regueiro-Ferreira & Cadaval Sampedro, 2022). Conversely, the result could also suggest that renewable energy aid creates a moral hazard problem, whereby recipients have less incentive to implement or enforce energy taxes while expecting more aid in the future. The former explanation seems less plausible as empirical evidence suggests low renewable energy adoption rates in Sub-Saharan African countries (Combes et al., 2016; Diaz-Sanchez et al., 2022; Morrissey, 2012). Thus, the most likely explanation is that renewable energy aid displaces climate change taxes by crowding out domestic resources or political will to mobilize environmental taxation, confirming the Samaritan dilemma theory. This could imply that renewable energy aid is substitutive and reduces climate change tax efforts in these countries.

4.2.2 EDA and Air Pollution Tax Effort

The results show that EDA has a significant positive influence on air pollution tax efforts among middle-income countries (MICs), while an insignificant negative relationship is reported among low-income countries (LICs). The finding suggests that renewable energy aid has a complementary effect on air pollution tax efforts in MICs, confirming other studies such as Machado (2010), Mascagni and Timmis (2017), and Wen et al. (2023). This could be due to several factors, such as using aid to facilitate knowledge transfer and capacity-building initiatives and enhancing technical expertise and institutional capacity. Similarly, Machado (2010) revealed that conditional aid, which requires recipient countries to meet specific requirements (e.g., improving tax capacity), could explain the positive link between foreign aid and tax effort.

On the other hand, the finding that EDA has an insignificant negative effect on air pollution tax

effort in LICs may be explained by studies that suggest that low-income countries may not tax energy-related pollution due to the need to support poor households (Ohlendorf et al., 2021; Prasad, 2022; Spinesi, 2022). Thus, in low-income countries, fossil fuels are predominantly used for heating, cooking, and lighting, hence often taxed at low rates or subsidized. On such a premise, the decision to tax may have little to do with EDA, since poverty eradication is prioritised over environmental protection. Therefore, the observed differential results across the MIC and LIC samples may be explained by the fact that low-income countries may have less incentive and capacity to implement energy taxes than middle-income countries, especially if they face more urgent needs such as poverty reduction, healthcare, and education (Bhattacharya, 2019).

4.2.3 EDA and Aggregate Environmental Tax Effort

The results indicate that EDA positively impacts aggregate environmental tax efforts in MICs. However, in LICs, the effect is negative. This difference may be due to several factors. Energy foreign aid can affect the relative prices of fossil fuels and clean energy sources differently in different countries. For instance, if aid lowers the cost of renewable energy in MICs, it may reduce fossil fuel demand and increase the tax base for air pollution taxes. Conversely, if aid subsidizes fossil fuel consumption or production in LICs, it may increase fossil fuel demand and reduce the tax base for energy taxes.

Additionally, Gomez-Echeverri (2018) suggests that MICs often have better institutional capacity and infrastructure than LICs, enabling them to effectively utilize energy-related foreign aid while avoiding its negative effect on environmental tax efforts. In contrast, LICs might face greater challenges due to limited resources, weak institutions, and inadequate infrastructure (Gomez-Echeverri, 2018; Wolf et al., 2013). Also, economic considerations and development priorities

may explain the differential results. LICs often face more pressing economic needs and development priorities than MICs and may prioritise addressing poverty, basic infrastructure, and social development over environmental initiatives (Abdenur, 2023; Ben Mim et al., 2022; Painuly, 2001; Yang & Park, 2020). As a result, energy-related foreign aid might be diverted towards addressing these immediate development needs rather than focusing on environmental tax efforts.

The difference in results between climate change tax efforts and air pollution tax efforts may stem from their different scopes and objectives. Climate change tax is a global and long-term issue, usually based on the carbon content of fossil fuels and their contribution to global warming (Orru et al., 2017; Pearce, 1991; Zimmer & Koch, 2017). In contrast, air pollution taxation is based on emissions of local pollutants such as particulate matter, sulfur dioxide, and nitrogen oxides, which affect local air quality (Manisalidis et al., 2020; Orru et al., 2017). As a result, the effect of EDA on climate change and air pollution taxes may not be perfectly correlated since they have different scopes and designs.

4.2.4 Governance Quality and Environmental Tax Effort

Consistent with the existing literature (Daude et al., 2013b; Liu et al., 2023a; Sebele-Mpofu, 2020), we observe that governance quality has a significant positive effect on all three environmental tax effort categories (i.e., AETE, APTE, and CCTE), and this was true for both samples. Governance quality can influence the design and implementation of energy related environmental taxes. For example, a country with high governance quality can set environmental tax rates that reflect the social cost of pollution and emissions, adjust them over time according to changing circumstances, and enforce them effectively and fairly (Daude et al., 2013b; Liu et al., 2023). Also, governance quality can influence public acceptance and support of energy taxes. For example, a government

with high governance quality can use environmental tax revenues for environmental and social purposes and ensure that the tax burden is equitably distributed among different groups (Sebele-Mpofu, 2020). Therefore, governance quality can positively affect environmental tax efforts by improving environmental taxation's performance, legitimacy, and coherence (Liu et al., 2023; Sebele-Mpofu, 2020).

4.2.5 Control Variables and Environmental Tax Effort

From Table 3.6, the relationship between the size of the agricultural sector and environmental tax effort varies by income level. In middle-income countries (MICs), the agricultural sector is not a significant factor for any of the three energy taxes we examine, but it positively correlates with them. In low-income countries (LICs), the size of the agricultural sector has a significant negative effect on all three environmental tax categories. This agrees with Gnanon (2022) and Barros et al. (2023), who showed that the agricultural sector is more likely to reduce tax efforts in less developed countries. Thus, individuals in LIC countries rely more on subsistence agriculture for their survival and income, especially in rural areas. Therefore, energy taxes on agriculture could worsen poverty, food insecurity, and social instability, so governments in these countries might avoid imposing them (Besley & Persson, 2014; Gnanon, 2022). Besides, the subsistence nature of agriculture in LICs makes it complex and challenging to tax (Besley & Persson, 2014; Gnanon, 2022; Gupta et al., 2021; Morrissey et al., 2016). These may explain why the size of the agricultural sector reduces environmental tax effort in LICs.

We also report a significant positive effect of trade openness on the three categories of energy taxes for the MIC sample. As mentioned earlier and in line with prior literature (Bazillier et al., 2016; Bazillier et al., 2017; Le et al., 2012), trade openness can create more opportunities for

governments to raise their environmental tax efforts. The rationale is that trade openness can increase the motivation for governments to safeguard the environment, as environmental standards can affect international trade. For instance, a country that levies high energy taxes may be perceived as more eco-friendly, enhancing its global image and attracting investment. Moreover, since higher trade openness is linked to higher economic growth rates, open economies may grow faster, and consequently, more energy taxes can be collected with the expanding tax base (Fatima et al., 2023; Le et al., 2012).

Similarly, for the LIC sample, the results reveal that trade openness has a significant positive effect on climate change tax effort and aggregate environmental tax effort but not air pollution tax effort. Regarding the disparities in climate change and air pollution tax findings, low-income countries might face international pressure and commitments related to addressing climate change and reducing greenhouse gas emissions (Barros et al., 2023; Gnanon, 2021; Ho et al., 2023). Thus, trade openness can lead to greater exposure to global environmental initiatives and international agreements, prompting these countries to implement climate change tax efforts. Conversely, air pollution tax efforts, primarily addressing local pollution issues, may not receive the same level of international attention or commitment.

The effect of gross domestic product (GDP) per capita on the three categories of environmental tax efforts is negative and significant for both the low- and middle-income country (LIC and MIC) samples. This finding aligns with the existing literature on the relationship between economic development and environmental tax policies (Barros et al., 2023; Besley & Persson, 2014). One possible explanation for the negative relationship is that in LICs and MICs, people may prioritize other basic needs, such as food, healthcare, and education, over environmental protection, and thus be less willing to pay higher taxes for environmental purposes (Barros et al., 2023; Besley &

Persson, 2014). As countries develop economically, their citizens tend to have their basic needs met to a greater extent, and they may then shift their focus and preferences towards environmental quality and be more willing to support environmental tax policies (Anwar et al., 2022; Demissew Beyene & Kotosz, 2020; Gill et al., 2018; Leal & Marques, 2022).

Additionally, the environmental Kuznets hypothesis suggests that in the early stages of economic development, environmental degradation and pollution tend to increase, as the focus is on economic growth and industrialization (Demissew Beyene & Kotosz, 2020; Leal & Marques, 2022). However, as countries become wealthier, they may have more resources and capacity to invest in environmentally friendly policies, such as environmental tax efforts, which can help address these environmental challenges (Anwar et al., 2022; Demissew Beyene & Kotosz, 2020; Gill et al., 2018; Leal & Marques, 2022).

This critical analysis suggests that the negative relationship between GDP per capita and environmental tax efforts in LICs and MICs may be due to a combination of factors, including the prioritization of basic needs over environmental concerns, as well as the environmental Kuznets curve, where economic development initially exacerbates environmental problems before countries have the resources and willingness to address them through policy interventions like environmental taxation. Further research is needed to fully understand the mechanisms underlying this relationship in the context of developing countries.

4.3 Asymmetric Analysis and Time-Varying Granger Non-Causality

First, to establish the asymmetric effects of the independent variables at different quantile conditions of the dependent variables, we have adopted the smoothed instrumental variable panel quantile regression. Thus, we run a regression at each dependent variable's 10th, 25th, 50th, and 75th conditional quantiles. The estimated results are found in Table 3.7.

The results in Table 3.7 show the asymmetric quantile regression results. The impact of the independent variables on the dependent variables varies across different quantiles for each of the three dependent variables for both LIC and MIC samples. Notwithstanding, the observed relationships between the variables are qualitatively consistent with that obtained from the IV-GMM estimation.

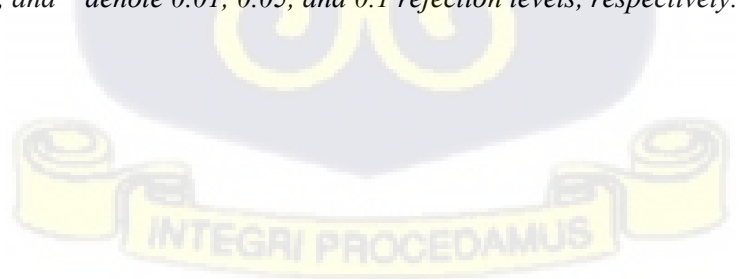
For instance, the effect of energy development assistance on climate change tax effort is negative across all conditional quantiles (i.e., 10th, 25th, 50th, and 75th) for both LIC and MIC samples. Similarly, governance quality has a positive significant effect on all categories of environmental taxes across all conditional quantiles, which is valid for both samples. The other variables also established relationships comparable to those obtained from the IV-GMM estimation, confirming the robustness of our findings.



Table 3. 7: Smoothed Instrumental Variable Quantile Regression Estimates

MIC	Climate Change Tax Effort				Air Pollution Tax Effort				Aggregate Environmental Tax Effort			
	q10	q25	q50	q75	q10	q25	q50	q75	q10	q25	q50	q75
EDA	-0.170*** (-3.64)	-0.092*** (-3.52)	-0.082*** (-7.31)	-0.083*** (-5.14)	0.201*** (-3.63)	0.126** (-3.03)	0.065*** (-8.26)	0.055*** (-3.8)	0.184** (-3.26)	0.105*** (-3.8)	0.093*** (-4.38)	0.071*** (-4.4)
SAgric	0.079 (-0.84)	0.076 (-0.86)	0.076 (-0.80)	0.066 (-0.65)	0.084 (-1.22)	0.006 (-0.10)	0.028 (-1.02)	0.084 (-1.08)	0.090 (-1.28)	0.107 (-1.84)	0.066 (-0.65)	0.0373 (-0.95)
TOpenness	0.499*** (-5.89)	0.506*** (-6.03)	0.506*** (-6.44)	0.488*** (-4.77)	0.251** (-3.29)	0.206** (-2.79)	0.153*** (-5.31)	0.139*** (-4.33)	0.184** (-3.26)	0.105*** (-3.8)	0.135** (-2.91)	0.115* (-2.04)
REGQ	0.679*** (-3.64)	0.657*** (-4.25)	0.644*** (-3.77)	0.643*** (-5.46)	0.626*** (-3.94)	0.329*** (-6.22)	0.608*** (-4.12)	0.542*** (-4.74)	0.358*** (-4.91)	0.580*** (-5.88)	0.630*** (-5.27)	0.751*** (-5.71)
GDPPC	-0.212** (-2.62)	-0.145** (-2.65)	-0.136*** (-4.67)	-0.115** (-3.09)	-0.218* (-2.37)	-0.200* (-2.21)	-0.121*** (-5.42)	-0.0737 (-1.56)	-0.275*** (-3.51)	-0.174*** (-3.53)	-0.173*** (-3.79)	-0.105** (-3.29)
Sshadow	-0.474*** (-4.70)	-0.473*** (-4.44)	-0.473*** (-4.43)	-0.388** (-2.78)	-0.0934*** (-4.38)	-0.0717*** (-4.4)	0.302** (-3.22)	-0.315** (-2.91)	-0.190*** (-3.34)	-0.275*** (-3.51)	-0.174*** (-3.53)	-0.173*** (-3.79)
LIC												
EDA	-0.377*** (-4.40)	-0.347** (-2.67)	-0.347** (-2.73)	-0.347** (-2.72)	-0.199* (-2.08)	-0.193 (-1.75)	0.200 (-1.92)	0.200 (-1.71)	-0.189** (-3.29)	-0.317** (-3.16)	-0.237** (-2.67)	-0.330** (-3.26)
SAgric	-0.341*** (-3.48)	-0.350*** (-3.78)	-0.332*** (-3.42)	-0.332*** (-3.64)	-0.379*** (-4.38)	-0.405*** (-4.86)	-0.372*** (-4.30)	-0.372*** (-4.58)	-0.371* (-2.45)	-0.372* (-2.49)	-0.372** (-2.83)	-0.377* (-2.36)
TOpenness	0.387*** (-4.2)	0.387*** (-4.07)	0.387*** (-4.39)	0.387*** (-4)	0.208* (-2.57)	0.171 (-1.89)	0.208* (-2.48)	0.208* (-2.49)	0.289* (-2.28)	0.259* (-2.28)	0.263*** (-3.81)	0.0968 (-1.87)
REGQ	0.553*** (-7.99)	0.535*** (-6.94)	0.580*** (-8.69)	0.580*** (-8.15)	0.435** (-2.81)	0.255* (-2.16)	0.437** (-2.98)	0.437** (-3.06)	0.619*** (-3.32)	0.602** (-2.95)	0.627*** (-3.99)	0.627*** (-4.22)
GDPPC	-0.183* (-2.08)	-0.172* (-2.09)	-0.332* (-1.96)	-0.372* (-2.01)	-0.180* (-2.3)	-0.249* (-1.99)	-0.181* (-2.33)	0.181* (-2.29)	-0.527*** (-4.05)	-0.563** (-3.18)	-0.397** (-2.66)	-0.413** (-2.77)
Sshadow	-0.155*** (-7.50)	-0.113*** (-4.36)	-0.157*** (-5.88)	-0.101** (-2.69)	0.290** (-2.59)	-0.166* (-2.05)	0.291** (-2.71)	0.291* (-2.46)	-0.078*** (-4.84)	-0.090*** (-5.65)	-0.090*** (-5.13)	-0.122*** (-5.92)

Note: *t*-statistics in parenthesis. ***, **, and * denote 0.01, 0.05, and 0.1 rejection levels, respectively.



Additionally, we investigated whether the predictor variables are together helpful in predicting the dependent variables using the time-varying Granger non-causality test proposed by Juodis et al. (2021). Juodis et al.'s (2021) tests for Granger non-causality can detect Granger non-causality even if it varies across units or over time. Moreover, it is robust against heteroskedasticity in the data as it relies on heteroskedasticity and autocorrelation consistent (HAC) estimation of the asymptotic variance.

Table 3. 8: Time-Varying Granger Non-Causality Test

Dependent variable	Number of units	BIC Criteria	Number of lags	Wald HPJ	P Value
MIC Sample					
AETE	8	-398.1978	2	98.8994	0.000
CCTE	8	338.8789	2	61.4367	0.000
APTE	8	-461.2537	2	43.5399	0.000
LIC Sample					
AETE	7	-289.7937	2	102.8712	0.000
CCTE	7	-478.3377	2	113.3494	0.000
APTE	7	-349.3731	2	75.7549	0.000

The test is conducted under the null hypothesis that independent variables do not cause the dependent variable. From Table 3.8, the HPJ Wald test statistic and corresponding p-values of 0.00 for the three environmental tax categories suggest that the independent variables in all three regression models are relevant in predicting the dependent variables at a 1% significance level. This gives credence to the choice of independent variables regressed on environmental tax effort.

5. Conclusion and Policy Implication

This study examined how renewable energy aid and governance quality affect different types of environmental tax efforts in Sub-Saharan African countries. Renewable energy aid, governance quality, and environmental taxation are key tools for promoting green growth and sustainable

development globally. However, they need to be aligned and coordinated in a way that considers their varying impacts. The result provides reasonable basis to conclude that the effect of renewable energy aid on environmental tax effort is heterogenous, depending on the type of environmental tax effort being considered, as well as the income levels of countries involved. Notwithstanding, governance quality tend to improve all categories of environmental tax effort, regardless of the income levels of countries considered. These findings have policy implications, both for middle and low-income Sub-Saharan African countries.

5.1 Low Income SSA Countries

The results from low-income Sub-Saharan African (SSA) countries reveal that inflows of renewable energy aid reduce all three categories of environmental tax effort. However, the quality of governance improves all examined categories of environmental tax effort, namely Climate Change Tax Effort, Air Pollution Tax Effort, and Aggregate Environmental Tax Effort.

Given the prevalent challenges associated with weak governance structures in many low-income SSA nations, targeted strategies are necessary to enhance governance. This ensures the efficient utilization and management of aid funds, preventing them from undermining environmental tax efforts. Notably, policymakers should focus on extensive institutional reforms. These reforms should aim to strengthen governance structures for both tax administration and efficient aid utilization. Addressing corruption, inefficiency, and lack of transparency within government agencies is vital for building trust in the governance system. Implementing anti-corruption measures, such as improved accountability mechanisms and transparent procurement processes, can help create an environment where aid funds are effectively directed towards their intended purposes. By improving the quality of governance, countries can establish a framework that

encourages responsible fiscal management, ensuring that aid supports, rather than impedes, domestic tax efforts.

Also, the conditions attached to renewable energy aid should be carefully designed to encourage, rather than undermine, environmental tax efforts. Policymakers should establish clear and enforceable agreements that link the disbursement of aid to concurrent improvements in environmental tax frameworks. This may involve setting benchmarks for tax collection efficiency, regulatory enforcement, and the implementation of green fiscal policies. By aligning aid with enhanced environmental taxation, countries can strike a balance between promoting renewable energy and maintaining fiscal responsibility.

The Samaritan dilemma hypothesis suggests the need to encourage political will and commitment to mobilize domestic resources. Low-income countries should prioritize building political will and commitment to mobilize domestic resources for environmental protection, rather than relying solely on external aid. This requires a shift in mindset, where environmental protection is seen as a national priority and a moral obligation, rather than a means to attract foreign funding. Political leaders should champion this cause and work to build cross-sector alliances to drive change. By demonstrating a genuine commitment to environmental protection, low-income countries can build trust with international partners and attract support that is aligned with their own priorities and values. This approach helps to avoid the pitfalls of the Samaritan dilemma, where well-intentioned aid can sometimes perpetuate dependency and undermine local ownership. Instead, low-income countries can take control of their own environmental destiny, leveraging their own resources and capabilities to drive sustainable development.

5.2 Middle Income SSA Countries

For middle-income Sub-Saharan African (SSA) countries, renewable energy aid decreases the tax

effort for climate change but increases it for air pollution and aggregate environmental tax efforts. However, the quality of governance enhances all three categories of environmental tax effort. Climate change has a global and long-term impact, while air pollution has more immediate and local effects. Consequently, more foreign aid is directed towards addressing climate change than air pollution. This large influx of climate change aid could substitute for domestic climate change tax efforts, disincentivizing the mobilization of domestic climate taxes.

To counteract the negative impact of foreign energy aid on climate change tax effort, middle-income SSA countries should consider customizing their environmental tax policies. Specifically, policymakers should explore the implementation of climate change taxes that directly link renewable energy aid funds to specific environmental projects. This ensures that the influx of

foreign energy aid directly contributes to energy-related climate change initiatives, mitigating any adverse effects on environmental tax efforts.

In addition, middle income SSA countries should focus on strengthening their domestic efforts to mobilize climate change taxes through measures such as improving climate change tax administration and governance quality. For instance, governance quality is shown to have a positive association with environmental tax efforts, necessitating the development of a robust institutional governance framework tailored to energy transition. Such a framework is vital in curbing corruption, fostering transparency, and encouraging accountability in the utilization of energy aid and the generation of environmental tax revenues. Additionally, aid providers can play a crucial role in enhancing effective climate tax administration by making aid conditional upon recipient countries' efforts to improve their domestic tax systems and reduce aid dependency (Crivelli & Gupta, 2017).

On the other hand, the positive effect of renewable energy aid on air pollution and aggregate environmental tax effort in middle-income SSA countries reveals the complementary effect of aid on tax effort. The result is encouraging as it suggests that aid inflows do not crowd out domestic tax efforts for air pollution. However, we are not in a position to recommend that SSA countries should seek more conventional energy aid, as this may create aid dependency and undermine tax efforts later. Instead, this result reveals that SSA countries can potentially mobilize domestic environmental taxes towards mitigating air pollution and aggregate environmental tax effort. Therefore, foreign assistance should aim to harness this potential to the point where SSA becomes self-reliant in funding energy transition. One way to achieve this is to prioritize aid that takes the form of catalytic finance. Catalytic finance is a type of financing designed to catalyze additional investment in a particular sector or region. Catalytic finance from development assistance can promote energy transition by providing technical assistance to develop domestic tax capacity.

6. Research Limitations

The study's sample focuses solely on the Sub-Saharan African region to allow for an in-depth discussion. However, other regions have not been explored and offer opportunities for further research. Additionally, the negative impact of energy aid on climate change tax efforts warrants further investigation due to its positive and negative implications. On the one hand, it could indicate that energy aid has helped transition to renewable energy and reduced the need for additional environmental tax efforts. On the other hand, it could suggest that energy aid is displacing domestic revenue mobilization through taxes. Therefore, further studies are required to enhance knowledge on the subject.

CHAPTER FOUR

THRESHOLD EFFECTS OF ENERGY DEVELOPMENT ASSISTANCE ON ENERGY TRANSITION EFFICIENCY: THE ROLE OF GOVERNANCE EFFECTIVENESS



Abstract

The acceleration of clean energy deployment in developing economies is often hindered by a lack of funding. These countries typically depend on Energy Development Assistance (EDA) to finance their energy transition. However, the efficacy of EDA is a matter of debate, with some arguing that it mirrors the donors' priorities more than the recipients' needs, leading to suboptimal results. This study brings a fresh perspective to this discussion by examining how varying levels of EDA inflows affect the efficiency of renewable energy transition (RETEF), and how this relationship is moderated by the effectiveness of accounting and governance (AGE). The study first introduces an intuitive metric for calculating values for renewable energy transition progress (RET), which are subsequently used to measure transition efficiency through data envelopment analysis (DEA). Using a panel of 17 countries (2000–2019), the study then estimates the asymmetric effect of low and high EDA inflows on RETEF and the joint effect of high EDA inflows and AGE on RETEF. The DEA results suggest that RETEF in the sample countries is primarily propelled by pure efficiency improvements, with limited gains in scale and technical efficiency. Furthermore, the Multiple Threshold Nonlinear Autoregressive Distributed Lag (MTNARDL) model results reveal a positive correlation between low to high EDA inflows and RETEF but a negative correlation when EDA inflows are extremely high. However, when extremely high EDA inflows interact with AGE, they have a positive impact on RETEF. This implies that enhancing accounting and governance capacity in recipient countries can boost energy transition efficiency.

Keywords: aid dependency; energy transition efficiency; accounting and governance effectiveness; absorptive capacity; MTNARDL



-
3. This chapter has undergone review with the *Journal of Environmental Management*.

1.1 Introduction

This paper explores the nonlinear effects of energy development assistance (EDA or energy aid) on renewable energy transition efficiency in aid recipient countries (RETEF) and the role of accounting and governance effectiveness in this relationship. There is a long-standing debate on whether development assistance (DA) helps or hinders the development of recipient countries, with some critics claiming that DA serves the interests of donor countries and creates inefficiencies in recipient countries (Combes et al., 2016; Tang & Bundhoo, 2017; Yang & Park, 2020). We add to the ongoing discourse by narrowing our focus to the transition to renewable energy in developing nations, where EDA financing constitutes a primary component of government expenditure on renewable energy (Combes et al., 2016; Kim, 2019; Müller & Claar, 2021).

The transition from the Millennium Development Goals (MDGs) to the Sustainable Development Goals (SDGs) has brought energy issues into sharper focus. Unlike the MDGs, which did not directly tackle energy concerns, the seventh SDG aims to facilitate a shift towards cleaner and more affordable energy. This transition is driven by the escalating levels of pollution related to energy, which contribute to over 75.6% (37.6 gt CO₂e) of global greenhouse gases (Cheng et al., 2021a; Green, 2021; Jackson et al., 2022). This pollution leads to climate change, food insecurity, and heightened health risks (International Energy Agency-IEA, 2022; Li et al., 2021). In developed countries, the energy transition has evolved from traditional biomass to fossil fuels, then to natural gas and renewable energy sources as income levels rose (Li et al., 2021). However, given the risks associated with energy emissions, developing countries are encouraged to expedite their shift towards low-carbon energy sources compared to the pace at which developed countries did (Li et al., 2023).

At the same time that countries are expected to expedite energy transition, transition costs are

prohibitive, leading to considerable investment gaps in developing countries (IEA, 2022; International Renewable Energy Agency-IRENA, 2021). The IEA (2021) acknowledges such investment gaps, stating that financial investments constitute “the missing link to accelerate clean energy deployment in developing economies”. To worsen matters, private sector participation in funding energy transition is limited in developing countries, creating extensive reliance on EDA to support government expenditure on energy transition (IEA, 2021; IMF/OECD, 2021; Alemu & Lee, 2015; Luthra et al., 2015). However, this raises an important question: can EDA lead to the anticipated energy transition outcomes, or is there a possibility of failure? Answering this question is very crucial in achieving an efficient and just energy transition because if development assistance had been a cure-all for development issues, poverty would not have been a topic of discussion at international summits for the past seven decades.

There is a long-standing debate on the effectiveness of DA in promoting the interests of recipient countries (Moolio & Kong, 2016; Sothan, 2018; Tang & Bundhoo, 2017). Some contend that development assistance does not contribute much to the development of recipient countries and should no longer be given (Alesina & Dollar, 2000; IRENA & AfDB, 2022; Li et al., 2021). For instance, some existing studies suggest that development aid can perpetuate power imbalances and reinforce inequalities between DA providers and recipient countries (Alesina & Dollar, 2000; Andersen et al., 2022; Li et al., 2021). Thus, donor countries may dictate the terms and conditions of the aid, which could lead to the prioritization of donor interests over those of the recipient countries, resulting in an inefficient transition (Alesina & Dollar, 2000; Andersen et al., 2022; Boudreau, 2023; Li et al., 2021; Rahman & Giessen, 2017). Conversely, other empirical evidence indicates that DA inflows can enhance development outcomes, such as RETEF (Adebayo & Beton Kalmaz, 2020; Maruta & Banerjee, 2021; Refaei & Sameti, 2015). As debates on the role

of DA persist, the need to look at the phenomenon from another perspective becomes even more critical.

Many existing studies suffer from the limitation of combining various forms of DA into a single amount and assessing its impact on development outcomes (Combes et al., 2016; Maruta & Banerjee, 2021). However, recent advancements in aid research suggest that the question has evolved from whether aggregated DA is beneficial to determining which specific type of assistance is more advantageous (Clemens et al., 2012; Maruta & Banerjee, 2021). This study explicitly emphasizes EDA and its effects on RETEF. Additionally, the unsettled discourse on the relationship between DA and development outcomes can be attributed to methodological gaps in prior literature. Existing studies have examined the relationship purely from a linear functional form specification (Maruta & Banerjee, 2021). Of course, some recent energy studies embrace nonlinear functional forms; however, the nexus between EDA and RETEF has not been their focus. Based on the dependency and institutional absorptive capacity theories, we hypothesize that different levels of EDA may have different impacts on RETEF and test the same using a novel Multiple Threshold Nonlinear ARDL technique (MTNARDL).

The MTNARDL allows us to explore the effects of extremely high, moderate, and lower regimes of EDA inflows on RETEF, since there are theoretical reasons to believe that different levels of EDA can have different effects on RETEF. Additionally, given the dependency and absorptive capacity theories' suggestion that higher EDA inflows can culminate in inefficient outcomes, the study examines whether the effect of higher EDA inflows on RETEF is conditioned by Accounting and Governance Effectiveness (AGE).

This study is relevant in diverse ways. Firstly, it examines the effectiveness of EDA in achieving RETEF in developing countries, which has not been systematically studied before (Maruta &

Banerjee, 2021). Secondly, it proposes a simple and intuitive metric for computing renewable energy transition progress, which is then used to calculate transition efficiency scores via data envelopment analysis (DEA). Metrics such as energy intensity ratio are predominantly used to measure energy transition in the literature (Gielen et al., 2019; Lin & Wang, 2021; Proskuryakova & Kovalev, 2015). However, energy intensity only expresses energy consumption as a ratio of GDP, hence not directly accounting for the transition from nonrenewable to renewable energy (Proskuryakova & Kovalev, 2015). Finally, the study shows how a higher dependency on EDA can still achieve RETEF through the interacting effect of AGE. This is crucial because some of the existing literature, which found a negative relationship between aid dependence and development progress in recipient countries, has called for a reduction in aid intake. However, such a recommendation can be counterproductive since most developing countries still have huge funding gaps for energy transition. Hence, we show how higher EDA levels can be conditioned by AGE to achieve RETEF.

1.2 Nonlinear Effects of EDA on RETEF: Theoretical Perspectives

The aid dependency theory argues that the global economic system perpetuates a relationship of dependence between developed and developing countries, with developed countries exerting control over means of production, technology, and finance. As a result, developing countries rely heavily on developed countries for investment, technology, and trade, thus allowing aid providers to exert influence on recipient countries (Henderson & Sommer, 2022; Malatesta & Smith, 2014). When aid recipient countries become overly reliant on energy aid, there is little incentive to invest adequately in building local capacity, including research and development of renewable energy technologies, human resource development, and institutional capacity required for efficient energy transition (Borter & Malik, 2023; Harris, 2023; Whitfield, 2010).

Additionally, higher dependence on EDA may not promote the interests of recipient countries and instead fund foreign companies or consultants to undertake energy projects, which does not contribute to developing local capacity and transition efficiency (Harris, 2023; Mahembe & Odhiambo, 2017; Moyo & Tsakata Mafuso, 2017). Notably, some studies have called out Das from the OECD, suggesting that OECD Das are more inclined to support recipient countries that have greater investment from donor countries, with the ultimate goal of using aid funds to promote policies that are more favorable to foreign investment from the donor (Henderson & Sommer, 2022; Mahembe & Odhiambo, 2017; Moyo & Tsakata Mafuso, 2017). This can culminate in situations where energy aid misaligns with local energy development plans and priorities, resulting in projects that do not address the specific energy needs of the recipient countries, causing transition inefficiencies (Combes et al., 2016; Maruta & Banerjee, 2021).

Conversely, lower EDA inflows can provide sufficient resources to support energy transition initiatives while leaving room for local ownership and decision-making, which can increase the effectiveness and efficiency of energy transition (Bi et al., 2014; Combes et al., 2016). By implication, the dependency theory raises the expectation that lower to moderate levels of EDA inflows should facilitate RETEF while higher levels reduce it.

1.3 Accounting and Governance Effectiveness and Foreign Aid

At the heart of the debate surrounding the efficacy of energy development assistance lies the critical role of accounting and governance practices in recipient countries. Robust financial controls, transparent reporting, and accountable decision-making processes emerge as key determinants of whether external financing for renewable energy transitions translates into tangible progress or falls short of its intended objectives (Alaali & Alshahrani, 2022; Siddique et al., 2020). One primary concern is the potential for corruption and the fungibility of aid, where funds may be

diverted from their intended purpose of renewable energy development to other, less impactful uses (Durodola et al., 2020). Rigorous accounting systems that track the flow of funds and their utilization can help mitigate these risks. Recipient governments must demonstrate the credible absorption and productive allocation of EDA resources through comprehensive financial reporting (Kaberuka & Sène, 2014). This, in turn, can build the confidence of donor agencies and facilitate more efficient disbursement of assistance.

Equally important are the governance mechanisms that ensure accountability and transparency in decision-making processes. Well-functioning oversight and external scrutiny structures help guarantee that EDA funds are directed towards the most impactful renewable energy investments and initiatives, rather than being siphoned off for unrelated priorities (Durodola et al., 2020). Transparent procurement procedures, independent audits, and public disclosure of project information can further strengthen the credibility of aid utilization in the eyes of donors.

The existing literature suggests that enhancing the quality of accounting and governance in recipient countries is a crucial prerequisite for leveraging EDA to drive efficient and equitable renewable energy transitions. When these systems are robust, with strong financial controls and accountable decision-making, external financing can be more effectively absorbed and deployed towards sustainable energy objectives. But where they are weak, aid may fall victim to corruption and fungibility, failing to catalyze the desired transformation of national energy systems.

1.4 Absorptive Capacity and the Interacting Role of AGE

The institutional absorptive capacity of recipient countries is a key determinant of the outcomes of energy development assistance (EDA) (Feeny et al., 2019; Maruta & Banerjee, 2021; Ogundipe et al., 2020). This theory suggests that the ability of institutions in aid recipient countries to effectively manage and utilize EDA inflows is heavily influenced by their capacity, particularly in

the domains of accounting and governance (AGE) (Adedokun, 2017; Fon & Alon, 2022). However, in the context of developing countries, especially in Africa, these institutional capacities are often severely lacking.

Many African nations face significant challenges in building and maintaining robust AGE frameworks. Rampant corruption, weak governance structures, and lack of transparency impede effective management of EDA inflows. These structural deficiencies mean that recipient countries can only manage and utilize a limited amount of EDA effectively. Beyond this threshold, the lack of necessary institutional capacity leads to mismanagement and inefficiency (Feeny et al., 2019; Maruta & Banerjee, 2021; Ogundipe et al., 2020). Consequently, it is crucial for countries to realistically assess their institutional capacity and receive aid amounts that match their ability to manage it effectively.

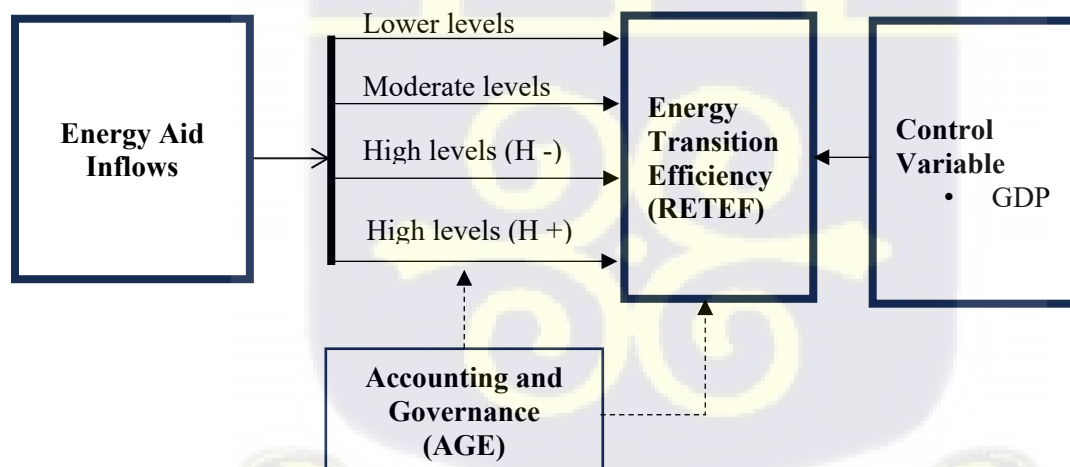
The theory advocates for the development of robust institutional capacities to mitigate the risk of energy transition inefficiencies. This includes fostering transparency, accountability, and stakeholder participation in energy decision-making. However, in practice, many African countries struggle to implement these capacity-building mechanisms. Independent audits, effective governance frameworks, stakeholder engagement, anti-corruption initiatives, and fair market competition remain elusive goals (Feeny et al., 2019; Kaya & Kaya, 2020; Maruta & Banerjee, 2021; Maruta et al., 2020; Ogundipe et al., 2020). The lack of these mechanisms often results in the perpetuation of corruption and inefficiency, further complicating the effective use of EDA.

Moreover, the theory suggests that strengthening AGE capacity can challenge the dominant power structures and practices that allow providers of EDA to prioritize their own interests over those of recipient countries. This power imbalance is particularly pronounced in many African nations, where donor countries and agencies often impose their agendas, sidelining the actual needs and

priorities of the recipient nations (Kaur & Sitlhou, 2017; Maruta et al., 2020; Su et al., 2021). Strengthening AGE capacities could compel donors to be more transparent and accountable, aligning their actions with the energy transition objectives of the recipient countries. However, achieving this alignment remains a significant challenge (Combes et al., 2016; Maruta et al., 2020; Su et al., 2021). Therefore, the institutional absorptive capacity theory highlights the critical need for robust accounting and governance institutions in aid recipient countries, especially in Africa, to ensure that EDA leads to the desired outcomes. Without addressing the deep-rooted issues of corruption, weak governance, and lack of transparency, the effectiveness of higher EDA inflows in achieving efficient energy transitions will remain severely compromised.

1.5 Conceptual Model

Figure 4.2 Conceptual framework (Paper Three)



Source: Author's construct, 2024

The discussions of the effect of EDA on the threshold effect of EDA on RETEF, and the moderating effect of AGE is shown in Figure 4.2. From Figure 4.2, lower to moderate inflows of energy aid is expected to have a positive effect on RETEF.

However, higher inflows of energy aid may culminate in aid dependency, thereby having a negative impact on RETEF. However, high inflows of EDA is expected to achieve a positive effect on RETEF when it is moderated by effective accounting and governance institutions.

The rest of the study is organized into four sections. The second section presents the research methodology, the third section presents preliminary results, and the fourth section discusses the empirical results of the study, while the last section concludes and draws implications.

2.0 Methodology

The study first examines the effect of higher and lower EDA inflows on RETEF in SSA and East Asian countries. Additionally, the study interacts AGE with higher levels of EDA inflows to assess their joint effect on RETEFF. We follow four paths to achieve these. First, we create a measure for renewable energy transition (RET) and use it to compute the transition progress of the countries analyzed. Second, the Malmquist productivity index is used to calculate RET efficiency scores (RETEF). Third, we specify and estimate the first research model, which emphasizes the relationship between three thresholds of EDA and RETEF. We proceed by estimating a second model involving the interaction effect of AGE.

2.1 Data

For the DEA analysis, 50 developing countries (i.e., Decision Making Units-DMUs) that are EDA recipients were analyzed for periods ranging 2000-2019, although the subsequent regression analysis emphasized seven SSA and ten east Asian countries (based on data availability) analyzed for the 20-year period (2000-2019). Using a larger sample to create the efficiency scores is beneficial as it gives a more global efficiency score, especially considering that energy transition

is a global phenomenon. Also, a larger number of DMUs can provide a more accurate and reliable estimation of the efficiency frontier and increase the discrimination power of DEA (Amin & Toloo, 2007; Khezrimotlagh, 2015; Khezrimotlagh et al., 2021). However, narrowing down the sample for the regression analysis is based on data availability and other factors explained in section 3.

This study uses four variables: renewable energy development assistance (EDA), renewable energy transition efficiency (RETEF), accounting and governance effectiveness (AGE), and gross domestic product growth (GDP). GDP is a control variable, and AGE is an interaction variable in the second model specification. The World Bank's WDI database provides data for AGE and GDP, while IRENA's database provides data for EDA. EDA is a composite variable that sums up the assistance received for various renewable technologies: solar, wind, hydropower, geothermal, bioenergy, and multiple renewables. The equation for EDA is such that: $EDA = EDAsolar_{it} + EDAwind_{it} + EDAhydropower_{it} + EDAgeothermal_{it} + EDAbioenergy_{it} + EDAmultitech_{it}$ (1) for period i and country t .

2.2 Measurements and Preliminary Analysis

2.2.1 Measurement of Renewable Energy Transition (RET) Progress

For any given country i and a given year t , RET_{it} is measured as the share of nonrenewable energy consumption in final energy consumption ($SNRE_{it}$) replaced by the share of renewable energy consumption in final energy consumption (SRE_{it}). Where;

$$SNRE_{it} = \left(\frac{NRECO_{it}}{FECO_{it}} * 100 \right) \quad (2), \text{ and}$$

$$SRE_{it} = \left(\frac{RECO_{it}}{FECO_{it}} * 100 \right) \quad (3),$$

$FECO_{it}$ is the final energy consumption; $NRECO_{it}$ is nonrenewable energy consumption; and

RECO_{it} is renewable energy consumption. The excess of the SRE_{it} value over the SNRE_{it} value represents the proportion of nonrenewable energy consumption replaced by renewable energy consumption in a giving year. Therefore,

$$\text{Renewable Energy Transition (RET)}_{it} = (SRE_{it} - SNRE_{it}) = \left[\left(\frac{RECO_{it}}{FECO_{it}} * 100 \right) - \left(\frac{NRECO_{it}}{FECO_{it}} * 100 \right) \right] \quad (4),$$

Finally, to define RET_{it} with reference to the proportionate change from the consumption of nonrenewable energy to renewable energy, equation (4) is expressed over (2), hence:

$$RET_{it} = \left[\frac{(SRE_{it}) - (SNRE_{it})}{(SNRE_{it})} \right] = \left[\frac{\left(\frac{RECO_{it}}{FECO_{it}} \right) - \left(\frac{NRECO_{it}}{FECO_{it}} \right)}{\left(\frac{NRECO_{it}}{FECO_{it}} \right)} \right] * 100 \quad (5)$$

From equation (5), a positive RET_{it} value in a given *i* and *t* suggests that more renewable energy was consumed relative to the proportion of nonrenewable energy consumed, hence signifying transition progress; the reverse is true. It is important to note that the formula is divided by the GDP of each country to make the resultant RET values comparable. The variables in the formular are sourced from the World Bank's Databank.

By applying the formular in equation 5, we obtain the RET values contained in Table 4.1 for a global sample of 50 EDA recipient countries for periods spanning 2000 to 2019.

In Table 4.1, positive (RET) values indicate that a country has progressed in replacing nonrenewable energy consumption with renewable energy in final energy consumption. Sub-Saharan African (SSA) countries dominate the top ten spots. Notably, the top ten countries are DR Congo, Uganda, Ethiopia, Tanzania, Mozambique, Rwanda, Zambia, Nepal, Nigeria, and Cameroon. This finding is consistent with the data provided by the World Development Indicators (WDI) regarding the share of renewable energy consumption in final energy consumption (Figure 4.1).

From Figure 4.1, the Democratic Republic of Congo has the highest average share of renewable energy consumption over the periods considered. This is followed by Ethiopia and Uganda, all from the SSA region. For instance, for the 2019 period, the share of renewable energy in total energy consumption was 96.24%, 88.92%, and 90.22% for the Dr Congo, Ethiopia, and Uganda. On the other hand, Jordan has the least share of renewable energy consumption over the periods considered and among the 50 countries analyzed.



Table 4. 1 : RET Progress Scores

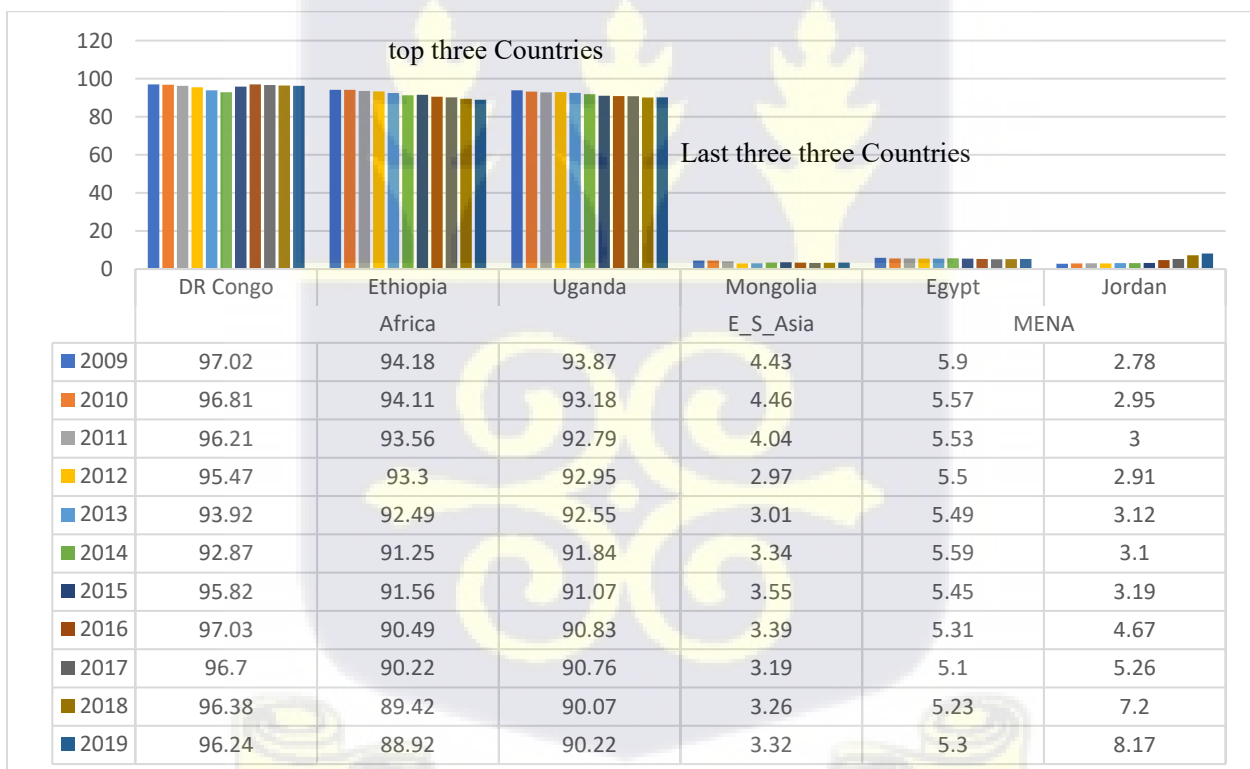
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total	Rank
DR Congo	46.54	58.24	55.80	47.26	45.17	36.76	35.45	33.34	31.00	31.56	29.35	24.39	20.08	14.45	12.03	21.92	31.67	28.30	25.62	24.60	653.53	1st
Uganda	18.04	18.92	19.51	19.19	18.08	14.98	14.18	13.97	13.95	14.31	12.66	11.87	12.18	11.42	10.25	9.20	8.91	8.82	8.07	8.22	266.74	2nd
Ethiopia	20.47	16.52	16.28	15.33	15.04	16.98	16.32	15.12	14.92	15.18	14.98	13.53	12.93	11.32	9.43	9.85	8.52	8.22	7.45	7.03	265.40	3rd
Tanzania	13.95	12.64	11.26	11.18	9.83	8.81	8.53	8.86	8.32	9.01	7.74	6.67	5.22	4.84	4.84	4.50	4.99	4.63	4.78	4.77	155.37	4th
Mozambique	13.72	12.31	12.75	11.76	12.16	13.80	12.41	6.02	6.41	5.20	4.62	5.13	4.73	4.15	3.53	3.21	2.59	2.74	2.89	2.56	142.69	5th
Rwanda	5.56	5.63	5.77	5.87	6.03	7.30	8.63	8.32	8.67	8.57	8.71	7.65	6.91	6.67	6.30	5.30	5.26	5.13	4.45	2.52	129.27	6th
Zambia	7.98	7.77	7.58	7.26	7.33	6.83	7.46	8.33	7.40	6.83	6.76	5.86	4.51	4.48	4.16	3.91	3.91	3.52	3.64	4.45	119.98	7th
Nepal	6.54	6.17	7.95	7.47	8.31	7.54	9.43	9.51	8.49	7.03	5.87	5.66	4.54	5.17	4.27	4.68	2.81	2.24	1.89	2.42	117.99	8th
Nigeria	5.25	4.52	4.49	3.87	4.27	4.25	5.11	5.86	5.27	6.83	5.39	4.51	4.48	3.61	3.17	3.60	3.56	3.66	3.64	3.38	88.72	9th
Cameroon	4.49	4.80	4.78	4.80	4.91	5.30	4.90	3.21	3.21	2.82	2.71	2.68	2.66	2.46	2.31	2.56	2.71	2.80	2.82	2.86	69.80	10th
Malawi	3.75	3.93	3.99	3.82	3.70	3.94	3.81	3.62	3.10	3.00	3.32	3.04	3.03	2.92	3.78	3.23	2.69	2.16	1.71	1.71	64.26	11th
Mali	4.05	3.59	4.09	5.04	3.41	3.66	3.45	2.73	2.00	2.69	2.82	2.73	2.69	3.24	3.24	2.98	2.19	2.23	2.28	2.28	61.40	12th
B. Faso	4.85	4.13	2.84	2.78	4.07	5.43	4.50	3.69	3.86	4.10	3.39	3.15	2.38	2.07	2.04	1.66	1.61	1.23	1.03	0.84	59.66	13th
Kenya	2.73	3.05	3.15	3.97	3.65	3.34	2.96	3.09	3.17	2.62	2.26	2.41	2.70	2.30	1.99	1.58	1.44	1.48	1.63	1.13	50.63	14th
Cambodia	3.43	3.13	3.25	2.98	3.18	2.82	2.55	1.97	1.87	1.13	0.84	0.78	0.81	0.85	0.75	0.54	0.38	0.29	0.29	0.14	31.98	15th
Sri Lanka	0.79	0.70	0.64	0.58	0.60	0.51	0.64	0.51	0.60	0.74	0.62	0.45	0.54	0.49	0.34	0.12	0.04	-0.03	0.06	0.00	8.96	16th
Tajikistan	0.66	0.78	0.79	0.82	0.59	0.76	0.60	0.16	0.20	0.54	0.62	0.50	0.26	0.23	-0.15	-0.07	-0.30	-0.29	-0.35	-0.37	5.99	17th
Ghana	1.52	1.26	0.91	0.81	0.66	0.59	0.41	0.20	0.34	0.08	0.08	0.00	-0.13	-0.14	-0.09	-0.21	-0.17	-0.20	-0.29	-0.28	5.36	18th
Nicaragua	0.41	0.31	0.21	0.06	0.05	0.12	0.14	0.11	0.16	0.20	0.19	0.14	0.14	0.19	0.13	0.00	-0.02	-0.04	0.06	0.03	2.58	19th
Pakistan	0.04	0.06	0.06	0.00	-0.08	-0.08	-0.11	-0.19	-0.13	-0.13	-0.10	-0.12	-0.11	-0.07	-0.11	-0.15	-0.22	-0.27	-0.24	-0.23	-2.17	20th
Brazil	-0.26	-0.30	-0.25	-0.18	-0.18	-0.14	-0.12	-0.11	-0.11	-0.04	-0.12	-0.17	-0.23	-0.27	-0.28	-0.23	-0.17	-0.17	-0.11	-0.09	-3.53	21st
Bangladesh	0.44	0.26	0.19	0.11	0.09	0.03	-0.05	-0.11	-0.18	-0.24	-0.33	-0.38	-0.40	-0.41	-0.45	-0.53	-0.56	-0.60	-0.63	-0.67	-4.43	22nd
Senegal	-0.09	-0.15	-0.22	-0.23	-0.34	-0.32	-0.23	-0.33	-0.34	0.05	-0.02	-0.08	-0.02	-0.26	-0.26	-0.36	-0.42	-0.39	-0.43	-0.41	-4.84	23rd
Vietnam	0.37	0.28	0.09	0.03	-0.16	-0.21	-0.21	-0.28	-0.35	-0.41	-0.47	-0.43	-0.39	-0.40	-0.42	-0.56	-0.71	-0.67	-0.72	-0.77	-6.40	24th
Georgia	-0.10	0.13	0.31	0.24	0.20	-0.29	-0.41	-0.43	-0.43	-0.42	-0.36	-0.54	-0.60	-0.50	-0.54	-0.61	-0.62	-0.61	-0.61	-0.66	-6.85	25th
India	-0.12	-0.11	-0.16	-0.16	-0.18	-0.21	-0.24	-0.29	-0.35	-0.40	-0.43	-0.46	-0.47	-0.47	-0.49	-0.50	-0.51	-0.52	-0.51	-0.51	-7.08	26th
Indonesia	-0.16	-0.20	-0.19	-0.25	-0.29	-0.29	-0.33	-0.33	-0.30	-0.38	-0.47	-0.55	-0.60	-0.58	-0.60	-0.64	-0.61	-0.65	-0.73	-0.76	-8.91	27th

Peru	-0.37	-0.30	-0.33	-0.31	-0.39	-0.38	-0.37	-0.44	-0.49	-0.51	-0.53	-0.56	-0.55	-0.60	-0.60	-0.62	-0.63	-0.62	-0.61	-0.63	-9.83	28th	
Namibia	-0.47	-0.56	-0.49	-0.50	-0.47	-0.47	-0.45	-0.44	-0.52	-0.50	-0.55	-0.54	-0.54	-0.56	-0.57	-0.59	-0.58	-0.57	-0.56	-0.56	-10.50	29th	
Philippines	-0.50	-0.53	-0.54	-0.56	-0.57	-0.55	-0.50	-0.52	-0.49	-0.49	-0.52	-0.49	-0.48	-0.51	-0.52	-0.56	-0.60	-0.62	-0.62	-0.64	-10.79	30th	
Colombia	-0.61	-0.63	-0.60	-0.56	-0.59	-0.59	-0.58	-0.56	-0.57	-0.55	-0.58	-0.59	-0.59	-0.52	-0.52	-0.54	-0.56	-0.52	-0.56	-0.56	-11.36	31st	
Chile	-0.54	-0.53	-0.51	-0.54	-0.54	-0.52	-0.51	-0.56	-0.55	-0.54	-0.63	-0.60	-0.57	-0.57	-0.63	-0.67	-0.67	-0.68	-0.66	-0.66	-11.67	32nd	
Afghanistan	-0.18	-0.16	-0.39	-0.42	-0.21	-0.49	-0.53	-0.60	-0.73	-0.80	-0.82	-0.86	-0.82	-0.80	-0.77	-0.79	-0.75	-0.76	-0.78	-0.77	-12.43	33rd	
Thailand	-0.72	-0.75	-0.75	-0.75	-0.75	-0.75	-0.74	-0.72	-0.71	-0.70	-0.70	-0.70	-0.69	-0.70	-0.68	-0.71	-0.71	-0.71	-0.69	-0.68	-14.33	34th	
Bosnia and Herzegovina	-0.76	-0.75	-0.73	-0.75	-0.75	-0.75	-0.78	-0.83	-0.83	-0.79	-0.76	-0.84	-0.82	-0.76	-0.69	-0.66	-0.70	-0.77	-0.45	-0.41	-14.57	35th	
Serbia	-0.72	-0.76	-0.78	-0.81	-0.83	-0.81	-0.82	-0.84	-0.82	-0.74	-0.74	-0.79	-0.76	-0.75	-0.70	-0.73	-0.74	-0.75	-0.73	-0.73	-15.33	36th	
Bolivia	-0.58	-0.57	-0.61	-0.64	-0.66	-0.70	-0.73	-0.75	-0.78	-0.81	-0.82	-0.84	-0.85	-0.86	-0.88	-0.91	-0.91	-0.92	-0.92	-0.91	-15.66	37th	
Domin. Rep	-0.76	-0.77	-0.78	-0.77	-0.74	-0.76	-0.78	-0.78	-0.79	-0.79	-0.80	-0.80	-0.80	-0.80	-0.79	-0.83	-0.82	-0.80	-0.81	-0.84	-15.80	38th	
China	-0.58	-0.60	-0.63	-0.69	-0.75	-0.79	-0.80	-0.83	-0.84	-0.84	-0.86	-0.87	-0.87	-0.87	-0.86	-0.86	-0.86	-0.85	-0.84	-0.83	-15.92	39th	
Ecuador	-0.76	-0.79	-0.79	-0.80	-0.80	-0.81	-0.83	-0.81	-0.82	-0.85	-0.87	-0.85	-0.85	-0.87	-0.86	-0.85	-0.83	-0.79	-0.80	-0.78	-16.42	40th	
Morocco	-0.82	-0.82	-0.82	-0.81	-0.70	-0.75	-0.78	-0.80	-0.83	-0.83	-0.84	-0.87	-0.88	-0.87	-0.87	-0.87	-0.88	-0.88	-0.88	-0.88	-16.69	41st	
Turkey	-0.79	-0.78	-0.79	-0.81	-0.80	-0.82	-0.83	-0.86	-0.86	-0.85	-0.83	-0.85	-0.85	-0.84	-0.87	-0.85	-0.85	-0.87	-0.87	-0.84	-16.69	42nd	
Tunisia	-0.83	-0.83	-0.83	-0.84	-0.84	-0.83	-0.83	-0.83	-0.83	-0.81	-0.86	-0.85	-0.85	-0.85	-0.85	-0.86	-0.86	-0.87	-0.86	-0.86	-16.87	43rd	
South Africa	-0.81	-0.81	-0.84	-0.85	-0.86	-0.88	-0.88	-0.88	-0.87	-0.88	-0.87	-0.87	-0.88	-0.89	-0.89	-0.89	-0.88	-0.88	-0.89	-0.88	-17.38	44th	
Mexico	-0.86	-0.87	-0.88	-0.89	-0.89	-0.89	-0.89	-0.90	-0.89	-0.90	-0.90	-0.90	-0.90	-0.90	-0.89	-0.90	-0.90	-0.89	-0.89	-0.88	-17.80	45th	
Argentina	-0.89	-0.87	-0.87	-0.88	-0.90	-0.89	-0.90	-0.92	-0.92	-0.91	-0.90	-0.90	-0.91	-0.90	-0.89	-0.90	-0.90	-0.88	-0.88	-0.88	-17.88	46th	
Armenia	-0.92	-0.94	-0.90	-0.89	-0.90	-0.93	-0.92	-0.92	-0.93	-0.92	-0.90	-0.91	-0.93	-0.93	-0.92	-0.88	-0.85	-0.86	-0.87	-0.88	-18.12	47th	
Egypt	-0.91	-0.92	-0.92	-0.92	-0.92	-0.93	-0.93	-0.94	-0.93	-0.94	-0.94	-0.94	-0.94	-0.94	-0.94	-0.94	-0.94	-0.95	-0.94	-0.94	-18.68	48th	
Mongolia	-0.94	-0.94	-0.93	-0.94	-0.94	-0.94	-0.95	-0.95	-0.95	-0.95	-0.95	-0.96	-0.97	-0.97	-0.97	-0.96	-0.96	-0.97	-0.97	-0.97	-19.07	49th	
Jordan	-0.98	-0.98	-0.98	-0.98	-0.98	-0.98	-0.98	-0.98	-0.97	-0.97	-0.97	-0.97	-0.97	-0.97	-0.97	-0.97	-0.97	-0.95	-0.94	-0.92	-0.91	-19.32	50th



The result of the RET scores in Table 4.1 and Figure 4.1 is corroborated by the Mo Ibrahim Foundation (2022), which suggests that unclean energy sources, especially fossil fuels, only account for a little over half of the energy supply in Africa (Ben, 2022). This contradicts those in other regions where fossil fuels dominate the energy supply. For instance, almost all of the energy supply in the Middle East is constituted by fossil fuels (99.2%), while in Asia Pacific and North America, the rate stands at 84% and 81.7%, respectively. Similarly, fossil fuels constitute roughly two-thirds of the energy supply in Europe (71.3%) and Central and South America (65.8%).

Figure 4. 1: Share of renewable energy consumption



Source: World Bank Databank, 2023

While we observe that SSA countries lead the chart for share of renewable energy consumption, this may not adequately depict transition progress. For instance, Ethiopia has an electrification

rate of only 45% but a renewable energy consumption share of 93%, mainly due to traditional biomass. This suggests that achieving a decarbonized economy requires more than increasing the share of renewables – transition efficiency must therefore be prioritized (Abdi, 2023; IEA, 2021; Ringel et al., 2021).

2.2.3 Measurement of Renewable Energy Transition Efficiency (RETEF)

Renewable energy transition efficiency refers to the ratio of renewable energy output to renewable energy input (Li et al., 2020; Mohammad, et al., 2021). It measures how well a country or region can convert scarce renewable energy resources into useful energy services. After generating RET values in Table 4.1, the study uses the RET values to compute RET efficiency index (RETEFit) via DEA and the Malmquist Total Factor Productivity Index (TFP). Within the energy literature, DEA is commonly used to compute energy efficiency indices due to its ability to handle multiple inputs and outputs, its flexibility in handling different levels of aggregation, and its ability to account for the heterogeneity of decision-making units (i.e., countries) being evaluated (Fidanoski et al., 2021). The Malmquist index is a useful technique for analyzing the time-based evolution of energy efficiency (Cui & Zhang, 2017; Mohd Chachuli et al., 2020). It enables the examination of the total factor energy efficiency changes, including changes in production technology progress (tc), technical efficiency ($Effch$), pure technical efficiency changes ($Pech$), and scale efficiency changes ($Sech$). Cui and Zhang (2017) note that the method provides practical and informative analysis because of its decomposition abilities.

Setting t as the base period, the output-based TFP in period $t + 1$ is expressed:

$$M(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} * \left[\frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})} * \frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)} \right]^{0.5} \quad (6)$$

$x^{t+1}, y^{t+1}, x^t, y^t$ represent input and output vectors of t and $t+1$ periods independently. D^t, D^{t+1} represent the distance function of t and $t+1$ period.

2.2.3.1 Selection of inputs and outputs for DEA analysis

In DEA analysis, it is essential to select the appropriate inputs and outputs to define the scope of the analysis and the relevant performance measures. The few studies emphasizing renewable energy efficiency suggest that the “input of renewable energy is mainly reflected in the installed capacity” (Li et al., 2022, p. 442). This is re-emphasized by Chen et al. (2022) and Bi et al. (2014), who used installed renewable capacity as inputs for renewable energy generation and consumption. Additionally, researchers involved in renewable energy scientific research and development are another crucial input for the renewable energy transition (Li & Shi, 2014). The number of scientific research outputs in renewable energy represents the human capital (e.g., knowledge and expertise) invested in the transition to renewable energy (Li & Shi, 2014; Pang et al., 2022; Zafar et al., 2019). Furthermore, scientific research contributes to the expansion of knowledge and understanding of renewable energy, which can be applied in policymaking, investment decisions, and other strategic initiatives relating to energy transition (Khalil et al., 2010; Li & Ullah, 2022b; Zafar et al., 2019).

Following this literature, we select two input indicators encompassing total installed renewable capacity and human capital invested in renewable energy development. The total installed capacity is composed of the installed capacity for hydropower, wind power, solar, biomass, and geothermal, which can be obtained from the WDI database. The human capital invested in renewable energy development is measured by the number of scientific research outputs on renewable energy development, as obtained from the Scopus database. The output of interest is RET. Using the Malmquist DEA, the average efficiency scores of 50 countries are presented in

Table 4.2.

From the results (Table 4.2), a score greater than 1 indicates efficiency improvement, whereas a score less than 1 indicates deterioration over time. Also, a score of 1 indicates that there has been no change. Judging by the Malmquist index (*mi*), none of the SSA countries that made it to the top ten on the RET Table maintained their spot in the case of RETEF, and only three SSA countries made it into the top 20 list, with South Africa, Namibia, and Senegal occupying the 13th, 16th, and 20th spots, respectively. Surprisingly, DR. Congo, which ranked 1st in RET (Table 4.1), only ranked 49th in RETEF, scoring a Malmquist index (*mi*) of 0.90. Moreover, the last ten spots on the RETEF table are 70% occupied by SSA countries, which previously occupied the top 10 RET lists. On the other hand, Jordan, which had the lowest score (i.e., -0.98) on the RET table, has the highest RETEF score.

Considering that renewable energy transition efficiency is measured as the ratio of renewable energy output to renewable energy input, the reduced performance observed for the countries suggests that they use more inputs to produce less output, indicating a lower efficiency in their renewable energy systems. From a developing country's perspective, this reduced efficiency could be attributed to several factors. First, the lack of advanced technology and infrastructure can lead to inefficiencies in the generation, transmission, and distribution of renewable energy. For instance, outdated or poorly maintained equipment can result in significant energy losses. Second, the lack of skilled personnel and technical expertise can also contribute to lower efficiency. Without proper training and knowledge, the operation and maintenance of renewable energy systems can be suboptimal, leading to decreased performance.

Therefore, by comparing the RET and RETEF performance of SSA countries, one can conclude that the fact that a country is making RET progress does not mean they are progressing efficiently,

hence justifying the need for a shift from mere energy transition to energy transition efficiency.

Table 4. 2: Renewable Energy Transition Efficiency Index (2000-2019)

DMU	<i>mi</i>	<i>tc</i>	<i>pech</i>	<i>sech</i>
Jordan	1.15	0.94	1.25	0.99
Mongolia	1.12	0.93	1.00	1.20
Armenia	1.12	0.93	1.21	0.98
Egypt	1.09	0.93	1.21	0.97
Tunisia	1.07	0.93	1.14	1.00
Argentina	1.07	0.92	1.20	0.96
Mexico	1.06	0.93	1.19	0.96
Dominican Republic	1.05	0.92	1.14	1.00
Morocco	1.04	0.92	1.16	0.97
Turkey	1.03	0.93	1.16	0.95
Serbia	1.03	0.92	1.15	0.97
Bolivia	1.03	0.93	1.11	0.99
South Africa	1.03	0.93	1.16	0.95
Ecuador	1.02	0.92	1.15	0.96
Bosnia and Herzegovina	1.02	0.91	1.15	0.97
Namibia	1.01	0.93	1.10	0.99
Thailand	1.01	0.93	1.15	0.95
Colombia	1.00	0.90	1.13	0.97
Philippines	0.99	0.91	1.12	0.97
Senegal	0.99	0.93	1.05	1.01
Chile	0.99	0.92	1.12	0.95
Peru	0.98	0.92	1.11	0.97
Afghanistan	0.98	0.92	1.08	0.99
Brazil	0.98	0.92	1.10	0.97
China	0.98	0.92	1.13	0.94
Georgia	0.98	0.92	1.09	0.97
Indonesia	0.98	0.92	1.10	0.97
India	0.98	0.92	1.09	0.96
Bangladesh	0.97	0.93	1.06	0.99
Nicaragua	0.97	0.93	1.06	0.99
Sri Lanka	0.97	0.94	1.06	0.98
Burkina Faso	0.96	0.94	1.00	1.01
Cambodia	0.95	0.94	1.00	1.02
Pakistan	0.95	0.91	1.09	0.96
Ghana	0.95	0.92	1.05	0.98
Mali	0.95	0.93	1.01	1.00
Tajikistan	0.94	0.91	1.07	0.97
Cameroon	0.94	0.92	1.03	0.99
Malawi	0.94	0.92	1.02	0.99
Nigeria	0.94	0.93	1.03	0.98
Kenya	0.93	0.93	1.04	0.97

Rwanda	0.93	0.92	1.00	1.01
Zambia	0.93	0.93	1.02	0.98
Vietnam	0.93	0.92	1.08	0.94
Nepal	0.93	0.93	1.02	0.98
Tanzania	0.92	0.93	1.01	0.99
Uganda	0.90	0.93	1.00	0.98
Mozambique	0.90	0.91	1.02	0.98
DR. Congo	0.90	0.90	1.00	1.00
Ethiopia	0.89	0.93	1.00	0.95

Note: This Table (Table 4.2) contains the RETEF values, which are subsequently used as the dependent variable for the regression analysis.

Overall, the efficiency indexes of the developing countries analyzed is driven by pure efficiency change (*pech*) and in some rare instances, scale efficiency change (*sech*). Conversely, the results suggest a general deterioration in technological or technical efficiency progress (*tc*), which measures the efficiency change in technology or methods of production used in the energy transition process. The limited technical efficiency progress may suggest that the countries may lack the resources or infrastructure necessary to fully benefit from investments in renewable energy technology and research (Barykin et al., 2023; Shahbaz et al., 2021; Tabrizian, 2019). Another possible explanation is that these countries may be focusing on immediate efficiency and cost-saving gains rather than long-term investments in technology and innovation. Thus, while *pech* and *sech* can undoubtedly improve overall efficiency, they may not drive the kind of technological breakthroughs required for sustainable energy transition.

Having generated the RETEF values in Table 4.2, the study uses these RETEF values as the dependent variable of interest in the subsequent regression analysis.

3. Regression Analysis

The regression analysis emphasizes seven middle-income African nations, and ten middle-income East Asian nations studied over twenty years (2000-20019), as described in Table 4.3.

Apart from data availability being a reason for the chosen sample, the choice of SSA and East

Asian countries will allow us to assess whether the results will vary across regions with low fossil fuel dependence (i.e., SSA) and high fossil fuel dependence (East Asia) (IEA, 2020; IRENA, 2022). The literature suggests that transition efficiencies may be enhanced or hampered by the extent of fossil fuel consumption. For instance, in regions with high consumption of fossil fuels, political and economic factors (e.g., subsidies for fossil fuels) may be at play in influencing energy transition efficiency (Bridge & Gailing, 2020; Power et al., 2016). Moreover, the

3.1 Regression Model Specification and Estimation

This research incorporates two distinct models, each employing the MTNARDL estimation technique. The MTNARDL model is designed to calculate both the long-term and short-term parameters of the research model. Furthermore, it incorporates an error correction term to guarantee the long-term equilibrium of the estimated parameters. In addition, the MTNARDL model's robustness is further enhanced by its ability to handle potential non-linearities in the relationships between variables. This is particularly crucial in the nexus between EDA and RETEFF where relationships are often non-linear. Therefore, the use of the MTNARDL model not only ensures accurate parameter estimation but also enhances the reliability and validity of the research findings.

The first model examines the effect of different thresholds of EDA inflows (i.e., lower, moderate, and high thresholds) on RETEF, introducing GDP growth as a control variable. On the other hand, the second research model focuses on the moderating effect of Accounting and Governance Effectiveness (AGE) on the relationship between the highest EDA threshold and RETEF. Generally, the models can be presented as follows:

$$\text{Model I: RETEF} = f(\text{EDA}_{\varphi_1}, \text{EDA}_{\varphi_2}, \text{EDA}_{\varphi_3}, \text{GDP}) \quad (7)$$

$$\text{Model II: RETEF} = f(\text{EDA}_{\varphi_3}, \text{AGE}, \text{EDA}_{\varphi_3} * \text{AGE}, \text{GDP}) \quad (8)$$

Where φ_1 , φ_2 , and φ_3 represents low, moderate, and high EDA regimes. It is worth noting that the thresholds are different conditional quantiles of the independent variable (i.e., EDA). Decomposing EDA into different thresholds is informed by the aid dependency and absorptive capacity theories, both of which suggests that different levels of inflows of foreign aid (EDA) may produce varying effects on RETEF in the aid recipient countries.

To derive the thresholds, the study follows Li and Guo (2022), and Jalal and Gopinathan (2022). First, we divide EDA into two quantiles, involving the 30th and 70th quantiles. After this, the partial sum decomposition is used to decompose the 30th and 70th quantiles into three partial sum regime series, encompassing; (1) EDA inflows below or equal to 30th quantile, which represents very low levels of EDA inflows into aid recipient countries, (2) EDA inflows above 30th quantile but below 70th quantile, representing a moderate to high inflow of EDA, 3) EDA inflows above 70th quantile, representing extremely high dependence on EDA inflows among EDA recipient countries. These are discussed further under the MTNARDL specification below.

Also, Gross Domestic Product (GDP) is a control variable in equation 7 and 8. The level of a country's GDP can significantly influence its energy transition process. Economically prosperous countries, often indicated by higher GDP, tend to have more resources to invest in new technologies and infrastructure for energy transition (Neofytou et al., 2020; Best, 1017). They are also more likely to have a higher demand for cleaner and more efficient energy sources due to increased industrialization and urbanization. Conversely, countries with lower GDP may lack the necessary resources for such transitions. Therefore, controlling for GDP allows isolating the effect

of energy development assistance on energy transition, independent of the economic status of the countries in Sub-Saharan Africa. This ensures a more accurate and nuanced understanding of the relationship between energy development assistance and energy transition.

3.1.1 MTNARDL Model Specification

MTNARDL is an extension of the Nonlinear Autoregressive Distributed Lag Model (NARDL) proposed by Shin et al. (2014). In Shin et al.'s (2014) NARDL model, the regressor is only disintegrated into positive and negative partial sums without dividing it into different thresholds. Thus, a standard NARDL specification of Shin et al. (2014) for RETEF (EDA , GDP) will take the form below:

$$\Delta RETEF_{it} = \beta_0 + \beta 1_i RETEF_{i,t-1} + \beta 2_i^+ EDA_{i,t-1}^+ + \beta 3_i^- EDA_{i,t-1}^- + \beta 4_i GDP_{i,t-1} + \sum_{j=1}^{N1} \lambda_{ij} \Delta RETEF_{2i,t-1} + \sum_{j=1}^{N2} (\lambda_{ij} \Delta^+ EDA_{i,t-1}^+ + \lambda_{ij} \Delta^- EDA_{i,t-1}^-) + \sum_{j=1}^{N3} (\varphi_{ij} \Delta GDP_{i,t-1}) + \mu_i + \varepsilon_{i,t}$$

(9)

where EDA^+ and EDA^- represent positive and negative shocks in EDA . The shocks are calculated as positive and negative partial sum decompositions of changes. The error correction version of equation (9) would be as follows:

$$\Delta RETEF_{it} = T_i P_{i,t-1} + \sum_{j=1}^{N1} \lambda_{ij} \Delta RETEF_{2i,t-1} + \sum_{j=1}^{N2} (\lambda_{ij} \Delta^+ EDA_{i,t-1}^+ + \lambda_{ij} \Delta^- EDA_{i,t-1}^-) + \sum_{j=1}^{N3} (\varphi_{ij} \Delta GDP_{i,t-1}) + \mu_i + \varepsilon_{i,t}$$

(10)

$P_{i,t-1}$ specified in equation (10) captures the long-run equilibrium in the asymmetry panel ARDL, whereas T_i measures the speed of adjustment after deviation from long-run equilibrium.

Notwithstanding, the standard NARDL by Shin et al. (2014) does not indicate the asymmetric transmission of the regressor with major and minor fluctuations. Therefore, the MTNARDL model

offers an additional benefit by taking into account the impact of extremely high and low values of the independent variable on the dependent variable. It also detects the response of major to minor changes in the independent variable. As a result, the model is more resilient to anomalies, can more effectively capture underlying relationships between the variables, and can produce consistent results even with a small sample size (Ullah et al., 2020).

To apply the MTNARDL model, we follow procedures utilized in Li and Guo (2022), and Jalal and Gopinathan (2022). First, we introduce two thresholds of EDA at the 30th and 70th quantiles. Second, we decompose the thresholds of EDA into three partial sum regime series, as indicated below:

$$RETEF_t^i = EDA_0^i + EDA_t^i(\varphi_1) + EDA_t^i(\varphi_2) + EDA_t^i(\varphi_3) \quad (11).$$

In specification (11), $EDA_t^i(\varphi_1)$, $EDA_t^i(\varphi_2)$ and $EDA_t^i(\varphi_3)$ are three partial sums that are set at the 30th and 70th threshold quantiles of EDA. Thus, setting T_{30} , and T_{70} as the 30th and 70th quantiles, respectively, the three partial sums were derived as follows:

$$EDA_t^i(\varphi_1) = \sum_{j=1}^t \Delta EDA_j^i(\varphi_1) = \sum_{j=1}^t \Delta EDA_j^i I \{ \Delta EDA_j^i \leq T_{30} \} \quad (11a)$$

$$EDA_t^i(\varphi_2) = \sum_{j=1}^t \Delta EDA_j^i(\varphi_2) = \sum_{j=1}^t \Delta EDA_j^i I \{ T_{70} \geq \Delta EDA_j^i > T_{30} \} \quad (11b)$$

$$EDA_t^i(\varphi_3) = \sum_{j=1}^t \Delta EDA_j^i(\varphi_3) = \sum_{j=1}^t \Delta EDA_j^i I \{ \Delta EDA_j^i > T_{70} \} \quad (11c)$$

From specifications (11a), (11b), and (11c), $EDA_t^i(\varphi_1)$ is the lowest regime of EDA, which is below or equal to the 30th quantile threshold of EDA inflows. $EDA_t^i(\varphi_2)$ is the inner corridor of EDA inflows greater than the 30th quantile threshold but less than or equal to 70th threshold. $EDA_t^i(\varphi_3)$ is the higher regime of EDA inflows greater than 70th threshold. Therefore, the second regression model which interacts the highest regime of EDA with AGE can also be re-

specified as:

$$\text{RETEF}_{it} = \beta_0 + \beta_1(\text{EDA}_t^i(\varphi_3))_{it} + \beta_2\text{AGE}_{it} + \beta_3 [(\text{EDA}_t^i(\varphi_3) * \text{AGE}_{it})] + \text{GDP}_{it} + \varepsilon_{it} \quad (12).$$

Thus, from specification (12), $\beta_3 [(\text{EDA}_t^i(\varphi_3) * \text{AGE}_{it})]$ is the interaction term between the highest threshold of EDA and accounting and governance quality.

4. Preliminary Analysis

Table 4.3 describes the variables used in the regression analysis in terms of their mean values and standard deviation.

Table 4. 3: Descriptive Statistics

Country	Statistics	EDA	GDP	RETEF	AGE
<i>LMIC SSA Countries (T=19, n= 7, N=133)</i>					
Ghana	Mean	2.251	2.053	0.951	0.608
	SD	1.753	0.325	0.199	0.073
Cameroon	Mean	2.987	1.807	0.983	0.156
	SD	2.233	0.197	0.088	0.070
Kenya	Mean	4.660	1.815	0.961	0.355
	SD	1.764	0.378	0.094	0.094
Nigeria	Mean	4.146	1.855	0.981	0.202
	SD	2.559	0.800	0.062	0.342
Senegal	Mean	2.818	1.759	0.979	0.491
	SD	1.356	0.371	0.139	0.100
Tanzania	Mean	2.501	2.127	0.975	0.336
	SD	1.427	0.101	0.089	0.091
Zambia	Mean	3.923	2.029	1.025	0.247
	SD	2.094	0.321	0.305	0.120
<i>LMIC EAST ASIAN Countries (T=19, n= 10, N=170)</i>					
Bangladesh	Mean	3.796	2.087	0.930	0.211
	SD	1.666	0.129	0.067	0.056
Cambodia	Mean	3.220	2.210	0.959	0.140
	SD	2.015	0.394	0.188	0.118
India	Mean	5.962	2.129	0.947	0.674
	SD	1.380	0.224	0.030	0.077
Indonesia	Mean	4.815	1.981	0.933	0.544
	SD	1.748	0.098	0.168	0.133
Mongolia	Mean	2.560	2.059	0.973	0.470
	SD	1.375	0.712	0.151	0.113
Nepal	Mean	3.775	1.799	0.968	0.111
	SD	1.182	0.402	0.073	0.131
Pakistan	Mean	4.741	1.802	0.945	0.297

	SD	2.256	0.284	0.080	0.099
Philippines	Mean	2.970	1.992	0.965	0.714
	SD	1.487	0.255	0.171	0.075
Sri Lanka	Mean	2.869	1.807	0.974	0.615
	SD	1.910	0.749	0.093	0.064
Vietnam	Mean	3.821	2.149	0.928	0.581
	SD	1.883	0.083	0.300	0.094

Note: SD = Standard Deviation, T= number of time period, n= number of panels, N = number of observations.

Table 4.3 elucidates the descriptive statistical analysis of multiple variables, namely EDA, GDP, RETEF, and AGE, across various nations. For each nation, the table presents the arithmetic mean and standard deviation (SD) of these variables. The arithmetic mean serves as an indicator of central tendency, providing insight into the data's focal point, while the standard deviation offers a perspective on the dispersion of data around this mean. The nations are bifurcated into two distinct categories: Lower Middle-Income Sub-Saharan African (LMIC SSA) Countries and Lower Middle-Income East Asian (LMIC East Asian) Countries.

For instance, the highest mean EDA among all countries is India with 5.962, followed by Kenya with 4.660. The lowest mean EDA among all countries is Ghana with 2.251, followed by Tanzania with 2.501. The highest mean GDP among all countries is India with 2.129, followed by Indonesia with 1.981. The lowest mean GDP among all countries is Nepal with 1.799, followed by Senegal with 1.759. Similarly, the highest mean AGE among all countries is Philippines with 0.714, followed by India with 0.674. The lowest mean AGE among all countries is Nepal with 0.111, followed by Cambodia with 0.140. The SD values show how dispersed the variables are from the mean.

3.2 Unit Root Test

Just like the standard ARDL, MTNARDL applies to variables regardless of whether they are integrated of order one (I(1)) or zero (I(0)). This makes the models more flexible and expands

their applicability to a wider range of variables (Li & Guo, 2022). However, the model cannot be applied when any of the variables are beyond order one, justifying the need to assess the unit root before MTNARDL analysis. The result of the unit root test is contained in Table 4.4.

Table 4. 4: Unit Root Test

		Phillips-Perron				Augmented Dickey Fuller			
SSA SAMPLE									
At Level I(0)									
		RETEF	GOV	EDA	GDP	RETEF	GOV	EDA	GDP
Constant	t-Statistic	0.00	0.75	0.03	0.02	0.00	0.61	0.03	0.01
	Prob.	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.16
		***	***	***	n0	***	***	***	n0
Const & Trend	t-Statistic	0.00	0.04	0.01	0.02	0.00	0.04	0.01	0.02
	Prob.	0.00	0.02	0.00	0.08	0.00	0.15	0.01	0.07
		***	**	***	*	***	n0	**	*
No Cons. & Trend	t-Statistic	0.42	0.97	0.33	0.63	0.38	0.80	0.77	0.50
	Prob.	0.67	0.00	0.11	0.35	0.67	0.00	0.84	0.14
		n0	***	n0	n0	n0	***	n0	n0
At First Difference I(1)									
Cons	t-Statistic	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
	Prob.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
		***	***	***	***	***	***	***	***
Cons & Trend	t-Statistic	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.01
	Prob.	0.00	0.00	0.00	0.00	0.00	0.03	0.07	0.01
		***	***	***	***	***	**	*	**
No Cons. & Trend	t-Statistic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Prob.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		***	***	***	***	***	***	***	***
EAST ASIAN SAMPLE									
At Level									
With Constant	t-Statistic	0.04	0.47	0.34	0.02	0.04	0.44	0.02	0.02
	Prob.	0.00	0.89	0.02	0.02	0.00	0.95	0.02	0.02
		***	n0	**	**	***	n0	**	**
Cons & Trend	t-Statistic	0.10	0.44	0.03	0.18	0.10	0.44	0.03	0.11
	Prob.	0.00	0.08	0.02	0.07	0.00	0.09	0.02	0.13
		***	*	**	*	***	*	**	n0
No Cons. & Trend	t-Statistic	0.64	0.84	0.75	0.54	0.76	0.84	0.62	0.53
	Prob.	0.39	0.98	0.64	0.83	0.54	0.99	0.73	0.80
		n0	n0	n0	n0	n0	n0	n0	n0
At First Difference I(1)									
With Constant	t-Statistic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Prob.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		***	***	***	***	***	***	***	***
Cons. & Trend	t-Statistic	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.02

	Prob.	0.00 ***	0.00 ***	0.00 ***	0.00 ***	0.00 ***	0.00 ***	0.00 ***	0.00 ***
No Cons & Trend	t-Statistic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Prob.	0.00 ***	0.00 ***	0.00 ***	0.00 ***	0.00 ***	0.00 ***	0.00 ***	0.00 ***

Notes: (*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant, cons is Constant

Table 4.4 contains the results of the unit root tests using the Phillips-Perron and augmented Dickey-Fuller tests for both samples. The null hypothesis is that the time series is non-stationary or has a unit root. The alternative hypothesis is that the time series is stationary. Each test was conducted in three strands: with constants, with constants and trends, and without constants and trends. It can be observed that most of the variables were stationary at I(0) for both samples. All variables that were not stationary at I(0) became stationary at first differencing I(1). Therefore, assumptions of stationarity have been met. This provides justification for estimating the regression models.

4. Empirical Results and Discussion

4.1 The Relationship between EDA Regimes and RETEF (Model I)

We report the results of model 1 in Table 4.5 using the pooled mean group estimator. The Kao residual cointegration test confirms a long-run cointegrating relationship among the variables, allowing us to estimate the MTNARDL model (See Table 4.5). Also, the error correction term (COINTEQ01) indicates the extent and speed of adjustment to the long-run equilibrium following a shock. Our estimate of -1.541 (p-value: 0.000) shows that the model exhibits a fast and stable adjustment process.

In accordance with the studies of da Silva et al. (2018), Jaidane-Mazigh et al. (2022), and Hakeem et al. (2023), our discussion primarily centers on long-run estimates, not the short-run ones. The

study employs the pooled mean group (PMG) estimator, which enforces homogeneity in the long-run estimators but not in the short-run ones (da Silva et al., 2018; Jaidane-Mazigh et al., 2022; Hakeem et al., 2023). The PMG estimator’s capacity to permit heterogeneity in the short-run parameters while constraining the long-run coefficients to be identical across groups is particularly beneficial in this context. It offers a more accurate depiction of reality, where countries (or groups) may respond differently to changes in the short run, but they tend to converge towards a common equilibrium in the long run (da Silva et al., 2018; Jaidane-Mazigh et al., 2022; Hakeem et al., 2023). Consequently, our focus on long-run estimates enables us to identify these commonalities, providing a more robust and reliable foundation for policy recommendations. Furthermore, studies have demonstrated that phenomena such as energy transition funding policies reveal their full impact over a prolonged period, making the analysis of long-run effects more insightful and relevant (da Silva et al., 2018).

For the SSA sample, EDA within the lower regime’s range positively associates with RETEFF. Similarly, EDA within the inner corridors of the lower and upper quantiles affects RETEF positively. On the contrary, the upper regime of EDA is negatively associated with RETEF. By implication, EDA inflows up to the 70th threshold can enhance RETEF, while those above this threshold lead to inefficiencies in energy transition.

Table 4. 5 Model I Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
SSA COUNTRIES				
Long Run Equation				
GDP	-0.015	0.017	-0.887	0.381
$EDA_t^i(\varphi_3)$	-0.017	0.007	-2.554	0.0148***
$EDA_t^i(\varphi_2)$	0.066	0.020	3.356	0.0018***
$EDA_t^i(\varphi_1)$	0.019	0.006	3.098	0.0037***
Short Run Equation				

COINTEQ01	-1.541	0.329	-4.683	0.000***
D(RETEF(-1))	0.250	0.239	1.043	0.304
D(GDP)	-0.055	0.073	-0.764	0.450
D(GDP(-1))	-0.096	0.104	-0.923	0.362
$D(EDA_t^i(\varphi_3))$	-0.010	0.018	-0.547	0.588
$D(EDA_t^i(\varphi_3) (-1))$	0.030	0.029	1.028	0.311
$D(EDA_t^i(\varphi_2))$	-0.024	0.118	-0.207	0.837
$D(EDA_t^i(\varphi_2) (-1))$	-0.040	0.048	-0.829	0.412
$D(EDA_t^i(\varphi_1))$	-0.028	0.027	-1.023	0.313
$D(EDA_t^i(\varphi_1) (-1))$	0.010	0.024	0.421	0.676
Kao residual cointegration test				
ADF			2.880	0.002***
Residual Variance			0.065	
HAC variance			0.007	

EAST ASIAN COUNTRIES

	Coefficient	Std. Error	t-Statistic	Prob.*
Long Run Equation				
$EDA_t^i(\varphi_3)$	-0.020	0.010	-2.138	0.036**
$EDA_t^i(\varphi_1)$	0.020	0.010	2.050	0.044**
$EDA_t^i(\varphi_2)$	-0.011	0.015	-0.708	0.482
GDP	-0.091	0.027	-3.368	0.001***
Short Run Equation				
COINTEQ01	-1.281	0.213	-6.003	0.000***
$D(EDA_t^i(\varphi_3))$	0.007	0.018	0.419	0.677
$D(EDA_t^i(\varphi_3) (-1))$	-0.032	0.039	-0.821	0.415
$D(EDA_t^i(\varphi_1))$	-0.064	0.031	-2.069	0.043**
$D(EDA_t^i(\varphi_1) (-1))$	-0.020	0.030	-0.648	0.519
$D(EDA_t^i(\varphi_2))$	-0.084	0.094	-0.895	0.374
$D(EDA_t^i(\varphi_2) (-1))$	0.470	0.360	1.307	0.196
D(GDP)	-0.206	0.258	-0.799	0.427
D(GDP(-1))	-0.176	0.181	-0.970	0.336
Kao residual cointegration test				
ADF			2.182	0.002***
Residual Variance			0.058	
HAC variance			0.007	

Note 1: Akaike information criterion (AIC), maximum lag 2 as suggested by AIC and most parsimonious. ***, **, and * denote 0.01, 0.05, and 0.1 rejection levels, respectively.

Additionally, GDP failed to establish a significant relationship with RETEF, although the relationship was negative. The East Asia Sample showed a positive association between the lower EDA regime and RETEF; the middle regime showed an insignificant negative relationship, while the upper regime established a significant negative association. GDP growth in the East Asian

region had a significant negative effect on RETEF, contrary to the insignificant relationship observed in the SSA sample. A potential explanation is that fossil fuels underpin the economic growth of East Asian countries, which may result in a negative association between GDP growth and renewable energy transition efficiency (Hanif et al., 2019). In any case, both samples demonstrate that lower levels of EDA enhance RETEF while higher levels reduce it. Reasons for such observed relationships are discussed below:

Lower levels of development assistance may be more targeted and effectively utilized, positively impacting renewable energy transition efficiency (Fotio et al., 2022; Wang et al., 2021). At lower levels of development assistance, EDA may help to fill the critical financing, technical, and capacity gaps that are necessary for a successful renewable energy transition (Haque & Rashid, 2022; Pfeiffer & Mulder, 2013; Taibi et al., 2016; Wang et al., 2021; Wilkins, 2010). Similarly, lower levels of development assistance may less likely come with strings attached or conditions that prioritize donor interests over recipient country needs. Thus, such EDA may reflect a more demand-driven and recipient-led approach, where the recipient countries or regions identify their priorities and seek the appropriate donor support (Minasyan et al., 2017). This aligns with Kilby and Dreher's (2010) finding that aid motivated by recipient needs positively affects developmental outcomes, while aid motivated by donor interests has a negative effect.

Private sector participation in the energy transition is limited in developing countries, especially in Africa. It is possible that higher levels of EDA may “crowd out” private investment in renewable energy, leading to reduced innovation and efficiency in renewable energy development (Berthélemy, 2007; Mutenyo & Asmah, 2010; Selaya & Sunesen, 2012). Similarly, higher EDA inflows can lead to a rent-seeking mentality, in which innovation and entrepreneurship are stifled in favor of seeking government funding, hence reducing transition

efficiency (Djankov et al., 2008; Easterly, 2006; Svensson, 2000). Worse of all, rent-seeking behaviour can take various forms already prevalent in developing countries, including lobbying, corruption, patronage, or rent extraction (Moyo, 2010; Svensson, 2000). These behaviours can distort the allocation of resources, create inefficiencies, and undermine the institutions and governance systems required for an efficient energy transition (Asongu & Nwachukwu, 2016; Moyo, 2010; Svensson, 2000).

Moreover, the fiscal effects may explain why higher EDA levels may reduce RETEF (Combes et al., 2016). Large inflows of EDA can reduce governments' incentive to maintain or increase tax efforts, and in some cases, foreign aid may substitute for domestic tax revenues (Chatterjee et al., 2012; McGillivray & Morrissey, 2001; Moss et al., 2008; Teera & Hudson, 2004). This can become a disincentive to an efficient energy transition where taxes on fossil energy consumption are the casualties. For instance, reduced taxes on fossil energy use can lower the price of fossil fuels and raise their demand. This can also discourage investment in renewables, which become less competitive and appealing to investors. Such challenges can hinder the energy transition in developing countries, where fossil and carbon tax capacities are weak (UN Handbook on Carbon Taxation for Developing Countries, 2021). This can slow down the growth of renewable energy industries and hinder an efficient transition to a more sustainable energy system. It is also true that a reduction in fossil fuel taxes will increase fossil energy consumption, leading to increased energy-related emissions while defeating energy-related climate goals.

More importantly, the issue of absorptive capacity may also explain why lower to moderate levels of EDA facilitate RETEF relative to higher levels of EDA. Thus, the effectiveness of EDA in achieving RETEF may be conditioned by a country's internal institutional capacity to absorb and utilize resources (Ben Mim et al., 2022; Painuly, 2001; Yang & Park, 2020). Historically,

developing countries have been plagued by poor institutional quality, making them less capable of managing higher levels of EDA inflows (Ben Mim et al., 2022; Painuly, 2001; Xiaosong & Siyuan, 2020; Yang & Park, 2020). Mostly, developing countries receiving high levels of development assistance have weak absorptive capacity in four areas: macroeconomic, budgetary, public sector, and social capacity (Feeny & De Silva, 2012; Gray & Khan, 2006). Due to weak absorptive capacity, higher levels of EDA could challenge accountability and oversight in several ways.

First, when developing countries become overly dependent on aid, they may become less accountable to their own citizens and more accountable to donors (Findley et al., 2017; Ping et al., 2022). Such a lack of accountability increases the risk that funds allocated for renewable energy projects may be misused or diverted for other purposes. Besides, a lack of transparency resulting from a lack of accountability can make it challenging to evaluate project effectiveness, identify areas for improvement, and hold responsible parties accountable for their actions.

Moreover, where there is a lack of accountability, there may be a lack of stakeholder engagement in the renewable energy transition process. This can make it challenging to ensure that renewable energy projects are designed and implemented with the needs and priorities of local communities in mind, further exacerbating inefficiencies in the transition process.

4.2 The Interaction Effect of AGE and Higher EDA Levels (Model II)

Table 4.6 contains the results of the second model. The second model focuses on the joint effect of AGE and the highest regime of EDA on RETEF.

Table 4. 6: Model II Results

	Coefficient	Std. Error	t-Statistic	Prob.*
SSA SAMPLE				
Long Run Equation				
$EDA_t^i(\varphi_3)$	0.050	0.009	5.595	0.000***
$EDA_t^i(\varphi_3) * AGE$	0.040	0.015	2.632	0.012***
GDP	-0.317	0.035	-9.126	0.000***
AGE	0.049	0.084	0.585	0.561
Short Run Equation				
COINTEQ01	-1.138	0.293	-3.886	0.000***
$D(EDA_t^i(\varphi_3))$	-0.021	0.041	-0.509	0.614
$D(EDA_t^i(\varphi_3) (-1))$	0.033	0.023	1.415	0.164
$D(EDA_t^i(\varphi_3) * AGE)$	-0.030	0.140	-0.215	0.830
$D(EDA_t^i(\varphi_3) * AGE (-1))$	-0.137	0.042	-3.232	0.002***
D(GDP)	0.259	0.105	2.462	0.018***
D(GDP(-1))	0.268	0.152	1.764	0.085*
D(GOV)	0.247	0.622	0.396	0.694
D(GOV(-1))	0.436	0.313	1.394	0.170
C	1.973	0.538	3.667	0.001***
@TREND	-0.066	0.022	-2.967	0.005***
EAST ASIA SAMPLE				
Long Run Equation				
$EDA_t^i(\varphi_3)$	0.035	0.007	4.760	0.000***
$EDA_t^i(\varphi_3) * AGE$	0.043	0.011	4.091	0.000***
GOV	0.453	0.082	5.501	0.000***
GDP	-0.170	0.022	-7.773	0.000***
Short Run Equation				
COINTEQ01	-1.245	0.110	-11.288	0.000***
$D(EDA_t^i(\varphi_3))$	0.024	0.073	0.330	0.742
$D(EDA_t^i(\varphi_3) (-1))$	0.034	0.049	0.699	0.487
$D(EDA_t^i(\varphi_3) * AGE)$	-0.112	0.100	-1.121	0.266
$D(EDA_t^i(\varphi_3) * AGE (-1))$	-0.115	0.073	-1.578	0.119
D(GOV)	0.738	0.707	1.043	0.301
D(GOV(-1))	0.925	0.887	1.042	0.301
D(GDP)	0.051	0.222	0.230	0.819
D(GDP(-1))	0.001	0.077	0.007	0.995
C	1.598	0.181	8.818	0.000***
@TREND	-0.067	0.012	-5.749	0.000***

Note 1: Akaike information criterion (AIC), maximum lag 2 as suggested by AIC and most parsimonious. ***, **, and * denote 0.01, 0.05, and 0.1 rejection levels, respectively.

In both samples (SSA and East Asia), the long-run analysis suggests that the interaction between higher EDA levels and AGE positively affects RETEF. By implication, the effect of higher inflows of EDA on RETEF is conditioned by AGE. The result is consistent with a host of existing studies, which find that institutional quality is necessary to ensure that development assistance yields

intended outcomes (Amin et al., 2022; Balcilar et al., 2020). A major challenge with higher levels of development assistance in developing countries is the lack of focus, misallocation of resources, corruption, under-development of domestic capacity, and crowding out private investment (Amin et al., 2022; Arvin et al., 2022; Balcilar et al., 2020; Sovacool & Dworkin, 2014).

However, effective accounting and governance institutions can ensure that higher inflows of energy-related development assistance do not produce the devastating outcomes of aid dependency, as mentioned before. Effective accounting and governance institutions can provide greater transparency and reliable information on energy sector performance, costs, benefits, and risks. Besides, it can ensure accountability and oversight of energy projects and policies while promoting good governance and anti-corruption measures (Balcilar et al., 2020; Driffield & Jones, 2013; Zardoub & Sboui, 2021).

Additionally, effective governance systems can help to ensure that energy-related development assistance is used in line with the recipient country's priorities and needs, which can mitigate concerns about aid being used solely to promote the interests of the donor country (Sovacool et al., 2016; Sovacool et al., 2017). The challenge that EDA may underdevelop domestic capacity by limiting ownership, technology transfer, local business growth, and sustainability can be mitigated with the interacting effects of AGE. AGE can ensure that the decision-making process is transparent, inclusive, and participatory, allowing domestic actors to have a say in the energy transition process (Dobracev et al., 2021; Saadaoui & Chtourou, 2022; Yang & Park, 2020). This can promote local ownership, create a sense of accountability, and ensure that energy projects align with national development priorities (Hogan et al., 2022). Moreover, AGE can help build local financial management skills and create a conducive environment for domestic businesses to grow and provide goods and services for energy projects.

Notwithstanding, the results depict a negative association between GDP growth and RETEF, suggesting that growth in economic activities in SSAs may reduce RETEF. The negative effect of GDP growth on RETEF suggests that economic growth in the countries examined may have come with increased fossil energy consumption in production. This finding is consistent with the Environmental Kuznets Curve (EKC) hypothesis, which suggests that environmental degradation increases at the initial stages of economic growth but declines after a certain level of development is reached (Anwar et al., 2022; Gill et al., 2018). Thus, the sample used in this study is lower-middle-income countries at the initial stages of development, which may explain the observed negative relationship. However, the positive direct path between AGE and RETEF is insignificant, suggesting that AGE and EDA must interact with higher EDA levels to produce RETEF. The short-run analysis yielded mixed results. However, we emphasize the long-run results since the PMG estimator ensures homogeneity in the long-run estimators but not the short-run ones. Therefore, the short-run ones can vary from country to country.

5.0 Conclusions

Using a DEA and MTNARDL approach, this study examined the effect of low, moderate, and high energy development assistance (EDA) levels on renewable energy transition efficiency in recipient countries (i.e., seven Sub-Saharan and ten East Asian countries). It also examined the joint effect of higher EDA inflows and accounting and governance effectiveness (AGE) on RETEF. The study proceeded from developing an intuitive measure for renewable energy transition (RET) and using the resultant values to compute the transition efficiency index (RETEF) via the Malmquist Total Factor Productivity Index. The series generated for RETEF became the dependent variable on which EDA and AGE were regressed.

The preliminary analysis revealed that countries in the SSA region had the highest score for RET but the least for RETEF. This provides a premise to suggest that having a higher share of renewable energy in final energy consumption does not guarantee that a country's transition to renewable energy is just and efficient. Thus, shifting from mere transition to transition efficiency becomes imperative. Also, the preliminary results revealed that transition efficiency in developing countries is driven by pure efficiency change and, in some cases, scale efficiency change. However, the contribution of technical progress to transition efficiency was minimal, revealing the need for developing countries to improve the technical capacities required for an efficient energy transition. This calls for increased investment in research and development of renewable energy technologies and innovation systems to enhance the technical efficiency and productivity of energy use. Also, the need to adopt more effective policies and regulations that can stimulate technological diffusion and the adoption of best practices among different energy sectors is imperative. This can be achieved by fostering more regional cooperation and integration that can facilitate knowledge sharing, technology transfer, and market expansion for renewable energy sources.

The substantive regression analysis revealed that lower levels of EDA inflows facilitate RETEF, while higher levels reduce it. However, higher EDA levels enhance RETEF when it interacts with AGE. These results have policy implications for both providers and recipients of energy development assistance, as far as EDA, governance, and RETEF is concerned.

First, EDA providers and recipients need to prioritize EDA in the form of catalytic finance. Catalytic finance is a type of financing that is designed to catalyze additional investment in a particular sector or region. It can overcome challenges of aid dependency, such as crowding out private investment, underdevelopment of domestic capacity, and other issues that can arise when

aid is used to finance development projects. Catalytic finance from development assistance can help promote energy transition efficiency in recipient countries by providing technical assistance and concessional finance instruments to remove market barriers, build a more robust pipeline of projects, and improve the risk-return profile of individual investments. At the moment, only a handful of donors emphasize this. Within the African Region, the Sustainable Energy Fund for Africa (SEFA) is a multi-donor special fund managed by the African Development Bank and provides catalytic finance to unlock private sector investments in renewable energy and energy efficiency in Africa. We encourage other similar fund setups that target different areas of the energy transition process, such as research and development, knowledge acquisition and transfer, innovation, energy governance and accountability, among others. Thus, such catalytic schemes can help develop local capacity, improve private sector participation in energy transition, and break the vicious cycle of aid dependency.

Strengthening institutional capacities, particularly accounting and governance systems, can help recipient countries absorb higher energy development assistance (EDA) inflows without causing energy transition inefficiencies. One way to achieve this is to establish dedicated agencies to oversee the planning, budgeting, implementing, monitoring, and evaluating of renewable energy transition projects. Morocco has made progress in this area by creating the Moroccan Agency for Sustainable Energy (MASEN), which oversees the development and implementation of large-scale solar power plants, such as the Noor Ouarzazate complex, the world's largest concentrated solar power plant. Also, membership in organizations such as the International Renewable Energy Agency (IRENA) can help strengthen governance and accounting capacities by providing technical and capacity-building assistance to member countries. Accordingly, donors should provide energy development assistance in conjunction with accounting and governance

effectiveness measures. They should focus on promoting transparency and accountability in the management of funds and strengthening the governance structures and institutions that oversee the energy sector in recipient countries. This can be achieved by conducting thorough assessments of the governance and institutional capacity of the recipient country's energy sector before providing assistance. Additionally, providing technical assistance and capacity-building support to help build the recipient country's capacity to manage energy resources and infrastructure effectively, establishing clear and transparent accountability mechanisms, including regular reporting and monitoring of progress, value for money (VFM) audits, and encouraging the recipient country to adopt and implement good governance practices.

Thirdly, as part of the governance arrangements for EDA, it is important for EDA providers to coordinate and collaborate to align their objectives, policies, and practices regarding the energy transition of recipient countries. Currently, both bilateral and multilateral sources provide EDA to developing nations. However, without proper coordination among these donors, aid proliferation into recipient countries can lead to duplication, fragmentation, and inconsistencies in the energy transition process (Lawson, 2013). This problem has been long-standing, as Whittington and Calhoun (1988: p. 296) argued more than 20 years ago that uncoordinated aid is "at least partly responsible for the failure of African economies to utilize their development assistance effectively." As part of governance arrangements, donor coordination can help enhance synergy, complementarity, and the innovation required for an efficient energy transition. Grantcraft, San Diego Grantmakers, and Bridgespan are popular collaboration models for coordinating donor activities. However, there are long-standing challenges to applying these models.

Interviews conducted by McCormick and Schmitz (2011, p. 162) in Kenya and Indonesia

revealed that “the move to coordinate had shifted the burden of transaction costs from government to the donors, and some donor’s tendency to want their own projects have led to competition and duplication.” McCormick and Schmitz (2011) also revealed that donors do not want to give up their right to autonomous action, and despite the rhetoric of ‘partnership’, the national interests of donors are paramount. Following these challenges, we recommend Bridgespan’s extended model of fund- the-funder coordination strategy. The fund-the-funder approach is an integrated collaboration mechanism involving a re-granting organization in which more than one donor invests in another donor with expertise in a specified area. In this scenario, all competing interests will be addressed at the funder level, and the funder with the most expertise in the chosen area of energy transition takes charge of making the grants to recipient countries. This can reduce the risk of fragmentation and duplication in recipient countries, reduce coordination costs, and improve energy transition efficiency.

Moreover, positive outcomes of energy development assistance on energy transition efficiency can be enhanced by developing and maintaining an energy transition plan coherent with long-term climate targets. An energy transition plan can enable recipient countries to leverage more from energy development assistance by allowing them to evaluate their own requirements (e.g., human resources, domestic capacity, financial resources, private investments, domestic fiscal capacity for energy, governance) for energy transition. This can empower them to solicit suitable support from the donors and execute solutions that are customized to their specific context. An awareness of these factors can also promote a more demand-driven and recipient-led approach, where the recipient countries or regions assume responsibility for their own energy transition process and cooperate with the donors as partners rather than passive beneficiaries. Furthermore, coherence between energy transition targets and long-term climate targets can also help guarantee

that the transition conforms to global initiatives to mitigate climate change, which is vital for attaining a sustainable energy future.

Finally, developing nations should engage in regional and international cooperation and knowledge sharing to learn from best practices and leverage synergies concerning EDA and RETEF. This recommendation is supported by the Clean Energy Ministerial (CEM), a global forum of energy ministers from different economies aiming to promote policies and programs that advance clean energy technology development and deployment. The CEM also facilitates collaboration among governments, private sector actors, civil society organizations, research institutions, and international organizations to accelerate clean energy transitions. India, for instance, has joined several CEM initiatives, such as the Clean Energy Solutions Center, the Global Lighting Challenge, the Power System Flexibility Campaign, and the International Solar Alliance. These networks help to build local capacity for energy transition while aligning energy transition goals with global carbon action goals.

This scientific research is not without limitations. Our sample for the regression analysis only captures middle-income developing countries in Asia and the Sub-Saharan African region. Therefore, our sample does not cover the least developed countries in the developing world; hence, generalization of the research findings should be made with caution. Additionally, our interaction of accounting and governance effectiveness does not specify the threshold of effectiveness required to produce energy transition efficiency. Besides, our renewable energy transition efficiency measurement is determined by our selection of inputs and outputs for the DEA analysis. Hence, the interpretation of the study's findings should be guided accordingly. Also, another interesting area requiring research attention is the nexus between dependence on energy development assistance and the fossil tax capacity of recipient countries since aid-

dependent countries may substitute foreign aid with domestic tax revenues.



CHAPTER FIVE

CONCLUSION



5.1 Overview

The main purpose of this research is to investigate the role of policy instruments (i.e., carbon taxes and environmentally related taxes), financial assistance (energy development aid), and governance quality in facilitating the energy transition agenda of SDG 7. The research purpose is decomposed into three related study objectives, where each objective is represented by a research paper. The main motivation of the study stems from the environmental and social problems emanating from the harmful effects of greenhouse gas emissions globally. Considering that energy consumption accounts for more than two-thirds of global GHG emissions, there have been recent calls for a shift from unclean energy consumption to cleaner sources, especially renewable energy (e.g., solar and hydropower). Also, there have been calls for a shift toward energy-efficient technologies that require a relatively lesser amount of energy consumption to produce the same energy service. These two pathways (i.e., energy efficiency and clean energy adoption) are together called the energy transition pathways.

Energy transition is essential for achieving the Sustainable Development Goals (SDGs), especially SDG 7 on affordable and clean energy and SDG 13 on climate action. However, it faces many challenges, such as financing, governance, and accounting. In terms of financing challenges, developed nations mainly address them through carbon pricing mechanisms such as carbon taxation, with expectations that carbon taxes can reduce energy-related CO₂ emissions, improve energy intensity, improve renewable energy adoption, and achieve overall welfare gains. On the other hand, developing countries primarily do not have such carbon taxes and rely on energy development assistance and general environmentally related taxes. Therefore, using three research articles, this thesis explores the interplay of environmental tax policy, energy development assistance, and governance quality in promoting sustainable energy transition.

Chapter Two (i.e., Paper 1) of the thesis examined the effect of carbon tax policy adoption on energy-related environmental and socio-economic outcomes in the EU, using a quasi-experimental design. The chapter utilized data from 23 EU nations, eight of which had enforced a carbon tax policy by 2019. The paper measured the energy-related environmental outcome of carbon tax policy using three indicators: CO₂ emissions per energy consumption, energy consumption per GDP output, and renewable energy capacity. The paper also measured the socio-economic dividend of carbon tax policy using the human development index. The findings reveal that carbon tax policy significantly reduces CO₂ emissions per unit of energy consumed and energy consumption per unit of GDP output. Also, it significantly enhances renewable energy capacity and the Human Development Index. The study also uncovers that the effect is more pronounced in nations that have consistently enforced carbon taxes compared to those that have never done so. In conclusion, the paper asserts that carbon tax policies can yield both environmental and socio-economic benefits in the EU. It advocates for broader adoption and harmonization of carbon taxes not only within the EU but also globally.

Chapter Three (i.e., Paper 2) examined the effect of renewable energy aid and governance quality on the environmental tax efforts of Sub-Saharan African countries. It uses panel data from 15 countries over 20 years and employs instrumental variable regression techniques to estimate statistical relationships. The paper finds that renewable energy aid has heterogeneous effects on environmental tax efforts, depending on the income level and the environmental domain. Specifically, it finds that renewable energy aid reduces climate change tax effort but increases air pollution tax effort and aggregate environmental tax effort among middle-income countries, while it negatively impacts all three categories of environmental tax efforts among low-income countries. It also finds that governance quality has a positive effect on all categories of environmental tax

efforts analyzed. The paper contributes to the literature by focusing on energy development assistance and environmental taxation, which have not been empirically studied before. It also provides policy implications for enhancing environmental tax mobilization and energy transition in Sub-Saharan Africa.

The Fourth Chapter (i.e., Paper 3) investigates how energy development assistance (EDA) affects the efficiency of energy transition (RETEF) in developing countries and how accounting and governance effectiveness (AGE) influence this relationship. The paper uses a multiple threshold nonlinear ARDL (MTNARDL) technique to examine the nonlinear effects of different regimes of EDA inflows (i.e., extremely low, moderate, and high) on RETEF and the interacting role of AGE in this relationship. The paper analyzes data from 17 sub-Saharan African countries over a period of 20 years (2000–2019). The paper finds that lower to moderate levels of EDA inflows (i.e., below or equal to 70% quantile) enhance RETEF, while higher levels (i.e., above 70% quantile) reduces it. However, this negative effect is mitigated when higher levels of EDA inflows are moderated by AGE. The paper also finds that most developing countries have made low technical progress in the transition to renewable energy, implying a lack of technological innovation and adoption.

5.2 Summary of Policy Implications

5.2.1 Chapter Two (Paper 1) Policy Implications

From the first paper, carbon taxes have significant environmental and socio-economic benefits, such as reducing CO₂ emissions per energy consumption, improving energy efficiency, increasing renewable energy adoption, and enhancing human development. These benefits are stronger in the long run, indicating that carbon taxes can promote a sustainable and just energy transition. Regardless of carbon tax's effectiveness, practical evidence indicates that not only do EU carbon taxes

differ significantly in rates, coverage, and design across EU countries, but also that these carbon tax rates are considerably lower than what is necessary for a sustainable energy transition. Consequently, the study makes the following policy recommendations to enhance the effectiveness of carbon tax policy as far as energy transition is concerned:

1. **Establishing a Minimum Carbon Tax Rate:** To ensure a sustainable energy transition, it is crucial to establish a minimum carbon tax rate across all EU countries. This will set a baseline for carbon pricing, encouraging industries to reduce their CO₂ emissions and invest in cleaner technologies. The rate should be high enough to have a significant impact on emission reduction, but also consider the economic realities of different countries. A starting point is for EU policymakers and stakeholders to revise and align their carbon tax rates to reflect the minimum level suggested by the High-Level Commission on Carbon Prices (2017). However, the minimum rate should also consider the different income levels and energy mixes of each country and allow for some flexibility and exemptions for the most vulnerable sectors and regions.
2. **Broadening the Coverage of the Tax:** Currently, the carbon tax does not apply uniformly across all sectors. To maximize its effectiveness, the tax should be expanded to cover all major sources of CO₂ emissions, including sectors that are currently exempt or under-taxed. This will ensure that all sectors contribute fairly to the reduction of CO₂ emissions. For example, the EU could extend the carbon tax to cover sectors that are not currently regulated by carbon tax policy, such as agriculture, waste, and transport. According to statistics by the European Commission, such an extension would increase the share of greenhouse gas emissions covered by the tax from 35% to 60%.

3. **Harmonizing the Tax Design:** Currently, the design of the carbon tax varies significantly across EU countries, leading to inconsistencies and inefficiencies. A harmonized carbon tax design refers to a uniform application of the carbon tax across all sectors and regions. This uniformity simplifies compliance for businesses, reduces the risk of carbon leakage (where businesses relocate to regions with lower or no carbon taxes), ensures fairness by treating all emitters equally, and enhances efficiency by avoiding the administrative complexity of managing varying tax rates and rules. For example, the EU could adopt a common methodology for calculating the carbon content of different products and materials based on their life cycle emissions. This would ensure that the tax reflects the true environmental impact of each product and avoids double taxation or under taxation. The EU could also harmonize the exemptions and rebates for low-carbon technologies and energy-intensive industries to avoid distorting competition and innovation.
4. **Implementing Carbon Border Adjustment Mechanism (CBAM):** The CBAM is a tool designed to prevent carbon leakage by levying charges on imported goods based on their carbon content. Implementing CBAM will ensure that businesses cannot evade carbon taxes by relocating to countries with less stringent climate policies. For example, the EU could apply CBAM to imports of steel, cement, aluminum, chemicals, and electricity, which are among the most carbon-intensive sectors. This would require importers to pay a carbon charge equivalent to the carbon price paid by EU producers. This would prevent foreign producers from gaining an unfair advantage over EU producers and encourage them to reduce their emissions.

5. **Regular Review and Adjustment:** The effectiveness of the carbon tax should be regularly reviewed and adjusted as necessary to reflect changes in scientific understanding, technological advancements, and economic conditions. This will ensure that the tax continues to drive a sustainable energy transition. For example, the EU could review and adjust the carbon tax rate every year, based on the latest scientific evidence and market conditions. This would ensure that the tax remains aligned with the EU's climate targets and reflects the changing costs and benefits of emission reduction. The EU could also monitor and evaluate the impacts of the tax on economic growth, social equity, environmental quality and introduce corrective measures if needed.
6. **Using Carbon Tax Revenues:** The revenues from the carbon tax could be used to fund renewable energy projects, similar to what Germany has done with its Energiewende initiative. Additionally, part of these revenues could be redistributed to citizens to offset any increases in energy costs, similar to the model used in Switzerland.

Additionally, Chapter Two (Paper 1) revealed that in the EU, the effect of carbon tax policies on energy efficiency measures of energy transition (i.e., CO₂ emissions, and energy intensity) was stronger than its effect on renewable energy adoption. In practical terms, this means that companies and individuals in the EU might respond more to carbon taxes by improving their energy efficiency and reducing their CO₂ emissions rather than by adopting renewable energy sources. Therefore, additional incentives or regulations might be needed to encourage the adoption of renewable energy sources.

Policymakers could introduce complementary policies that specifically target renewable energy adoption. These could include subsidies for renewable energy projects, feed-in tariffs, or

renewable portfolio standards. For instance, the subsidies can target households and businesses that adopt renewable energy sources such as solar panels or wind turbines. This will encourage more people to adopt renewable energy sources and reduce their reliance on fossil fuels. Also, more investment might be needed in renewable energy infrastructure. This could involve funding for research and development, grid upgrades, or public investment in renewable energy projects.

On the other hand, policymakers may consider implementing carbon tax policies that incentivize energy efficiency measures. The revenue generated from carbon taxes can be used to fund research and development of clean energy technologies, which can further promote the adoption of renewable energy. The role of public awareness and education is also relevant. If the public is more aware of the benefits of renewable energy and the impact of carbon emissions on climate change, they might be more willing to support policies that promote renewable energy adoption.

5.2.2 Chapter Three (Paper 2) Policy Implications

First, the study suggests that renewable energy aid can have different effects on environmental tax efforts depending on the income level and the environmental domain of the recipient country. Therefore, policymakers should carefully consider the potential trade-offs and complementarities between foreign aid and domestic resource mobilization when designing and implementing environmental tax policies. For instance, low-income countries may need to strengthen their fiscal capacity and tax administration to avoid the crowding-out effect of energy aid on their environmental tax efforts. On the other hand, middle-income countries may need to align their energy aid objectives with their environmental tax objectives to ensure coherence and synergy.

Second, Chapter Three of the study highlights the importance of governance quality in enhancing

environmental tax efforts in Sub-Saharan Africa. Governance quality can improve tax morale, public service delivery, fiscal transparency and accountability, and tax administration capacity, which are all essential for increasing the willingness and ability of taxpayers to contribute to the public good. Therefore, policymakers should prioritize improving governance quality by reducing corruption, strengthening the rule of law, enhancing voice and accountability, and ensuring regulatory quality. Importantly, providers of energy foreign assistance can make aid provision conditional upon recipient countries' commitment to improve their governance quality. This will force aid recipients to strengthen their governance institutions to continue receiving aid.

5.2.3 Chapter Four (Paper 3) Policy Implications

First, paper three suggests that the level of energy development assistance (EDA) received by a country can have different effects on renewable energy transition efficiency (RETEF). Therefore, policymakers should carefully assess the optimal level of EDA that can support their energy transition goals without creating dependency or inefficiency problems. Second, it indicates that higher EDA inflows can be beneficial for RETEF if they are accompanied by effective accounting and governance mechanisms that ensure transparency, accountability, participation, and alignment of interests between donors and recipients. Thus, policymakers should strengthen their institutional capacity and implement reforms that foster good governance practices in the energy sector, such as independent audits, stakeholder engagement, anti-corruption initiatives, and fair market competition. Third, it highlights the need for technological innovation and human capital development in renewable energy transition, as these factors can enhance the productivity and competitiveness of renewable energy sources and services.

Therefore, policymakers should invest more in the research and development of renewable energy technologies, as well as in the education and training of renewable energy experts and professionals. By doing so, policymakers can facilitate the transition to a low-carbon economy that is resilient, inclusive, and sustainable. Fourth, this study recommends the use of catalytic finance mechanisms by donors to leverage private investment in renewable energy projects. This can help overcome market barriers and reduce the risks associated with investing in renewable energy, particularly in developing countries.

Finally, this study recommends closer collaboration among donors in their support for the transition to renewable energy. This can help avoid duplication of energy aid, increase its effectiveness, and ensure that resources are allocated where they are most needed. Donors can collaborate by sharing information, coordinating their interventions, and aligning their strategies and priorities. By doing so, policymakers can accelerate the transition to a low-carbon economy and address the larger challenges of climate change and energy security.

5.3 Key theoretical contributions of the study

This study makes significant theoretical contributions to the fields of environmental economics and development studies, particularly in the areas of environmental double dividends theory and aid dependency theory.

Firstly, the research advances the environmental double dividends theory by addressing a critical gap in its measurement and application. Traditionally, the second dividend of this theory has been assessed using purely economic indicators, often yielding contradictory results. Responding to calls from scholars such as Faccioli et al. (2022) and Silva et al. (2021) for a more comprehensive

approach, this study introduces a novel measurement framework. By employing the Human Development Index (HDI) to gauge the second dividend, the research incorporates both economic and social dimensions. This multifaceted approach provides a more holistic view of the benefits derived from environmental taxation, moving beyond narrow economic metrics to capture broader societal impacts.

Secondly, the study makes a substantial contribution to the aid dependency theory by proposing and testing a more nuanced model of aid effects. Rather than treating aid as a monolithic factor, this research disaggregates it into lower, moderate, and higher thresholds. This approach challenges the assumption of a linear relationship between aid and its impacts on recipient countries. By doing so, the study offers a more sophisticated understanding of how different levels of aid may produce varying outcomes, potentially resolving some of the contradictions found in previous research on aid effectiveness.

Furthermore, the research extends the aid dependency theory by introducing an interaction between higher levels of aid inflows and institutional capacity on governance. This modification represents a significant theoretical advancement, as it acknowledges the complex interplay between external assistance and domestic governance structures. By exploring how institutional quality mediates the effects of substantial aid inflows, the study provides new insights into the conditions under which aid may be more or less effective in promoting development outcomes.

The integration of these theoretical advancements offers a more comprehensive framework for understanding the dynamics of sustainable energy transitions in developing countries. By combining insights from environmental economics and development studies, the research bridges

disciplinary boundaries and provides a more holistic perspective on the challenges and opportunities in promoting sustainable development.

Moreover, these theoretical contributions have important implications for policy design and implementation. The refined understanding of the double dividend effect, incorporating social dimensions through the HDI, can inform more effective and equitable environmental taxation policies. Similarly, the nuanced approach to aid dependency theory can guide international donors and recipient countries in structuring aid programs that are more likely to achieve their intended outcomes without creating harmful dependencies.

5.4 Limitations of the Thesis

First, in paper one, the study focuses only on the human development index (HDI) as the sole measure of the socio-economic impact of carbon taxation, but there may be other important indicators that are not considered, such as inequality.

In paper two, the study has focused only on energy-related environmental taxes, which may not capture the full spectrum of environmental taxation in the region.

In paper three, the sample captures 15 developing countries due to the non-availability of data. This may limit the extent of generalization.

5.5 Directions for Further Studies

1. In paper 1, future research could try to address the potential issue of unobserved factors affecting the validity of estimates by using alternative methods, such as instrumental variable regression. Additionally, expanding the scope of the study to include other important indicators such as inequality or innovation could provide a more comprehensive understanding of environmental and socio-economic performance of environmental taxes.

2. In paper 2, future research could expand the focus to include other forms of environmental taxation beyond energy-related taxes. Additionally, disaggregating energy aid based on the energy source (e.g., solar, hydropower) can provide insights into the nexus between energy aid and taxation

3. In paper 3, future research could disaggregate renewable energy aid to examine the heterogeneous effects of various kinds of energy development assistance on energy transition. For example, researchers could compare the effects of grants versus loans or aid for solar energy versus wind energy. Additionally, examining other factors that may influence renewable energy transition efficiency, such as environmental regulations, social acceptance, technological innovation, and market competition, could provide a more comprehensive understanding of the topic.



REFERENCES

- Abbas, S., Ahmed, Z., Sinha, A., Mariev, O., & Mahmood, F. (2023). Toward fostering environmental innovation in OECD countries: Do fiscal decentralization, carbon pricing, and renewable energy investments matter?. *Gondwana Research*.
- Abdenur A. (2023). What does Just Transition mean for Middle Income Countries? United Nation. <https://www.un.org/en/climatechange/what-does-just-transition-mean-middle-income-countries>.
- Abdi, A. H. (2023). Toward a sustainable development in sub-Saharan Africa: do economic complexity and renewable energy improve environmental quality?. *Environmental Science and Pollution Research*, 1-17.
- Abokyi, E., Appiah-Konadu, P., Abokyi, F., & Oteng-Abayie, E. F. (2019). Industrial growth and emissions of CO₂ in Ghana: The role of financial development and fossil fuel consumption. *Energy Reports*, 5, 1339-1353.
- Abou-Zaid, A., Alghamdi, M., Alabdulwahab, S., & Shahawy, S. A. (2023). Does foreign aid promote growth? Evidence from Africa. *African Journal of Economic and Sustainable Development*, 9(2), 116-137.
- Acht, M., Mahmoud, T. O., & Thiele, R. (2015). Corrupt governments do not receive more state-to-state aid: Governance and the delivery of foreign aid through non-state actors. *Journal of Development Economics*, 114, 20-33.
- Adebayo, T. S., & Beton Kalmaz, D. (2020). Ongoing debate between foreign aid and economic growth in Nigeria: a wavelet analysis. *Social Science Quarterly*, 101(5), 2032-2051.
- Adebayo, T. S., Ağa, M., & Kartal, M. T. (2023). Analyzing the co-movement between CO₂ emissions and disaggregated nonrenewable and renewable energy consumption in BRICS: evidence through the lens of wavelet coherence. *Environmental Science and Pollution Research*, 30(13), 38921-38938.
- Adedokun, A. J. (2017). Foreign aid, governance and economic growth in sub-Saharan Africa: Does one cap fit all?. *African Development Review*, 29(2), 184-196.
- Aggarwal, R., Ayhan, S., Jakob, M., & Steckel, J. C. (2021). Carbon Pricing and Household Welfare: Evidence from Uganda. *Duke Global Working Paper Series No. 38*
- Ahmad, M., Ahmed, Z., Riaz, M., & Yang, X. (2023). Modeling the linkage between climate-tech, energy transition, and CO₂ emissions: Do environmental regulations matter?. *Gondwana Research*.
- Ahmed, N., Sheikh, A. A., Hamid, Z., Senkus, P., Borda, R. C., Wysokińska-Senkus, A., & Glabiszewski, W. (2022). Exploring the causal relationship among green taxes, energy intensity, and energy consumption in nordic countries: Dumitrescu and Hurlin causality approach. *Energies*, 15(14), 5199.
- Ahonen, H. M., Kessler, J., Michaelowa, A., Espelage, A., & Hoch, S. (2022). Governance of fragmented compliance and voluntary carbon markets under the Paris Agreement. *Politics and Governance*, 10(1), epub.
- Ajaz, T., & Ahmad, E. (2010). The effect of corruption and governance on tax revenues. *The Pakistan Development Review*, 49(4), 405-417.
- Ajide, F. M. (2021). Shadow economy in Africa: how relevant is financial inclusion?. *Journal of Financial Regulation and Compliance*, 29(3), 297-316.
- Akitoby, B., Baum, A., Hackney, C., Harrison, O., Primus, K., & Salins, V. (2020). Tax revenue mobilization episodes in developing countries. *Policy Design and Practice*, 3(1), 1-29. <https://doi.org/10.1080/25741292.2019.1685729>
- Akrofi, M. M. (2021). An analysis of energy diversification and transition trends in Africa. *International Journal of Energy and water resources*, 5(1), 1-12.

- Al Shammre, A. S., Benhamed, A., Ben-Salha, O., & Jaidi, Z. (2023). Do Environmental Taxes Affect Carbon Dioxide Emissions in OECD Countries? Evidence from the Dynamic Panel Threshold Model. *Systems*, 11(6), 307.
- Alemu, A. M., & Lee, J. S. (2015). Foreign aid on economic growth in Africa: a comparison of low and middle-income countries. *South African Journal of Economic and Management Sciences*, 18(4), 449-462.
- Alesina, A., & Dollar, D. (2000). Who gives foreign aid to whom and why?. *Journal of economic growth*, 5, 33-63.
- Alia, D. Y., & Anago, R. E. K. (2014). Foreign aid effectiveness in African economies: Evidence from a panel threshold framework (No. 2014/015). WIDER Working Paper.
- Alm, J., Martinez-Vazquez, J., & Schneider, F. (2019). Taxing the shadow economy: The role of tax administration. *Public Finance Review*, 47(6), 1027-1057.
- Al-Mulali, U., Sab, C. N. B. C., & Fereidouni, H. G. (2012). Exploring the bi-directional long run relationship between urbanization, energy consumption, and carbon dioxide emission. *Energy*, 46(1), 156-167.nio
- Alola, A. A., & Nwulu, N. (2022). Do energy-pollution-resource-transport taxes yield double dividend for Nordic economies?. *Energy*, 254, 124275.
- Abbas, S., Ahmed, Z., Sinha, A., Mariev, O., & Mahmood, F. (2023). Toward fostering environmental innovation in OECD countries: Do fiscal decentralization, carbon pricing, and renewable energy investments matter?. *Gondwana Research*.
- Abdenur A. (2023). What does Just Transition mean for Middle Income Countries? United Nation.<https://www.un.org/en/climatechange/what-does-just-transition-mean-middle-income-countries>.
- Abdi, A. H. (2023). Toward a sustainable development in sub-Saharan Africa: do economic complexity and renewable energy improve environmental quality?. *Environmental Science and Pollution Research*, 1-17.
- Abokyi, E., Appiah-Konadu, P., Abokyi, F., & Oteng-Abayie, E. F. (2019). Industrial growth and emissions of CO₂ in Ghana: The role of financial development and fossil fuel consumption. *Energy Reports*, 5, 1339-1353.
- Abou-Zaid, A., Alghamdi, M., Alabdulwahab, S., & Shahawy, S. A. (2023). Does foreign aid promote growth? Evidence from Africa. *African Journal of Economic and Sustainable Development*, 9(2), 116-137.
- Acht, M., Mahmoud, T. O., & Thiele, R. (2015). Corrupt governments do not receive more state-to-state aid: Governance and the delivery of foreign aid through non-state actors. *Journal of Development Economics*, 114, 20-33.
- Adebayo, T. S., & Beton Kalmaz, D. (2020). Ongoing debate between foreign aid and economic growth in Nigeria: a wavelet analysis. *Social Science Quarterly*, 101(5), 2032-2051.
- Adebayo, T. S., Ağa, M., & Kartal, M. T. (2023). Analyzing the co-movement between CO₂ emissions and disaggregated nonrenewable and renewable energy consumption in BRICS: evidence through the lens of wavelet coherence. *Environmental Science and Pollution Research*, 30(13), 38921-38938.
- Adedokun, A. J. (2017). Foreign aid, governance and economic growth in sub-Saharan Africa: Does one cap fit all?. *African Development Review*, 29(2), 184-196.
- Aggarwal, R., Ayhan, S., Jakob, M., & Steckel, J. C. (2021). Carbon Pricing and Household Welfare: Evidence from Uganda. *Duke Global Working Paper Series No. 38*
- Ahmad, M., Ahmed, Z., Riaz, M., & Yang, X. (2023). Modeling the linkage between climate-tech, energy transition, and CO₂ emissions: Do environmental regulations matter?. *Gondwana Research*.
- Ahmed, N., Sheikh, A. A., Hamid, Z., Senkus, P., Borda, R. C., Wysokińska-Senkus, A., & Glabiszewski, W. (2022). Exploring the causal relationship among green taxes, energy intensity, and energy consumption in nordic countries: Dumitrescu and Hurlin causality approach. *Energies*, 15(14),

5199.

- Ahonen, H. M., Kessler, J., Michaelowa, A., Espelage, A., & Hoch, S. (2022). Governance of fragmented compliance and voluntary carbon markets under the Paris Agreement. *Politics and Governance*, 10(1), epub.
- Ajaz, T., & Ahmad, E. (2010). The effect of corruption and governance on tax revenues. *The Pakistan Development Review*, 49(4), 405-417.
- Ajide, F. M. (2021). Shadow economy in Africa: how relevant is financial inclusion?. *Journal of Financial Regulation and Compliance*, 29(3), 297-316.
- Akitoby, B., Baum, A., Hackney, C., Harrison, O., Primus, K., & Salins, V. (2020). Tax revenue mobilization episodes in developing countries. *Policy Design and Practice*, 3(1), 1-29. <https://doi.org/10.1080/25741292.2019.1685729>
- Akrofi, M. M. (2021). An analysis of energy diversification and transition trends in Africa. *International Journal of Energy and water resources*, 5(1), 1-12.
- Al Shammre, A. S., Benhamed, A., Ben-Salha, O., & Jaidi, Z. (2023). Do Environmental Taxes Affect Carbon Dioxide Emissions in OECD Countries? Evidence from the Dynamic Panel Threshold Model. *Systems*, 11(6), 307.
- Alaali, F., & Alshahrani, A. (2022). The impact of governance and corruption on the effectiveness of foreign aid: Evidence from developing countries. *International Journal of Finance & Economics*, 27(1), 941-957.
- Alemu, A. M., & Lee, J. S. (2015). Foreign aid on economic growth in Africa: a comparison of low and middle-income countries. *South African Journal of Economic and Management Sciences*, 18(4), 449-462.
- Alesina, A., & Dollar, D. (2000). Who gives foreign aid to whom and why?. *Journal of economic growth*, 5, 33-63.
- Alia, D. Y., & Anago, R. E. K. (2014). Foreign aid effectiveness in African economies: Evidence from a panel threshold framework (No. 2014/015). WIDER Working Paper.
- Alm, J., Martinez-Vazquez, J., & Schneider, F. (2019). Taxing the shadow economy: The role of tax administration. *Public Finance Review*, 47(6), 1027-1057.
- Al-Mulali, U., Sab, C. N. B. C., & Fereidouni, H. G. (2012). Exploring the bi-directional long run relationship between urbanization, energy consumption, and carbon dioxide emission. *Energy*, 46(1), 156-167.nio
- Alola, A. A., & Nwulu, N. (2022). Do energy-pollution-resource-transport taxes yield double dividend for Nordic economies?. *Energy*, 254, 124275.
- Aluko, O. A. (2020). The foreign aid–foreign direct investment relationship in Africa: The mediating role of institutional quality and financial development. *Economic affairs*, 40(1), 77-84.
- Amin, A., Ameer, W., Yousaf, H., & Akbar, M. (2022). Financial development, institutional quality, and the influence of various environmental factors on carbon dioxide emissions: exploring the nexus in China. *Frontiers in Environmental Science*, 9, 755.
- Amin, G. R., & Toloo, M. (2007). Finding the most efficient DMUs in DEA: An improved integrated model. *Computers & Industrial Engineering*, 52(1), 71-77.
- Ammendola, G. (2010). *Dead Aid: Why Aid Is Not Working and How There Is a Better Way for Africa by Dambisa Moyo The Aid Trap: Hard Truths About Ending Poverty by R. Glenn Hubbard and William Duggan: New York: Farrar, Straus & Giroux (2009), 24.00Hardcover,208pagesNewYork: ColumbiaBusinessSchoolPublishing(2009), 22.95 Hardcover, 212 pages.*
- Andersson, J. J. (2019). Carbon taxes and CO2 emissions: Sweden as a case study. *American Economic Journal: Economic Policy*, 11(4), 1-30.
- Andrew, J., Kaidonis, M. A., & Andrew, B. (2010). Carbon tax: Challenging neoliberal solutions to climate change. *Critical perspectives on accounting*, 21(7), 611-618.
- Anwar, M. A., Zhang, Q., Asmi, F., Hussain, N., Plantinga, A., Zafar, M. W., & Sinha, A. (2022). Global

- perspectives on environmental kuznets curve: A bibliometric review. *Gondwana Research*, 103, 135-145.
- Arif, I., & Rawat, A. S. (2018). Corruption, governance, and tax revenue: evidence from EAGLE countries. *Journal of Transnational Management*, 23(2-3), 119-133.
- Arvin, M. B., Pradhan, R. P., Nair, M. S., & Dabir-Alai, P. (2022). Exploring the temporal links between foreign aid, institutional quality, and CO2 emissions for poorer countries. *Energy and Buildings*, 270, 112287.
- Asongu, S. A., & Nwachukwu, J. C. (2016). Foreign aid and governance in Africa. *International Review of Applied Economics*, 30(1), 69-88.
- Asongu, S., & Jellal, M. (2016). Foreign aid fiscal policy: theory and evidence. *Comparative Economic Studies*, 58(2), 279-314.
- Awasthi, R., & Engelschalk, M. (2018). Taxation and the shadow economy: How the tax system can stimulate and enforce the formalization of business activities. *World Bank Policy Research Working Paper No. 8391*.
- Aydin, C., & Esen, Ö. (2018). Reducing CO2 emissions in the EU member states: Do environmental taxes work?. *Journal of Environmental Planning and Management*, 61(13), 2396-2420.
- Azam, M., Hunjra, A. I., Bouri, E., Tan, Y., & Al-Faryan, M. A. S. (2021). Impact of institutional quality on sustainable development: Evidence from developing countries. *Journal of Environmental Management*, 298, 113465
- Azhgaliyeva, D., Liu, Y., & Liddle, B. (2020). An empirical analysis of energy intensity and the role of policy instruments. *Energy Policy*, 145, 111773.
- Baker, E. D. (2022b). A just energy transition requires research at the intersection of policy and technology. *PLOS Climate*, 1(10), e0000084.
- Baker, L. (2022a). *The Political Economy of South Africa's Carbon Tax*. Institute of Development Studies.
- Balasubramaniam, D. (2023). Children's linear growth and mother's education in India: Do the pathways have a role to play?.
- Balcilar, M., Tokar, B., & Godwin, O. W. (2020). Examining the interactive growth effect of development aid and institutional quality in Sub-Saharan Africa. *Journal of Development Effectiveness*, 12(4), 361-376.
- Banerjee, R., Mishra, V., & Maruta, A. A. (2021). Energy poverty, health and education outcomes: evidence from the developing world. *Energy economics*, 101, 105447.
- Barros, V., Jalles, J. T., & Sarmiento, J. M. (2023). Drivers of the tax effort: evidence from a large panel. *Comparative Economic Studies*, 65(1), 96-136.
- Bartolomeo, M., Bennett, M., Bouma, J. J., Heydkamp, P., James, P., & Wolters, T. (2000). Environmental management accounting in Europe: current practice and future potential. *European Accounting Review*, 9(1), 31-52.
- Barykin, S. E., Sergeev, S. M., Mottaeva, A. B., De La Poza Plaza, E., Baydukova, N. V., & Gubenko, A. V. (2023). Evaluating energy financing considerations and sustainable energy innovation with the role of financial development and energy development. *Environmental Science and Pollution Research*, 30(3), 6849-6863.
- Bashir, M. F., Benjiang, M. A., Shahbaz, M., Shahzad, U., & Vo, X. V. (2021). Unveiling the heterogeneous impacts of environmental taxes on energy consumption and energy intensity: empirical evidence from OECD countries. *Energy*, 226, 120366.
- Bashir, M. F., Ma, B., Bashir, M. A., Radulescu, M., & Shahzad, U. (2022). Investigating the role of environmental taxes and regulations for renewable energy consumption: evidence from developed economies. *Economic Research-Ekonomska Istraživanja*, 35(1), 1262-1284.
- Baum, C. F., Schaffer, M. E., & Stillman, S. (2007). Enhanced routines for instrumental variables/generalized method of moments estimation and testing. *The Stata Journal*, 7(4), 465-506.
- Baumol, W. J., & Oates, W. E. (1988). *The theory of environmental policy*. Cambridge university press.
- Bayale, N. (2020). Foreign aid and fiscal resources mobilization in WAEMU countries: Ambiguous effects and new questions. *African Journal of Economic Review*, 8(2), 17-38.

- Bazillier, R., Hatte, S., & Vauday, J. (2016). Is Reputation At Stake When Environmentally Responsible Multinationals Invest Abroad? An Empirical Investigation (No. 2315). Orleans Economics Laboratory/Laboratoire d'Economie d'Orleans (LEO), University of Orleans.
- Bazillier, R., Hatte, S., & Vauday, J. (2017). Are environmentally responsible firms less vulnerable when investing abroad? The role of reputation. *Journal of Comparative Economics*, 45(3), 520-543.
- Bebbington, J., & Unerman, J. (2018). Achieving the United Nations Sustainable Development Goals: an enabling role for accounting research. *Accounting, Auditing & Accountability Journal*.
- Bebbington, J., & Unerman, J. (2020). Advancing research into accounting and the UN sustainable development goals. *Accounting, Auditing & Accountability Journal*, 33(7), 1657-1670.
- Becattini, V., Gabrielli, P., Frattini, L., Weisbach, D., & Mazzotti, M. (2022). A two-step carbon pricing scheme enabling a net-zero and net-negative CO₂-emissions world. *Climatic Change*, 171(1-2), 18.
- Ben Mim, S., Hedi, A., & Ben Ali, M. S. (2022). Industrialization, FDI and absorptive capacities: evidence from African Countries. *Economic Change and Restructuring*, 1-28.
- Ben, C. (2022). Research spotlight: Renewable energy in Africa. Mo Ibrahim Foundation. Retrieved March 23, 2023, from <https://mo.ibrahim.foundation/research-spotlight-renewable-energy-africa>
- Benedek, D., Crivelli, E., Gupta, S., & Muthoora, P. (2014). Foreign aid and revenue: Still a crowding-out effect?. *FinanzArchiv/public finance analysis*, 67-96.
- Berenson, M. (2018). From a Coercive to a Modern Tax State. In *Taxes and Trust: From Coercion to Compliance in Poland, Russia and Ukraine* (pp. 1-11). Cambridge: Cambridge University Press. doi:10.1017/9781108333580.001
- Berthélemy, J. C. (2007). Rent-seeking Behaviors and the Perpetuation of Aid Dependence: The Donor-Side Story. E. Aryeetey and A. Dinello, 108-36.
- Bertoldi, P. (2022). Policies for energy conservation and sufficiency: Review of existing policies and recommendations for new and effective policies in OECD countries. *Energy and Buildings*, 264, 112075.
- Besley, T., & Persson, T. (2013). Taxation and development. In *Handbook of public economics* (Vol. 5, pp. 51-110). Elsevier.
- Besley, T., & Persson, T. (2014). Why do developing countries tax so little?. *Journal of economic perspectives*, 28(4), 99-120.
- Best, R. (2017). Switching towards coal or renewable energy? The effects of financial capital on energy transitions. *Energy Economics*, 63, 75-83.
- Beuermann, C., Hermwille, L., Burck, J., Schinke, B., & Marten, F. (2014). Towards a global energy transformation. Friedrich-Ebert-Stiftung.
- Bhat, A. A., & Mishra, P. P. (2020). Evaluating the performance of carbon tax on green technology: evidence from India. *Environmental Science and Pollution Research*, 27, 2226-2237.
- Bhattacharya, M. (2019). The Environmental Kuznets Curve: A critical review of earlier literature. *Environmental Kuznets Curve (EKC)*, 9-14.
- Bi, G. B., Song, W., Zhou, P., & Liang, L. (2014). Does environmental regulation affect energy efficiency in China's thermal power generation? Empirical evidence from a slacks-based DEA model. *Energy Policy*, 66, 537-546.
- Blair, R. A., & Roessler, P. (2021). Foreign aid and state legitimacy: Evidence on Chinese and US aid to Africa from surveys, survey experiments, and behavioral games. *World Politics*, 73(2), 315-357. <https://doi.org/10.1017/S004388712000026X>
- Blair, R. A., & Winters, M. S. (2020). Foreign aid and state-society relations: Theory, evidence, and new directions for research. *Studies in Comparative International Development*, 55, 123-142.
- Bloomfield, J., & Fisher, M. J. (2019). Quantitative research design. *Journal of the Australasian Rehabilitation Nurses Association*, 22(2), 27-30.
- Bodea, C., & LeBas, A. (2014). The origins of voluntary compliance: Attitudes toward taxation in urban Nigeria. *British Journal of Political Science*, 46(1), 215-238. DOI:10.1017/S000712341400026X
- Böhringer, C., Schneider, J., & Asane-Otoo, E. (2021). Trade in carbon and carbon tariffs. *Environmental*

- and Resource Economics, 78, 669-708.
- Boly, A., & Gillanders, R. (2018). Anti-corruption policy making, discretionary power and institutional quality: An experimental analysis. *Journal of Economic Behavior & Organization*, 152, 314-327.
- Borner, D. K., & Malik, N. (2023). Aid Effectiveness, International Policy Transfer and Development and Post-Development Theory. In *African Experience in the Application of the Development Aid Effectiveness Principles: The Case of Kenya* (pp. 33-73). Singapore: Springer Nature Singapore.
- Boudreau, C. (2023, January 19). The Big Four accounting firms need sustainability experts — and are investing big in training in order to get them. *Business Insider*. <https://www.businessinsider.com/accounting-and-financial-firms-are-hiring-sustainability-experts-2022-6?r=US&IR=T>
- Bowles, P. (1989). Recipient needs and donor interests in the allocation of EEC aid to developing countries. *Canadian Journal of Development Studies/Revue canadienne d'études du développement*, 10(1), 7-19.
- Bräutigam, D. A., & Knack, S. (2004). Foreign aid, institutions, and governance in sub-Saharan Africa. *Economic development and cultural change*, 52(2), 255-285.
- Bräutigam, D., Fjeldstad, O. H., & Moore, M. (2008). *Taxation and state-building in developing countries: Capacity and consent*. Cambridge University Press.
- Bridge, G., & Gailing, L. (2020). New energy spaces: Towards a geographical political economy of energy transition. *Environment and Planning A: Economy and Space*, 52(6), 1037-1050.
- Brun, J. F., Chambas, G., & Guérineau, S. (2008). Official Development Assistance and Tax Mobilization (No. hal-00325714).
- Callaway, B., & Sant'Anna, P. H. (2021). Difference-in-differences with multiple time periods. *Journal of econometrics*, 225(2), 200-230.
- Carattini, S., Carvalho, M., & Fankhauser, S. (2018). Overcoming public resistance to carbon taxes. *Wiley Interdisciplinary Reviews: Climate Change*, 9(5), e531.
- Carley, S., & Konisky, D. M. (2020). The justice and equity implications of the clean energy transition. *Nature Energy*, 5(8), 569-577.
- Carraro, C., Galeotti, M., & Gallo, M. (1996). Environmental taxation and unemployment: some evidence on the 'double dividend hypothesis' in Europe. *Journal of Public Economics*, 62(1-2), 141-181.
- Chakraborty, P., & Dash, B. B. (2017). Why tax effort falls short of capacity in Indian states: A stochastic frontier approach. *Public Finance Review*, 45(2), 232-259.
- Chatterjee, S., Giuliano, P., & Kaya, I. (2012). Where has all the money gone? Foreign aid and the composition of government spending. *The BE Journal of Macroeconomics*, 12(1).
- Chen, B., Yang, Q., Li, J. S., & Chen, G. Q. (2017). Decoupling analysis on energy consumption, embodied GHG emissions and economic growth—The case study of Macao. *Renewable and Sustainable Energy Reviews*, 67, 662-672.
- Chen, X., Zhu, Q., Xu, C., Shen, Z., & Song, M. (2022). Energy and environmental efficiency of China's regional electric power industry by considering renewable energy constraints. *Energy & Environment*, 0958305X221139256.
- Chen, Y. H., Wang, C., Nie, P. Y., & Chen, Z. R. (2020). A clean innovation comparison between carbon tax and cap-and-trade system. *Energy Strategy Reviews*, 29, 100483.
- Chen, Y., & Lin, B. (2021). Understanding the green total factor energy efficiency gap between regional manufacturing—insight from infrastructure development. *Energy*, 237, 121553.
- Chen, Z. Y., & Nie, P. Y. (2016). Effects of carbon tax on social welfare: A case study of China. *Applied energy*, 183, 1607-1615.
- Cheng, K., Hsueh, H. P., Ranjbar, O., Wang, M. C., & Chang, T. (2021a). Urbanization, coal consumption and CO2 emissions nexus in China using bootstrap Fourier Granger causality test in quantiles. *Letters in Spatial and Resource Sciences*, 14(1), 31-49.
- Cheng, Y., Sinha, A., Ghosh, V., Sengupta, T., & Luo, H. (2021b). Carbon tax and energy innovation at crossroads of carbon neutrality: Designing a sustainable decarbonization policy. *Journal of*

- Environmental Management, 294, 112957.
- Chien, F., Zhang, Y., Li, L., & Huang, X. C. (2023). Impact of government governance and environmental taxes on sustainable energy transition in China: fresh evidence using a novel QARDL approach. *Environmental Science and Pollution Research*, 30(16), 48436-48448.
- Clemens, M. A., Radelet S, Bhavnani RR, Bazzi S. (2012) Counting chickens when they hatch: timing and the effects of aid on growth. *Econ J* 122(561):590–617
- Clist, P., & Morrissey, O. (2011). Aid and tax revenue: signs of a positive effect since the 1980s. *Journal of international development*, 23(2), 165-180.
- Combes, J. L., Ouedraogo, R., & Tapsoba, S. J. A. (2016). Structural shifts in aid dependency and fiscal policy in developing countries. *Applied Economics*, 48(46), 4426-4446.
- Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.
- Crivelli, E., & Gupta, S. (2017). Does Conditionality Mitigate the Potential Negative Effect of Aid on Revenues?. *The Journal of Development Studies*, 53(7), 1057-1074.
- Cui, N., & Hu, Y. (2023). Foreign aid and fiscal policy in a small-open economy with a non-market sector. *Foreign Trade Review*, 58(1), 144-175.
- Cui, N., & Zhang, Z. (2017). Estimation of Agricultural Production Efficiency in Heilongjiang Province Based on Supper-Efficiency DEA Model and Malmquist Index. *Northern Horticulture*, 22, 192-199.
- da Silva, P. P., Cerqueira, P. A., & Ogbe, W. (2018). Determinants of renewable energy growth in Sub-Saharan Africa: Evidence from panel ARDL. *Energy*, 156, 45-54.
- Dafermos, Y., & Nikolaidi, M. (2019). *Fiscal policy and ecological sustainability: a post-Keynesian perspective* (pp. 277-322). Springer International Publishing.
- Damianos, S. (2021). Aid diversion, accountability and questions unanswered: contextualizing the World Bank working paper on offshore capture of foreign aid. *Journal of Money Laundering Control*, 24(3), 633-646.
- Daude, C., Gutierrez, H., & Melguizo, A. (2013a). What drives tax morale? A focus on emerging economies. *Review of Public Economics*, 207(4), 9-40.
- Daude, C., Melguizo, A., & Neut, A. (2013b). Fiscal policy in Latin America: Better after all? *Emerging Markets Finance and Trade*, 49(4), 127-139.
- Davey, T. (2022). Developing countries can't afford climate change. Future of Life Institute. <https://futureoflife.org/recent-news/developing-countries-cant-afford-climate-change/#:~:text=In%20East%20Asia%20and%20the,capita%E2%80%9494a%20185%25%20increase.>
- De Mooij, R. A. (2020). Tax policy and inclusive growth. *IMF Working Papers*, 20(271), 1-41. <https://www.elibrary.imf.org/view/journals/001/2020/271/article-A001-en.xml>
- define tax effort
- Degirmenci, T., & Aydin, M. (2021). The effects of environmental taxes on environmental pollution and unemployment: A panel co-integration analysis on the validity of double dividend hypothesis for selected African countries. *International Journal of Finance & Economics*.
- Degirmenci, T., & Aydin, M. (2023). The effects of environmental taxes on environmental pollution and unemployment: A panel co-integration analysis on the validity of double dividend hypothesis for selected African countries. *International Journal of Finance & Economics*, 28(3), 2231-2238.
- del Guayo, Í., & Cuesta, Á. (2022). Towards a just energy transition: a critical analysis of the existing policies and regulations in Europe. *The Journal of World Energy Law & Business*, 15(3), 212-222.
- Dell'Anno, R., & Davidescu, A. A. (2019). Estimating shadow economy and tax evasion in Romania. A comparison by different estimation approaches. *Economic Analysis and Policy*, 63, 130-149.
- Deloitte. (2023, January 31). South Africa's carbon tax: Changes and implications for taxpayers. Deloitte. <https://www.deloitte.com/za/en/services/tax/perspectives/south-africas-carbon-tax-changes-and-implications-for-taxpayers.html>

- Demissew Beyene, S., & Kotosz, B. (2020). Testing the environmental Kuznets curve hypothesis: an empirical study for East African countries. *International Journal of Environmental Studies*, 77(4), 636-654.
- Denzin, N. K., & Lincoln, Y. S. (2011). *The SAGE handbook of qualitative research* (4th ed.). Sage Publications.
- Deserranno, E., Nansamba, A., & Qian, N. (2020). The unintended consequences of NGO-provided aid on government services in Uganda (No. w26928). National Bureau of Economic Research.
- Dias Soares, C. A. (2011). *The design features of environmental taxes* (Doctoral dissertation, London School of Economics and Political Science).
- Diaz-Sanchez, J. L., Tagem, A. M., & Mota, J. (2022). Tax revenue effort and aid in fragile states: The case of Comoros. *South African Journal of Economics*, 90(2), 175-195.
- Dietrich, S. (2016). Donor political economies and the pursuit of aid effectiveness. *International Organization*, 70(1), 65-102.
- Djankov, S., Montalvo, J. G., & Reynal-Querol, M. (2008). The curse of aid. *Journal of Economic Growth*, 13(3), 169-194. <https://doi.org/10.1007/s10887-008-9032-8>
- Dobracev, V., Matak, N., Sakulin, C., & Krajačić, G. (2021). Multilevel governance energy planning and policy: a view on local energy initiatives. *Energy, Sustainability and Society*, 11, 1-17.
- Doğan, B., Chu, L. K., Ghosh, S., Truong, H. H. D., & Balsalobre-Lorente, D. (2022). How environmental taxes and carbon emissions are related in the G7 economies?. *Renewable Energy*, 187, 645-656.
- Dolan, L. R. (2020). Rethinking foreign aid and legitimacy: views from aid recipients in Kenya. *Studies in Comparative International Development*, 55, 143-159.
- Domguia, E. N., Pondie, T. M., Ngounou, B. A., & Nkengfack, H. (2022). Does environmental tax kill employment? Evidence from OECD and non-OECD countries. *Journal of Cleaner Production*, 134873.
- d'Oultremont, C. (2010). *The EU's Emissions Trading Scheme: Achievements, Key Lessons, and Future Prospects*. Egmont Paper No. 40, December 2010.
- Driffield, N., & Jones, C. (2013). Impact of FDI, ODA and migrant remittances on economic growth in developing countries: A systems approach. *The European Journal of Development Research*, 25, 173-196.
- Durodola, O. D., Iroham, C. O., & Achuenu, E. (2020). The influence of corruption on foreign aid effectiveness in Nigeria. *International Journal of Financial, Accounting, and Management*, 2(1), 63-79.
- Earnst & Young. (2023, June). *EY Green Tax Tracker: Keeping pace with sustainability incentives, carbon regimes and environmental taxes*. MSN News. <https://www.msn.com/en-us/news/technology/elon-musk-is-right-ai-needs-to-slow-down-for-the-good-of-society/ar-AA19eAAp>
- Easterly, W. (2006). *The white man's burden: Why the West's efforts to aid the rest have done so much ill and so little good*. Oxford University Press.
- Ediger, V. Ş. (2019). An integrated review and analysis of multi-energy transition from fossil fuels to renewables. *Energy Procedia*, 156, 2-6.
- Ekins, P. and Speck, S. (1999). Competitiveness and Exemptions From Environmental Taxes in Europe. *Environmental and Resource Economics*, 13(4), 369-396.
- Elgin, C, M Kose, F Ohnsorge and S Yu. (2021), 'DP16497 Understanding Informality', CEPR Discussion Paper No. 16497. CEPR Press, Paris & London. <https://cepr.org/publications/dp16497>
- Empirical, A., & Langford, B. (2016). Tax Revenue Potential and Effort. *Journal International Growth*, 2(3), 1-30.
- Eurostat. (2020, December 18). *Environmental tax statistics - detailed analysis*
- Faccioli, M., Law, C., Caine, C. A., Berger, N., Yan, X., Weninger, F., ... & Bateman, I. J. (2022). Combined carbon and health taxes outperform single-purpose information or fiscal measures in designing sustainable food policies. *Nature Food*, 3(5), 331-340.
- Fahey, E. (2012). *The EU Emissions Trading Scheme and the Court of Justice: The "High Politics" of*

- Indirectly Promoting Global Standards. *German Law Journal*, 13(11), 1247-1268.
- Fang, G., Yang, K., Tian, L., & Ma, Y. (2022). Can environmental tax promote renewable energy consumption?—An empirical study from the typical countries along the Belt and Road. *Energy*, 260, 125193.
- Farooq, U. (2022). Foreign direct investment, foreign aid, and CO 2 emissions in Asian economies: does governance matter?. *Environmental Science and Pollution Research*, 1-16.
- Fatima, N., Yanting, Z., & Guohua, N. (2023). Role of environmentally related technologies and revenue taxes in environmental degradation in OECD countries. *Environmental Science and Pollution Research*, 1-16.
- Fazekas, M., & King, L. P. (2019). Perils of development funding? The tale of EU Funds and grand corruption in Central and Eastern Europe. *Regulation & Governance*, 13(3), 405-430.
- Feeny, S., & De Silva, A. (2012). Measuring absorptive capacity constraints to foreign aid. *Economic Modelling*, 29(3), 725-733.
- Feeny, S., Hansen, P., Knowles, S., McGillivray, M., & Ombler, F. (2019). Donor motives, public preferences and the allocation of UK foreign aid: A discrete choice experiment approach. *Review of World Economics*, 155, 511-537.
- Fidanoski, F., Simeonovski, K., & Cvetkoska, V. (2021). Energy efficiency in OECD countries: A DEA Approach. *Energies*, 14(4), 1185.
- Finan, T., & Kanie, N. (2018). Financing sustainable development? The role of foreign aid in Southeast Asia's energy transition. *Sustainable Development*, 26(4), 369-378. doi:10.1002/sd.2231
- Findley, M. G., Harris, A. S., Milner, H. V., & Nielson, D. L. (2017). Who controls foreign aid? Elite versus public perceptions of donor influence in aid-dependent Uganda. *International Organization*, 71(4), 633-663. Findley M.G., Harris A.S., Milner H.V., Nielson D.L., 2017. Who controls foreign aid? Elite versus public perceptions of donor influence in aid-dependent Uganda. *Int Organ.*, 71(4), 633-663.
- Findley, M. G., Powell, J., Strandow, D., & Tanner, J. (2011). The localized geography of foreign aid: A new dataset and application to violent armed conflict. *World Development*, 39(11), 1995-2009.
- Fisher, S., Bellinger, D. C., Cropper, M. L., Kumar, P., Binagwaho, A., Koudoukoupo, J. B., ... & Landrigan, P. J. (2021). Air pollution and development in Africa: impacts on health, the economy, and human capital. *The Lancet Planetary Health*, 5(10), e681-e688.
- Fjeldstad, O. H., & Tungodden, B. (2003). Fiscal corruption: A vice or a virtue?. *World Development*, 31(8), 1459-1467.
- Fon, R., & Alon, I. (2022). Governance, foreign aid, and Chinese foreign direct investment. *Thunderbird International Business Review*, 64(2), 179-201.
- Fotio, H. K., Nchofoung, T. N., & Asongu, S. A. (2022). Financing renewable energy generation in SSA: Does financial integration matter?. *Renewable Energy*, 201, 47-59.
- Fredriksson, A., & Oliveira, G. M. D. (2019). Impact evaluation using Difference-in-Differences. *RAUSP Management Journal*, 54, 519-532.
- Freire-González, J. (2018). Environmental taxation and the double dividend hypothesis in CGE modelling literature: A critical review. *Journal of Policy Modeling*, 40(1), 194-223.
- Fullerton, D., & Metcalf, G. E. (1997). Environmental taxes and the double-dividend hypothesis: did you really expect something for nothing?.
- Galdi, G., Verde, S., & Borghesi, S. (2021, October 29). The EU Emission Trading System (ETS). Florence School of Regulation. <https://fsr.eui.eu/the-eu-emission-trading-system-ets/>
- García, J.H., & Sterner, T. (2021). Carbon Taxes. *Oxford Research Encyclopedia of Environmental Science*.
- García-García, P., Carpintero, Ó., & Buendía, L. (2020). Just energy transitions to low carbon economies: A review of the concept and its effects on labour and income. *Energy Research & Social Science*, 70, 101664.
- García-Muros, X., Morris, J., & Paltsev, S. (2022). Toward a just energy transition: A distributional analysis

- of low-carbon policies in the USA. *Energy Economics*, 105, 105769.
- Ge, M., Friedrich, J., & Vigna, L. (2020, February 6). 4 charts explain greenhouse gas emissions by countries and sectors. World Resources Institute. Retrieved January 18, 2023, from <https://bit.ly/3ZLltzE>.
- Gephart, R. P., & Saylor, R. (2020). Qualitative designs and methodologies for business, management, and organizational research. In *Oxford Research Encyclopedia of Business and Management*.
- Ghazouani, A., Jebli, M. B., & Shahzad, U. (2021). Impacts of environmental taxes and technologies on greenhouse gas emissions: contextual evidence from leading emitter European countries. *Environmental Science and Pollution Research*, 28, 22758-22767.
- Ghazouani, A., Xia, W., Ben Jebli, M., & Shahzad, U. (2020). Exploring the role of carbon taxation policies on CO₂ emissions: contextual evidence from tax implementation and non-implementation European Countries. *Sustainability*, 12(20), 8680.
- Gielen, D., Boshell, F., Saygin, D., Bazilian, M. D., Wagner, N., & Gorini, R. (2019). The role of renewable energy in the global energy transformation. *Energy strategy reviews*, 24, 38-50.
- Gill, A. R., Viswanathan, K. K., & Hassan, S. (2018). The Environmental Kuznets Curve (EKC) and the environmental problem of the day. *Renewable and sustainable energy reviews*, 81, 1636-1642.
- Girouard, N. (2021, April 5). How to create economic growth without carbon emissions and environmental damage. Retrieved January 2, 2023, from <https://sdg-action.org/how-to-create-economic-growth-without-carbon-emissions-and-environmental-damage%ef%bf%bc>
- Gnangnon, S. K. (2022). Tax revenue instability and tax revenue in developed and developing countries. *Applied Economic Analysis*, 30(88), 18-37.
- Gnangnon, S. K., & Brun, J. F. (2019). Trade openness, tax reform and tax revenue in developing countries. *The World Economy*, 42(12), 3515-3536.
- Gnangnon, S.K. (2021). Tax Reform, Trade Openness and Export Product Diversification in Developing Countries. *CESifo Economic Studies*, 67(2), 210-234
- Godin, J., Liu, W., Ren, S., & Xu, C. C. (2021). Advances in recovery and utilization of carbon dioxide: A brief review. *Journal of Environmental Chemical Engineering*, 9(4), 105644.
- Goldstein, D., & Goldstein, A. (2015, December 15). What is the link between carbon emissions and poverty?. *World Economic Forum*. <https://www.weforum.org/agenda/2015/12/what-is-the-link-between-carbon-emissions-and-poverty/>
- Goldthau, A., & Sitter, N. (2019). Regulatory or market power Europe? EU leadership models for international energy governance. *New political economy of energy in Europe: Power to project, power to adapt*, 27-47.
- Gomez-Echeverri, L. (2018). A review of the nature of foreign aid to the energy sector over the last two decades. *Aid effectiveness for environmental sustainability*, 125-184.
- Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, 225(2), 254-277.
- Governors, September 2021, Italy, www.oecd.org/tax/tax-policy/imf-oecd-g20-report-tax-policy-and-climate-change.htm
- Gray, H., & Khan, M. (2006). State Weakness in Developing Countries and Strategies of Institutional Reform: Operational Implications for Anti-Corruption Policy and a Case Study of Tanzania.
- Green, M. (2021, February 9). Fossil fuel pollution causes one in five premature deaths globally -study. *Reuters*. <https://www.reuters.com/business/energy/fossil-fuel-pollution-causes-one-five-premature-deaths-globally-study-2021-02-09/>
- Gupta A., Mello L., and Sharan V. (2021). Determinants of Tax Revenue Efforts in Developing Countries. *International Journal of Economics and Finance* 13(8): 1-163
- Haites, E. (2018). Carbon taxes and greenhouse gas emissions trading systems: what have we

- learned?. *Climate policy*, 18(8), 955-966.
- Hájek, M., Zimmermannová, J., Helman, K., & Rozenský, L. (2019). Analysis of carbon tax efficiency in energy industries of selected EU countries. *Energy Policy*, 134, 110955.
- Hakeem, S., Ghauri, S. P., Ahmed, R. R., Streimikiene, D., & Streimikis, J. (2023). Development of Social Welfare Policies in the South Asian Association for Regional Cooperation (SAARC) Countries: Globalization and Democracy. *Social Indicators Research*, 167(1), 91-134.
- Hamann, R., Rennkamp, B., Kruger, W., & Musango, J. K. (2023). Corruption Undermines Justice in Clean Energy Transitions. *Environment: Science and Policy for Sustainable Development*, 65(4), 5-9.
- Hanif, I., Raza, S. M. F., Gago-de-Santos, P., & Abbas, Q. (2019). Fossil fuels, foreign direct investment, and economic growth have triggered CO2 emissions in emerging Asian economies: some empirical evidence. *Energy*, 171, 493-501.
- Haque, N., & Rashid, S. (2022). Effects of cumulative energy aid projects on renewable energy generation capacity. *Environmental Development*, 42, 100692.
- Harris, J. (2023). Exploring donor-driven skills development as a channel of continued aid dependency. *Third World Quarterly*, 1-20.
- Hashmi, R., & Alam, K. (2019). Dynamic relationship among environmental regulation, innovation, CO2 emissions, population, and economic growth in OECD countries: A panel investigation. *Journal of cleaner production*, 231, 1100-1109.
- Hassan, M., Oueslati, W., & Rousselière, D. (2020). Environmental taxes, reforms and economic growth: an empirical analysis of panel data. *Economic Systems*, 44(3), 100806.
- He, R., Luo, L., Shamsuddin, A., & Tang, Q. (2022). The value relevance of corporate investment in carbon abatement: The influence of national climate policy. *European Accounting Review*, 31(5), 1233-1261.
- Healy, N., & Barry, J. (2017). Politicizing energy justice and energy system transitions: Fossil fuel divestment and a “just transition”. *Energy policy*, 108, 451-459.
- Heffron, R. J., & McCauley, D. (2017). The concept of energy justice across the disciplines. *Energy Policy*, 105, 658-667.
- Henderson, K. E., & Sommer, J. (2022). Aiding fossil fuel dependency: a cross-national analysis of energy sector aid, national autonomy, and CO2 emissions in 122 nations. *International Journal of Sociology*, 52(1), 25-48.
- Ho, T.T., Tran, X.H. and Nguyen, Q.K. (2023). Tax revenue-economic growth relationship and the role of trade openness in developing countries. *Cogent Business & Management*, 10(2), 2213959
- Hogan, J. L., Warren, C. R., Simpson, M., & McCauley, D. (2022). What makes local energy projects acceptable? Probing the connection between ownership structures and community acceptance. *Energy Policy*, 171, 113257.
- Holechek, J. L., Geli, H. M., Sawalhah, M. N., & Valdez, R. (2022). A global assessment: can renewable energy replace fossil fuels by 2050?. *Sustainability*, 14(8), 4792.
- Hongxing, Y., Abban, O. J., & Dankyi Boadi, A. (2021). Foreign aid and economic growth: Do energy consumption, trade openness and CO2 emissions matter? A DSUR heterogeneous evidence from Africa’s trading blocs. *PLOS ONE*, 16(6), e0253457. <https://doi.org/10.1371/journal.pone.0253457>
- Horodnic, I. A., & Williams, C. C. (2016). An evaluation of the shadow economy in Baltic States: a tax morale perspective. *International Journal of Entrepreneurship and Small Business*, 28(2-3), 339-358.
- Huemer, M. (2013). *The Traditional Social Contract Theory*. In: *The Problem of Political Authority*. Palgrave Macmillan, London. https://doi.org/10.1057/9781137281661_2
- IEA (2021). *How Energy Efficiency Will Power Net Zero Climate Goals*, IEA, Paris <https://www.iea.org/commentaries/how-energy-efficiency-will-power-net-zero-climate-goals>
- IEA (2021). *World Energy Outlook 2021*
- IMF/OECD (2021), *Tax Policy and Climate Change: IMF/OECD Report for the G20 Finance Ministers*

- and Central Bank Governors, September 2021, Italy, www.oecd.org/tax/tax-policy/imf-oecd-g20-report-tax-policy-and-climate-change.htm
- Intergovernmental Panel on Climate Change. (2022). Climate change 2022: Impacts, adaptation and vulnerability. Intergovernmental Panel on Climate Change. <https://www.ipcc.ch/report/ar6/wg2/>
- International Energy Agency. (2022). CO2 Emissions in 2022 – Analysis. <https://www.iea.org/reports/co2-emissions-in-2022>
- International Hydropower Association. (2022, November). Hydropower is a low-carbon source of renewable energy and a reliable and cost-effective alternative to electricity generation by fossil fuels.Greenhouse gas emissions. Retrieved May 11, 2023, from <https://www.hydropower.org/factsheets/greenhouse-gas-emissions>.
- International Monetary Fund (2023, June 6). South Africa Carbon Pricing and Climate Mitigation Policy. [https://www.elibrary.imf.org/view/journals/002/2023/195/article-A003-en.xml#:~:text=The%20official%20carbon%20tax%20rate,about%20%248\)%20by%20end%202022.](https://www.elibrary.imf.org/view/journals/002/2023/195/article-A003-en.xml#:~:text=The%20official%20carbon%20tax%20rate,about%20%248)%20by%20end%202022.)
- International Renewable Energy Agency. (2019). Scaling up renewable energy deployment in Africa: Impact overview. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Feb/IRENA_Afr
- International Renewable Energy Agency. (2021). The Renewable Energy Transition in Africa. <https://www.irena.org/publications/2021/March/The-Renewable-Energy-Transition-in-Africa>
- IRENA and AfDB. (2022), Renewable Energy Market Analysis: Africa and Its Regions, International Renewable Energy Agency and African Development Bank, Abu Dhabi and Abidjan.
- Ireri, B., Shirley, R. (2021, September 2). Powering growth. IMF. <https://www.imf.org/en/Publications/fandd/issues/2021/09/fighting-climate-change-in-Africa-ireri>
- Ivanova, M. (2020). Everyone, everywhere: the global challenge of climate change. *Nature*.
- Jackson, R. B., Friedlingstein, P., Le Quéré, C., Abernethy, S., Andrew, R. M., Canadell, J. G., ... & Peters, G. P. (2022). Global fossil carbon emissions rebound near pre-COVID-19 levels. *Environmental Research Letters*, 17(3), 031001.
- Jacobsen, G., & Fischer, C. (2021). The Green New Deal and the future of carbon pricing. *Journal of Policy Analysis and Management*, 40(3), 988-995.
- Jaidane-Mazigh, L., Khefacha, I., & Smiri, B. (2022, November). Gender and Corruption in MENA Countries: New Evidence from the ARDL Approach. In *Economic Research Forum Working Papers* (No. 1611).
- Jalal, R., & Gopinathan, R. (2022). Time-varying and asymmetric impact of exchange rate on oil prices in India: Evidence from a multiple threshold nonlinear ARDL model. *Finance Research Letters*, 50, 103297.
- James, S. (1999). The future international tax environment and European tax harmonization: a personal view. *European Accounting Review*, 8(4), 731-747.
- Jebli, M. B., Farhani, S., & Guesmi, K. (2020). Renewable energy, CO2 emissions and value added: Empirical evidence from countries with different income levels. *Structural Change and Economic Dynamics*, 53, 402-410.
- Jenkins, K., Sovacool, B. K., & McCauley, D. (2018). Humanizing sociotechnical transitions through energy justice: An ethical framework for global transformative change. *Energy policy*, 117, 66-74.
- Jochmans, K., & Verardi, V. (2020). A portmanteau test for serial correlation in a linear panel model. *The Stata Journal*, 20(1), 149-161.
- Jones, S., Tarp, F., & Addison, T. (2017). Aid, growth and development: Have we come full circle? *Journal of Globalization and Development*, 8(1), 1-27.
- Juodis, A., Karavias, Y., & Sarafidis, V. (2021). A homogeneous approach to testing for Granger non-

- causality in heterogeneous panels. *Empirical Economics*, 60(1), 93-112.
- Kaberuka, W., & Sène, S. O. (2014). Donor aid and economic growth in Sub Saharan Africa: An empirical analysis. *American Journal of Economics*, 4(1), 49-55.
- Kaplan, D. M. (2022). Smoothed instrumental variables quantile regression. *The Stata Journal*, 22(2), 379-403. Kaplan, D. M. (2022), "Smoothed instrumental variables quantile regression." *The Stata Journal*, 22(2), 379-403. <https://doi.org/10.1177/1536867X221106404>
- Kaplan, D. M., & Sun, Y. (2017). Smoothed estimating equations for instrumental variables quantile regression. *Econometric Theory*, 33(1), 105-157. Kaplan, D. M., and Y. Sun. (2017), "Smoothed estimating equations for instrumental variables quantile regression." *Econometric Theory*, 33: 105-157. <https://doi.org/10.1017/S0266466615000407>
- Karmaker, S. C., Hosan, S., Chapman, A. J., & Saha, B. B. (2021). The role of environmental taxes on technological innovation. *Energy*, 232, 121052.
- Kaufmann, D. (2009). Aid effectiveness and governance: the good, the bad and the ugly. *Development Outreach*, 11(1), 26-29.
- Kaufmann, D., Kraay, A., & Mastruzzi, M. (2010). The worldwide governance indicators: methodology and analytical issues. *Hague Journal on the Rule of Law*, 3(2), 220-246.
- Kaur, N., & Sithou, L. (2017). Governance of Development Assistance: Issues and Challenges. *Indian Journal of Public Administration*, 63(2), 252-264.
- Kaya, I., & Kaya, O. (2020). Foreign aid, institutional quality and government fiscal behavior in emerging economies: An empirical investigation. *The Quarterly Review of Economics and Finance*, 76, 59-67.
- Kaya, Y., & Yokobori, K. (Eds.). (1997). *Environment, energy, and economy: strategies for sustainability* (Vol. 4). Tokyo: United Nations University Press.
- Kemoe, L., Lanci, L., Mitra, P., Muehlschlegel, T., Okou, C., Spray, J., ... & Unsal, F. (2022). Climate Change and Chronic Food Insecurity in Sub-Saharan Africa.
- Kettner-Marx, C., & Kletzan-Slamanig, D. (2018). Carbon taxes from an economic perspective (No. 554). WIFO Working Papers.
- Khalil, A. K., Mubarak, A. M., & Kaseb, S. A. (2010). Road map for renewable energy research and development in Egypt. *Journal of advanced research*, 1(1), 29-38.
- Khan, H., Dong, Y., Nuță, F. M., & Khan, I. (2023). Eco-innovations, green growth, and environmental taxes in EU countries: a panel quantile regression approach. *Environmental Science and Pollution Research*, 1-18. Khan, H., Dong, Y., Nuță, F.M. et al. Eco-innovations, green growth, and environmental taxes in EU countries: a panel quantile regression approach. *Environ Sci Pollut Res* (2023). <https://doi.org/10.1007/s11356-023-29957-w>
- Khan, M. H. (2001). Agricultural taxation in developing countries: a survey of issues and policy. *Agricultural Economics*, 24(3), 315-328.
- Khastar, M., Aslani, A., & Nejati, M. (2020). How does carbon tax affect social welfare and emission reduction in Finland?. *Energy Reports*, 6, 736-744.
- Khezrimotlagh, D. (2015). How to deal with numbers of decision-making units and variables in data envelopment analysis. arXiv preprint arXiv:1503.02306.
- Khezrimotlagh, D., Cook, W. D., & Zhu, J. (2021). Number of performance measures versus number of decision making units in DEA. *Annals of Operations Research*, 303, 529-562.
- Kilby, C., & Dreher, A. (2010). The impact of aid on growth revisited: Do donor motives matter? *Economics Letters*, 107(3), 338-340.
- Killingtveit, Å. (2019). Hydropower. In *Managing global warming* (pp. 265-315). Academic Press.
- Kim, J. E. (2019). Sustainable energy transition in developing countries: the role of energy aid donors. *Climate Policy*, 19(1), 1-16.
- Kim, S., & Gray, K. (2016). Overseas development aid as spatial fix? Examining South Korea's Africa policy. *Third World Quarterly*, 37(4), 649-664.
- Knack, S. (2001). Aid dependence and the quality of governance: Cross-country empirical tests. *Southern economic journal*, 68(2), 310-329.

- Köpl, A., & Schratzenstaller, M. (2022). Carbon taxation: A review of the empirical literature. *Journal of Economic Surveys*.
- Koumpias, A. M., Leonardo, G., & Martinez-Vazquez, J. (2020). Trust in government institutions and tax morale.
- Krane, J. (2017). Climate change and fossil fuel: An examination of risks for the energy industry and producer states. *MRS Energy & Sustainability*, 4.
- Kretschmer, B., Hübler, M., & Nunnenkamp, P. (2013). Does foreign aid reduce energy and carbon intensities of developing economies?. *Journal of International Development*, 25(1), 67-91.
- Kubler, D., Litschig, S., & Zamboni, Y. (2020). Governance quality and tax compliance in developing countries. *Journal of Public Economics*, 190, 104241
- Kurihara, Y. (2014). Does foreign aid promote economic growth. *Global Business and Economics Research Journal*, 3(4), 20-30.
- Kwakwa, P. A. (2021). What determines renewable energy consumption? Startling evidence from Ghana. *International Journal of Energy Sector Management*, 15(1), 101-118.
- Lawson, M. L. (2013). Foreign aid: international donor coordination of development assistance. Congressional Research Service.
- Le, T. M., Moreno-Dodson, B., & Bayraktar, N. (2012). Tax capacity and tax effort: Extended cross-country analysis from 1994 to 2009. *World Bank Policy Research Working Paper*, (6252).
- Leal, P. H., & Marques, A. C. (2022). Is globalization a driver for energy efficiency and sustainable development?. In *Energy-Growth Nexus in an Era of Globalization* (pp. 257-285). Elsevier.
- Lenton, P., Masiye, M., & Mosley, P. (2017). Taxpayer's dilemma: how can 'fiscal contracts' work in developing countries?. *Sheffield Economics Research Papers (SERPS)*, 201700(2017004).
- Leonardo, G., Koumpias, A. M., & Martinez-Vazquez, J. (2017, January). How Do Governments around the World Shape Tax Morale?. In *Proceedings. Annual Conference on Taxation and Minutes of the Annual Meeting of the National Tax Association* (Vol. 110). National Tax Association.
- Levinson, A. (2003). Environmental Regulatory Competition: A Status Report and Some New Evidence. *National Tax Journal*, 56(1), 91-1062.
- Li, D. D., Rishi, M., & Bae, J. H. (2021). Green official development Aid and carbon emissions: do institutions matter? *Environment and Development Economics*, 26(1), 88-107.
- Li, G., & Masui, T. (2019). Assessing the impacts of China's environmental tax using a dynamic computable general equilibrium model. *Journal of cleaner production*, 208, 316-324.
- Li, G., Wu, H., Jiang, J., & Zong, Q. (2023). Digital finance and the low-carbon energy transition (LCET) from the perspective of capital-biased technical progress. *Energy Economics*, 106623.
- Li, H. X., Edwards, D. J., Hosseini, M. R., & Costin, G. P. (2020). A review on renewable energy transition in Australia: An updated depiction. *Journal of cleaner production*, 242, 118475.
- Li, H., & Shi, J. F. (2014). Energy efficiency analysis on Chinese industrial sectors: an improved Super-SBM model with undesirable outputs. *Journal of Cleaner Production*, 65, 97-107.
- Li, W., & Ullah, S. (2022b). Research and development intensity and its influence on renewable energy consumption: evidence from selected Asian economies. *Environmental Science and Pollution Research*, 29(36), 54448-54455.
- Li, W., Ji, Z., & Dong, F. (2022). Global renewable energy power generation efficiency evaluation and influencing factors analysis. *Sustainable Production and Consumption*, 33, 438-453.
- Li, Y., & Guo, J. (2022). The asymmetric impacts of oil price and shocks on inflation in BRICS: a multiple threshold nonlinear ARDL model. *Applied Economics*, 54(12), 1377-1395.
- Lilliestam, J., Patt, A., & Bersalli, G. (2021). The effect of carbon pricing on technological change for full energy decarbonization: A review of empirical ex-post evidence. *Wiley Interdisciplinary Reviews: Climate Change*, 12(1), e681.
- Lin, B., & Wang, M. (2021). What drives energy intensity fall in China? Evidence from a meta-frontier approach. *Applied Energy*, 281, 116034.
- Lin, S., Liu, X., Yao, B., & Huang, Z. (2018). Controlling for confounding factors and revealing their

- interactions in genetic association meta-analyses: a computing method and application for stratification analyses. *Oncotarget*, 9(15), 12125–12136. <https://doi.org/10.18632/oncotarget.24335>
- Liu, H., Zafar, M. W., Sinha, A., & Khan, I. (2023a). The path to sustainable environment: Do environmental taxes and governance matter?. *Sustainable Development*.
- Liu, N., Yao, X., Wan, F., & Han, Y. (2023b). Are tax revenue recycling schemes based on industry-differentiated carbon tax conducive to realizing the “double dividend”?. *Energy Economics*, 106814.
- Luo, F., Li, X., & Peng, C. (2020). Study on the decoupling effect of energy consumption and economic growth in the construction industry of Guangxi (People's Republic of China) from the perspective of the circular economy. *SN Applied Sciences*, 2(6), 1-14.
- Luthra, S., Kumar, S., Garg, D., & Haleem, A. (2015). Barriers to renewable/sustainable energy technologies adoption: Indian perspective. *Renewable and sustainable energy reviews*, 41, 762-776.
- Luttmer, E. F., & Singhal, M. (2014). Tax morale. *Journal of economic perspectives*, 28(4), 149-168.
- Machado, R. (2010). Aid and fiscal policy in Nicaragua: A fiscal response analysis. *Journal of International Development: The Journal of the Development Studies Association*, 22(4), 483-502.
- Mahalik, M. K., Villanthenkodath, M. A., & Mallick, H. (2021). Assessing the effectiveness of total foreign aid and foreign energy aid inflows on environmental quality in India. *Energy Policy*, 149, 112015. <https://doi.org/10.1016/j.enpol.2020.112015>
- Mahembe, E., & Odhiambo, N. M. (2017). On the link between foreign aid and poverty reduction in developing countries. *Revista Galega de Economía*, 26(2), 113-128.
- Mahembe, E., & Odhiambo, N. M. (2019). Foreign aid and poverty reduction: A review of international literature. *Cogent Social Sciences*, 5(1), 1625741.
- Mahi, M., Ismail, I., Phoong, S. W., & Isa, C. R. (2021). Mapping trends and knowledge structure of energy efficiency research: what we know and where we are going. *Environmental Science and Pollution Research*, 28(27), 35327-35345.
- Maino, M. R., & Emrullahu, D. (2022). Climate change in Sub-Saharan Africa fragile states: evidence from panel estimations. *International Monetary Fund*.
- Malatesta, D., & Smith, C. R. (2014). Lessons from resource dependence theory for contemporary public and nonprofit management. *Public administration review*, 74(1), 14-25.
- Mangoting, Y., & Sukoharsono, E. G. (2015). Developing a model of tax compliance from social contract perspective: Mitigating the tax evasion. *Procedia-Social and Behavioral Sciences*, 211, 966-971.
- Manisalidis, I., Stavropoulou, E., Stavropoulos, A., & Bezirtzoglou, E. (2020). Environmental and health impacts of air pollution: a review. *Frontiers in public health*, 8, 14.
- Marineau, J. (2020). Aiding dependency: a cross-national analysis of foreign aid and tax compliance. *Studies in Comparative International Development*, 55, 228-256.
- Mariotti, C. (2015). Market-based mechanisms and climate change: EU and US approaches. *LUISS Working Papers*.
- Maruta, A. A., & Banerjee, R. (2021). Does energy aid improve energy efficiency in developing countries?. *Empirical Economics*, 61, 355-388.
- Maruta, A. A., Banerjee, R., & Cavoli, T. (2020). Foreign aid, institutional quality and economic growth: Evidence from the developing world. *Economic Modelling*, 89, 444-463.
- Mascagni, G., & Timmis, E. (2017). The fiscal effects of aid in Ethiopia: evidence from CVAR applications. *The Journal of Development Studies*, 53(7), 1037-1056.
- Matejicek, L., & Matejicek, L. (2017). Energy from Fossil Fuels: Digital Mapping of Sources and Environmental Issues. *Assessment of Energy Sources Using GIS*, 111-164.
- Mavromatidis, G., Orehounig, K., Richner, P., & Carmeliet, J. (2016). A strategy for reducing CO2 emissions from buildings with the Kaya identity—A Swiss energy system analysis and a case study. *Energy Policy*, 88, 343-354.
- McCormick, D., & Schmitz, H. (2011). Donor proliferation and co-ordination: experiences of Kenya and

- Indonesia. *Journal of Asian and African Studies*, 46(2), 149-168.
- McGillivray, M., & Morrissey, O. (2001). A review of evidence on the fiscal effects of aid.
- McKinsey Global Institute. (2022). The net-zero transition: What it would cost, what it could bring. Mckensey Global Institute.
- McMillan, L. (2011). Foreign aid and economic development. *School of Doctoral Studies (European Union) Journal*, 3, 158-165.
- Meade, J. E. (1973). *The theory of economic externalities: the control of environmental pollution and similar social costs* (Vol. 2). Brill Archive.
- Metcalf, G. E., & Stock, J. H. (2020). The macroeconomic impact of Europe's carbon taxes [nber Working Papers no. w27488].
- Milman, O. (2021, February 9). "Invisible killer": fossil fuels caused 8.7m deaths globally in 2018, research finds. *The Guardian*. <https://www.theguardian.com/environment/2021/feb/09/fossil-fuels-pollution-deaths-research>
- Minasyan, A., Nunnenkamp, P., & Richert, K. (2017). Does aid effectiveness depend on the quality of donors?. *World Development*, 100, 16-30.
- Minlah, M. K., & Zhang, X. (2021). Testing for the existence of the Environmental Kuznets Curve (EKC) for CO 2 emissions in Ghana: evidence from the bootstrap rolling window Granger causality test. *Environmental Science and Pollution Research*, 28, 2119-2131.
- Misra, F. (2019). Tax compliance: theories, research development and tax enforcement models. *International Journal of Business and Management Invention*, 8(10), 1-11.
- Mo Ibrahim Foundation. (2022). Addressing Africa's energy deficit: Climate change, renewables, and gas. Mo Ibrahim Foundation. <https://mo.ibrahim.foundation/sites/default/files/2022-09/addressing-africas-energy-deficit.pdf>
- Mohammad, N., Mohamad Ishak, W. W., Mustapa, S. I., & Ayodele, B. V. (2021). Natural gas as a key alternative energy source in sustainable renewable energy transition: a mini review. *Frontiers in Energy Research*, 9, 625023.
- Mohd Chachuli, F. S., Ahmad Ludin, N., Mat, S., & Sopian, K. (2020). Renewable energy performance evaluation studies using the data envelopment analysis (DEA): A systematic review. *Journal of Renewable and Sustainable Energy*, 12(6), 062701.
- Montinola, G.R., Taylor, T.W., & Largoza, G.L. (2020). Foreign Aid, Government Spending, and Contributions toward Public Goods: Experimental Evidence from the Philippines. *Studies in Comparative International Development*, 55, 204-227.
- Moolio, P., & Kong, S. (2016). Foreign aid and economic growth: Panel cointegration analysis for Cambodia, Lao PDR, Myanmar, and Vietnam. *Athens Journal of Business and Economics*, 2(4), 417-428. Moolio P., Kong S., 2016. Foreign aid and economic growth: Panel cointegration analysis for Cambodia, Lao PDR, Myanmar, and Vietnam. *Athens J Bus Econ.*, 2(4), 417-428.
- Moore, M., Fjeldstad, O. H., Isaksen, J., Lundstøl, O., McCluskey, R., & Prichard, W. (2015). Building tax capacity in developing countries.
- Moreira, S. B. (2005). Evaluating the impact of foreign aid on economic growth: A cross-country study. *Journal of Economic Development*, 30(2), 25-48.
- Morrison, K. M. (2015). *Nontaxation and representation*. Cambridge University Press.
- Morrissey, O. (2012). Aid and Fiscal Behaviour in Zambia: An Empirical Investigation. *Journal of Development Studies*, 48(4), 526–542. <https://doi.org/10.1080/00220388.2011.621820>
- Morrissey, O., Von Haldenwang, C., Von Schiller, A., Ivanyna, M., & Bordon, I. (2016). Tax revenue performance and vulnerability in developing countries. *The Journal of Development Studies*, 52(12), 1689-1703.
- Moss, T., Pettersson, G., & van de Walle, N. (2008). An Aid-Institutions Paradox? A Review essay on Aid

- Dependency and State Building in Sub-Saharan Africa'in W. Easterly (ed.) *Reinventing Foreign Aid*.
- Moyo, D. (2010). Aid effectiveness, transaction costs and conditionality in the development industry. *Journal of International Development*, 22(7), 957-962. <https://doi.org/10.1002/jid.1739>
- Moyo, L., & Tsakata Mafuso, L. (2017). The effectiveness of foreign aid on economic development in developing countries: A case of Zimbabwe (1980-2000). *Journal of Social Sciences*, 52(1-3), 173-187.
- Mukherjee, A., Bruijninx, P., & Junginger, M. (2023). Techno-economic competitiveness of renewable fuel alternatives in the marine sector. *Renewable and Sustainable Energy Reviews*, 174, 113127.
- Mukhopadhyay, S., & Gupta, R. K. (2014). Survey of qualitative research methodology in strategy research and implication for Indian researchers. *Vision*, 18(2), 109-123.
- Müller, F., & Claar, S. (2021). Auctioning a 'just energy transition'? South Africa's renewable energy procurement programme and its implications for transition strategies. *Review of African Political Economy*, 48(169), 333-351.
- Müller, F., Neumann, M., Elsner, C., & Claar, S. (2021). Assessing African energy transitions: renewable energy policies, energy justice, and SDG 7. *Politics and Governance*, 9(1), 119-130.
- Munyanyi, M. E., Churchill, S. A., & Mallick, H. (2022). Foreign aid and energy poverty: Sub-national evidence from Senegal. *Energy Economics*, 108, 105899. <https://doi.org/10.1016/j.eneco.2022.105899>
- Muoneke, O. B., Okere, K. I., & Egbo, O. P. (2023). Does political conflict tilt finance-renewable energy dynamics in Africa? Accounting for the multi-dimensional approach to financial development and threshold effect of political conflict. *Heliyon*, 9(3).
- Mutenyo, J., & Asmah, E. (2010). Does foreign direct investment crowd-out domestic private investment in Sub-Saharan Africa?. *African Finance Journal*, 12(1), 27-52.
- Nawaz, M. A., Hussain, M. S., Kamran, H. W., Ehsanullah, S., Maheen, R., & Shair, F. (2021). Trilemma association of energy consumption, carbon emission, and economic growth of BRICS and OECD regions: quantile regression estimation. *Environmental Science and Pollution Research*, 28, 16014-16028.
- Nchofoung, T. N., Fotio, H. K., & Miamo, C. W. (2023). Green taxation and renewable energy technologies adoption: A global evidence. *Renewable Energy Focus*, 44, 334-343.
- Neofytou, H., Nikas, A., & Doukas, H. (2020). Sustainable energy transition readiness: A multicriteria assessment index. *Renewable and Sustainable Energy Reviews*, 131, 109988.
- OECD (2018). *Effective Carbon Rates 2018: Pricing Carbon Emissions Through Taxes and Emissions Trading*. OECD Publishing, Paris.
- OECD. (2021). *OECD Economic Outlook, Volume 2021 Issue 1*
- OECD. (2023). *Environmental tax (indicator)*. doi: 10.1787/5a287eac-en (Accessed on 28
- Ogundipe, A. A., Oye, Q. E., Ogundipe, O. M., & Osabohien, R. (2020). Does infrastructural absorptive capacity stimulate FDI-Growth Nexus in ECOWAS?. *Cogent Economics & Finance*, 8(1), 1751487.
- Ohlendorf, N., Jakob, M., Minx, J. C., Schröder, C., & Steckel, J. C. (2021). Distributional impacts of carbon pricing: A meta-analysis. *Environmental and Resource Economics*, 78, 1-42.
- Olabi, A. G., & Abdelkareem, M. A. (2022). Renewable energy and climate change. *Renewable and Sustainable Energy Reviews*, 158, 112111.
- Olson, C., & Lenzmann, F. (2016). The social and economic consequences of the fossil fuel supply chain. *MRS Energy & Sustainability*, 3, E6.
- Orru, H., Ebi, K. L., & Forsberg, B. (2017). The interplay of climate change and air pollution on health. *Current environmental health reports*, 4, 504-513.
- Ortega-Ruiz, G., Mena-Nieto, A., & García-Ramos, J. E. (2020). Is India on the right pathway to reduce CO2 emissions? Decomposing an enlarged Kaya identity using the LMDI method for the period

1990–2016. *Science of The Total Environment*, 737, 139638.

- Oyedepo, S. O., & Adaramola, M. S. (2020). Renewable energy consumption in Africa: the role of economic well-being and economic freedom. *Energy, Sustainability and Society*, 10(1), 1-14. <https://doi.org/10.1186/s13705-020-00264-3>
- Painuly, J. P. (2001). Barriers to renewable energy penetration; a framework for analysis. *Renewable energy*, 24(1), 73-89.
- Pang, S. L., Wang, M. L., Hua, G. H., & Liu, Y. Q. (2022). Towards a Greener Future: How do R&D Factor Market Distortions Affect Green Total Factor Energy Efficiency?. *Advanced Sustainable Systems*, 6(7), 2200026.
- Papies, D., Ebbes, P., & Van Heerde, H. J. (2017). Addressing endogeneity in marketing models. *Advanced methods for modeling markets*, 581-627.
- Park, Y. S., Konge, L., & Artino, A. R. (2020). The positivism paradigm of research. *Academic medicine*, 95(5), 690-694.
- Parry, I. W., Black, S., & Zhunussova, K. (2022). Carbon Taxes or Emissions Trading Systems?: Instrument Choice and Design. *Staff Climate Notes*, 2022(006).
- Patterson, M. G. (1996). What is energy efficiency?: Concepts, indicators and methodological issues. *Energy policy*, 24(5), 377-390.
- Pearce, D. (1991). The role of carbon taxes in adjusting to global warming. *The economic journal*, 101(407), 938-948.
- Perkins, J.H. (2021). Electrical systems and the mitigation of climate change. *Journal of Environmental Studies and Sciences*, 11, 281-285.
- Pesaran, M. H., & Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of econometrics*, 142(1), 50-93.
- Pessino, C., & Fenochietto, R. (2010). Determining Countries' Tax Effort. *Public Economics: Taxation*.
- Peszko, G., Black, S., Platonova-Oquab, A., Heine, D., & Timilsina, G. (2019). Environmental Fiscal Reform in Morocco: Options and Pathways.
- Petrie, M., & Petrie, M. (2021). *Environmental Governance and the Greening of Fiscal Policy* (pp. 109-142). Springer International Publishing.
- Pfeiffer, B., & Mulder, P. (2013). Explaining the diffusion of renewable energy technology in developing countries. *Energy Economics*, 40, 285-296.
- Pham, N., & Pham, T. (2019). Foreign aid, recipient government's fiscal behavior, and economic growth. *Economics Bulletin*, 39(4), 2457-2466
- Pigou, AC (1920). *The Economics of Welfare*. London: Macmillan.
- Ping, S. N., Wang, Y. T., & Chang, W. Y. (2022). The effects of China's development projects on political accountability. *British Journal of Political Science*, 52(1), 65-84.
- Pomeranz, D. (2018). Raising money for the state: challenges of taxation in developing countries. DEC lecture series.
- Porter, L., Rickards, L., Verlie, B., Bosomworth, K., Moloney, S., Lay, B., ... & Pellow, D. (2020). Climate justice in a climate changed world. *Planning Theory & Practice*, 21(2), 293-321.
- Pourhoseingholi, M. A., Baghestani, A. R., & Vahedi, M. (2012). How to control confounding effects by statistical analysis. *Gastroenterology and hepatology from bed to bench*, 5(2), 79.
- Power, M., Newell, P., Baker, L., Bulkeley, H., Kirshner, J., & Smith, A. (2016). The political economy of energy transitions in Mozambique and South Africa: The role of the Rising Powers. *Energy Research & Social Science*, 17, 10-19.
- Prasad M. (2022). Hidden benefits and dangers of carbon tax. *PLOS Clim* 1(7): e0000052. <https://doi.org/10.1371/journal.pclm.0000052>
- Pretis, F. (2022). Does a carbon tax reduce CO2 emissions? Evidence from British Columbia. *Environmental and Resource Economics*, 83(1), 115-144.
- Prichard, W., Salardi, P., & Segal, P. (2014). Taxation, non-tax revenue and democracy: new evidence using new cross-country data. ICTD Working Paper 23.

- Proskuryakova, L., & Kovalev, A. (2015). Measuring energy efficiency: is energy intensity a good evidence base?. *Applied energy*, 138, 450-459.
- Pueyo, A. (2018). What constrains renewable energy investment in Sub-Saharan Africa? A comparison of Kenya and Ghana. *World Development*, 109, 85-100.
- Pui, K. L., & Othman, J. (2019). The influence of economic, technical, and social aspects on energy-associated CO₂ emissions in Malaysia: An extended Kaya identity approach. *Energy*, 181, 468-493.
- Qadir, S. A., Al-Motairi, H., Tahir, F., & Al-Fagih, L. (2021). Incentives and strategies for financing the renewable energy transition: A review. *Energy Reports*, 7, 3590-3606.
- Qu, X., & Sun, X. (2022). How to improve the function of government carbon tax in promoting enterprise carbon emission reduction: From the perspective of three-stage dynamic game. *Environmental Science and Pollution Research*, 29(21), 31348-31362.
- Quang, D. V., Milani, D., & Zahra, M. A. (2023). A review of potential routes to zero and negative emission technologies via the integration of renewable energies with CO₂ capture processes. *International Journal of Greenhouse Gas Control*, 124, 103862.
- Rahman, M. S., & Giessen, L. (2017). Formal and informal interests of donors to allocate aid: Spending patterns of USAID, GIZ, and EU forest development policy in Bangladesh. *World Development*, 94, 250-267.
- Rajaraman, I. (2003). Tackling Agriculture in a Developing Country: A Proposal for India (No. paper0322). International Center for Public Policy, Andrew Young School of Policy Studies, Georgia State University.
- Refaei, R., & Sameti, M. (2015). Official development assistance and economic growth in Iran. *International Journal of Management, Accounting and Economics*, 2(2), 125-135.
- Regueiro-Ferreira, R. M., & Cadaval Sampedro, M. (2022). Renewable energy taxes and environmental impacts: A critical reflection from the wind tax in Spain. *Energy & Environment*, 0958305X221083249.
- Remmer, K. L. (2004). Does foreign aid promote the expansion of government?. *American Journal of Political Science*, 48(1), 77-92.
- Ricciuti, R., Savoia, A., & Sen, K. (2019). How do political institutions affect fiscal capacity? Explaining taxation in developing economies. *Journal of Institutional Economics*, 15(2), 351-380.
- Ringel, M., Bruch, N., & Knodt, M. (2021). Is clean energy contested? Exploring which issues matter to stakeholders in the European Green Deal. *Energy Research & Social Science*, 77, 102083.
- Ritchie, H., Roser, M., & Rosado, P. (2022, October 27). Fossil fuels. *Our World in Data*. Retrieved January 2, 2023, from <https://ourworldindata.org/fossil-fuels>
- Iea. (n.d.). Executive summary – world energy outlook 2021 – analysis. IEA. Retrieved January 2, 2023, from <https://www.iea.org/reports/world-energy-outlook-2021/executive-summary>
- Roser, M., Ritchie, H., & Ortiz-Ospina, E. (2020). Renewable Energy. *Our World in Data*. <https://ourworldindata.org/renewable-energy>
- Ryan, A. M., Kontopantelis, E., Linden, A., & Burgess Jr, J. F. (2019). Now trending: Coping with non-parallel trends in difference-in-differences analysis. *Statistical methods in medical research*, 28(12), 3697-3711.
- Saadaoui, H., & Chtourou, N. (2022). Do institutional quality, financial development, and economic growth improve renewable energy transition? Some evidence from Tunisia. *Journal of the Knowledge Economy*, 1-32.
- Salter, J., & Wilkinson, O. (2023). Faith framing climate: a review of faith actors' definitions and usage of climate change. *Climate and Development*, 1-12.
- Sant'Anna, P. H., & Zhao, J. (2020). Doubly robust difference-in-differences estimators. *Journal of Econometrics*, 219(1), 101-122.
- Sarpong, K. A., Xu, W., Gyamfi, B. A., & Ofori, E. K. (2023). Can environmental taxes and green-energy offer carbon-free E7 economies? An empirical analysis in the framework of COP-26. *Environmental Science and Pollution Research*, 30(18), 51726-51739.

- Saunders, M. N., Lewis, P., Thornhill, A., & Bristow, A. (2015). Understanding research philosophy and approaches to theory development.
- Saunders, M., Lewis, P., & Thornhill, A. (2019). Research methods for business students eight edition. *QualitativeMarket Research: An International Journal*.
- Schneider, F., Buehn, A., & Montenegro, C. E. (2010). New estimates for the shadow economies all over the world. *International Economic Journal*, 24(4), 443-461.
- Schratzstaller, M., & Köppl, A. (2021). Taxation in Support of Green Transition. An Overview and Assessment of Existing Tax Practices to Reduce Greenhouse Gas Emissions. *WIFO Studies*.
- Schwerhoff, G., & Sy, M. (2017). Financing renewable energy in Africa—Key challenge of the sustainable development goals. *Renewable and Sustainable Energy Reviews*, 75, 393-401.
- Scott, S. V., & Ku, C. (Eds.). (2018). *Climate Change and the UN Security Council*.
- Sebele-Mpofu, F. Y. (2020). Governance quality and tax morale and compliance in Zimbabwe's informal sector. *Cogent Business & Management*, 7(1), 1794662.
- Sekaran, U., & Bougie, R. (2016). *Research methods for business: A skill building approach*. John Wiley & Sons.
- Selaya, P., & Sunesen, E. R. (2012). Does foreign aid increase foreign direct investment?. *World Development*, 40(11), 2155-2176.
- Shafiee, S., & Topal, E. (2009). When will fossil fuel reserves be diminished?. *Energy policy*, 37(1), 181-189.
- Shafiei, S., & Salim, R. A. (2014). Non-renewable and renewable energy consumption and CO2 emissions in OECD countries: a comparative analysis. *Energy policy*, 66, 547-556.
- Shahbaz, M., Topcu, B. A., Sarigül, S. S., & Vo, X. V. (2021). The effect of financial development on renewable energy demand: The case of developing countries. *Renewable Energy*, 178, 1370-1380.
- Shahsavari, A., & Akbari, M. (2018). Potential of solar energy in developing countries for reducing energy-related emissions. *Renewable and Sustainable Energy Reviews*, 90, 275-291.
- Shahzad, U. (2020). Environmental taxes, energy consumption, and environmental quality: Theoretical survey with policy implications. *Environmental Science and Pollution Research*, 27(20), 24848-24862.
- Shahzad, U., Ferraz, D., Doğan, B., & do Nascimento Rebelatto, D. A. (2020). Export product diversification and CO2 emissions: Contextual evidences from developing and developed economies. *Journal of Cleaner Production*, 276, 124146.
- Shamsi, S. F., & Farzanegan, M. R. (2021). Investigating the role of environmental taxes and environmental technologies on renewable energy consumption in OECD countries. *Journal of Environmental Economics and Policy*. <https://doi.org/10.1080/1331677X.2021.1962383>
- Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. *Festschrift in honor of Peter Schmidt: Econometric methods and applications*, 281-314.
- Shove, E. (2018). What is wrong with energy efficiency?. *Building Research & Information*, 46(7), 779-789.
- Siddique, H. M. A., Anwar, Z., Sharif, A., & Majeed, M. T. (2020). The role of energy aid, economic and political institutions in promoting renewable energy consumption: Evidence from developing economies. *Renewable Energy*, 156, 1105-1117.
- Silva, S., Soares, I., & Afonso, O. (2021). Assessing the double dividend of a third-generation environmental tax reform with resource substitution. *Environment, Development and Sustainability*, 23(10), 15145-15156.
- Silvia, F., Talia, V., & Di Matteo, M. (2021). Coal mining and policy responses: Are externalities appropriately addressed? A meta-analysis. *Environmental Science & Policy*, 126, 39-47.
- Skipper, S. J. (2022). *Wage Salience: A Method to Increase Financial Flows to the Global South* (Doctoral dissertation, University of Colorado at Denver).

- Skovgaard, J., Ferrari, S. S., & Knaggård, Å. (2019). Mapping and clustering the adoption of carbon pricing policies: what polities price carbon and why?. *Climate Policy*, 19(9), 1173-1185.
- Song, Y., & Zhang, M. (2019). Study on the gravity movement and decoupling state of global energy-related CO₂ emissions. *Journal of environmental management*, 245, 302-310.
- Sothan, S. (2018). Foreign aid and economic growth: evidence from Cambodia. *The Journal of International Trade & Economic Development*, 27(2), 168-183.
- Sovacool, B. K. (2021). Clean, low-carbon but corrupt? Examining corruption risks and solutions for the renewable energy sector in Mexico, Malaysia, Kenya and South Africa. *Energy Strategy Reviews*, 38, 100723.
- Sovacool, B. K., & Dworkin, M. H. (2014). *Global energy justice*. Cambridge University Press.
- Sovacool, B. K., Linnér, B. O., Sovacool, B. K., & Linnér, B. O. (2016). Introduction to the political economy of climate change adaptation (pp. 1-32). Palgrave Macmillan UK.
- Sovacool, B. K., Tan-Mullins, M., Ockwell, D., & Newell, P. (2017). Political economy, poverty, and polycentrism in the global environment facility's least developed countries fund (LDCF) for climate change adaptation. *Third World Quarterly*, 38(6), 1249-1271.
- Spinesi, L. (2022). The environmental tax: Effects on inequality and growth. *Environmental and Resource Economics*, 82(3), 529-572.
- Steenkamp, L. A. (2017). 4. To incentivise or penalise: an analysis of the proposed carbon tax. *The Green Market Transition: Carbon Taxes, Energy Subsidies and Smart Instrument Mixes*, 47.
- Stefan , E. (2022, July 8). Explainer: Which countries have introduced a carbon tax?. *World Economic Forum*. <https://www.weforum.org/agenda/2022/07/carbon-tax-emissions-countries/>
- Stiglitz, J.E., Stern, N., Duan, M., Edenhofer, O., Giraud, G., Heal, G., Lecocq, F., Morris, A., Moyer, E., Pangestu, M., Shukla, P.R., Sokona, Y. and Winkler, H. (2017). Report of the High-Level Commission on Carbon Prices. Washington, DC: World Bank. Available at: <https://www.carbonpricingleadership.org/report-of-the-highlevel-commission-on-carbon-prices/> [Accessed 7 July. 2023].
- Su, C. W., Sun, T., Ahmad, S., & Mirza, N. (2021). Does institutional quality and remittances inflow crowd-in private investment to avoid Dutch Disease? A case for emerging seven (E7) economies. *Resources Policy*, 72, 102111.
- Sun, Y., Mao, X., Yin, X., Liu, G., Zhang, J., & Zhao, Y. (2021). Optimizing carbon tax rates and revenue recycling schemes: Model development, and a case study for the Bohai Bay area, China. *Journal of Cleaner Production*, 296, 126519.
- Svensson, J. (2000). Foreign aid and rent-seeking. *Journal of International Economics*, 51(2), 437-461. [https://doi.org/10.1016/S0022-1996\(99\)00014-8](https://doi.org/10.1016/S0022-1996(99)00014-8)
- Szent-Iványi, B., & Timofejevs, P. F. (2021). Selective norm promotion in international development assistance: the drivers of naming and shaming advocacy among European non-governmental development organisations. *International Relations*, 35(1), 23-46.
- Taalas, P. (2021, October 19). Climate change triggers food insecurity, poverty and displacement in Africa | Africa Renewal. United Nations. <https://www.un.org/africarenewal/magazine/climate-change-triggers-food-insecurity-poverty-and-displacement-africa>
- Tabrizian, S. (2019). Technological innovation to achieve sustainable development—Renewable energy technologies diffusion in developing countries. *Sustainable Development*, 27(3), 537-544.
- Taibi, E., Gualberti, G., Bazilian, M., & Gielen, D. (2016). A framework for technology cooperation to accelerate the deployment of renewable energy in Pacific Island Countries. *Energy Policy*, 98, 778-790.
- Tang, K. B., & Bundhoo, D. (2017). Foreign aid and economic growth in developing countries: Evidence from Sub-Saharan Africa. *Theoretical Economics Letters*, 7(05), 1473.
- Teera, J. M., & Hudson, J. (2004). Tax performance: a comparative study. *Journal of international development*, 16(6), 785-802.
- The Tax Foundation. (2022). Carbon Taxes in Europe 2022. Retrieved from <https://taxfoundation.org/carbon-taxes-in-europe-2022/>

- Thisted, E. V., & Thisted, R. V. (2020). The diffusion of carbon taxes and emission trading schemes: The emerging norm of carbon pricing. *Environmental Politics*, 29(5), 804-824.
- Thornton, J. (2014). Does foreign aid reduce tax revenue? Further evidence. *Applied Economics*, 46(4), 359-373.
- Timilsina, G. (2022). Carbon taxes. *Journal of Economic Literature* (forthcoming).
- Timmons, J. F. (2005). The fiscal contract: States, taxes, and public services. *World Politics*, 57(4), 530-567.
- Timmons, J. F., & Garfias, F. (2015). Revealed corruption, taxation, and fiscal accountability: Evidence from Brazil. *World Development*, 70, 13-27.
- Tomás, M., García-Muros, X., Alonso-Elpede, E., Arto, I., Rodríguez-Zúñiga, A., Monge, C., & González-Eguino, M. (2023). Ensuring a just energy transition: A distributional analysis of diesel tax reform in Spain with stakeholder engagement. *Energy Policy*, 177, 113558.
- Torgler, B., Schneider, F., & Schaltegger, C. A. (2007). With or against the people? The impact of a bottom-up approach on tax morale and the shadow economy (No. 2007-04). CREMA Working Paper.
- Tullock, G. (1967). Excess benefit. *Water Resources Research*, 3(2), 643-644.
- Ullah, A., Zhao, X., Kamal, M. A., & Zheng, J. (2020). Modeling the relationship between military spending and stock market development (a) symmetrically in China: An empirical analysis via the NARDL approach. *Physica A: Statistical Mechanics and its Applications*, 554, 124106.
- Ulucak, R., Danish, & Kassouri, Y. (2020). An assessment of the environmental sustainability corridor: Investigating the non-linear effects of environmental taxation on CO2 emissions. *Sustainable Development*, 28(4), 1010-1018.
- UN Handbook on Carbon Taxation for Developing Countries (2021). United Nations\
- van den Bergh, J., & Savin, I. (2021). Impact of carbon pricing on low-carbon innovation and deep decarbonisation: controversies and path forward. *Environmental and Resource Economics*, 80(4), 705-715.
- Van Heerden, J., Gerlagh, R., Blignaut, J., Horridge, M., Hess, S., Mabugu, R., & Mabugu, M. (2006). Searching for triple dividends in South Africa: Fighting CO2 pollution and poverty while promoting growth. *The Energy Journal*, 27(2).
- Venmans, F., Ellis, J., & Nachtigall, D. (2020). Carbon pricing and competitiveness: are they at odds?. *Climate Policy*, 20(9), 1070-1091.
- Vohra, K., Vodonos, A., Schwartz, J., Marais, E. A., Sulprizio, M. P., & Mickley, L. J. (2021). Global mortality from outdoor fine particle pollution generated by fossil fuel combustion: Results from GEOS-Chem. *Environmental research*, 195, 110754.
- Waheed, R., Sarwar, S., & Wei, C. (2019). The survey of economic growth, energy consumption and carbon emission. *Energy Reports*, 5, 1103-1115.
- Wang, B., Zhu, J., Pierson, E., Ramazzotti, D., & Batzoglou, S. (2017). Controlling for confounding effects in single cell RNA sequencing studies using both negative and positive control genes. *Scientific Reports*, 7(1), 13295. <https://doi.org/10.1038/s41598-017-13665-w>
- Wang, K., Su, X., & Wang, S. (2023a). How does the energy-consuming rights trading policy affect China's carbon emission intensity? *Energy* (forthcoming).
- Wang, Q., & Wang, S. (2020). Is energy transition promoting the decoupling economic growth from emission growth? Evidence from the 186 countries. *Journal of Cleaner Production*, 260, 120768.
- Wang, Q., Guo, J., & Dong, Z. (2021). The positive impact of official development assistance (ODA) on renewable energy development: evidence from 34 Sub-Saharan Africa Countries. *Sustainable Production and Consumption*, 28, 532-542.
- Wang, Q., Guo, J., Li, R., Mikhaylov, A., & Moiseev, N. (2023b). Does technical assistance alleviate energy poverty in sub-Saharan African countries? A new perspective on spatial spillover effects of technical assistance. *Energy Strategy Reviews*, 45, 101047.
- Ward, M. (2020, September 22). "The time is now," says EY CEO Carmine Di Sibio, as the Big Four corporate accounting firms get serious about ethical governance and endorse official ESG reporting

- standards. Business Insider Africa. <https://africa.businessinsider.com/strategy/the-time-is-now-says-ey-ceo-carmine-di-sibio-as-the-big-four-corporate-accounting/yq49vwc>
- Wei, W., Cai, W., Guo, Y., Bai, C., & Yang, L. (2020). Decoupling relationship between energy consumption and economic growth in China's provinces from the perspective of resource security. *Resources Policy*, 68, 101693.
- Wen, H., Deng, W., & Guo, Q. (2021). The effects of the environmental protection tax law on heavily polluting firms in China. *Plos one*, 16(12), e0261342.
- Wen, J., Farooq, U., Tabash, M. I., El Refae, G. A., & Subhani, B. H. (2023). Governance and tax revenue: does foreign aid matter?. *International Review of Administrative Sciences*, 89(1), 273-291.
- Wesseh Jr, P. K., & Lin, B. (2018). Optimal carbon taxes for China and implications for power generation, welfare, and the environment. *Energy Policy*, 118, 1-8.
- Wesseh Jr, P. K., & Lin, B. (2019). Environmental policy and 'double dividend' in a transitional economy. *Energy Policy*, 134, 110947.
- Whitfield, L. (2010). The state elite, PRSPs and policy implementation in aid-dependent Ghana. *Third World Quarterly*, 31(5), 721-737.
- Whittington, D., & Calhoun, C. (1988). Who Really Wants Donor Coordination? *Development Policy Review*, 6(3), 295-309.
- Wilkins, G. (2010). *Technology transfer for renewable energy*. Taylor & Francis.
- Wolde-Rufael, Y., & Mulat-Weldemeskel, E. (2021). Do environmental taxes and environmental stringency policies reduce CO₂ emissions? Evidence from 7 emerging economies. *Environmental Science and Pollution Research*, 28, 22392-22408.
- Wolde-Rufael, Y., & Mulat-weldemeskel, E. (2021). Do environmental taxes and environmental stringency policies reduce CO₂ emissions? Evidence from 7 emerging economies. *Environmental Science and Pollution Research International*, 28, 22392 - 22408.
- Wolde-Rufael, Y., & Mulat-Weldemeskel, E. (2022). The moderating role of environmental tax and renewable energy in CO₂ emissions in Latin America and Caribbean countries: evidence from method of moments quantile regression. *Environmental Challenges*, 6,
- Wolf, C., Wang, X., & Warner, E. (2013). *China's foreign aid and government-sponsored investment activities: Scale, content, destinations, and implications* (p. viii). Santa Monica, CA: Rand Corporation.
- World Bank. (2023). "State and Trends of Carbon Pricing 2023". Washington, DC: World Bank.
- Wunderling, N., Winkelmann, R., Rockström, J., Loriani, S., Armstrong McKay, D. I., Ritchie, P. D., ... & Donges, J. F. (2023). Global warming overshoots increase risks of climate tipping cascades in a network model. *Nature Climate Change*, 13(1), 75-82.
- Xia, W., Apergis, N., Bashir, M. F., Ghosh, S., Doğan, B., & Shahzad, U. (2022). Investigating the role of globalization, and energy consumption for environmental externalities: empirical evidence from developed and developing economies. *Renewable Energy*, 183, 219-228.
- Xian-sen, L. I. (2015). Environmental Tax on International Cooperation and Coordination Based on Transnational Externality. *Journal of Beijing University of Posts and Telecommunications (Social Sciences Edition)*, 17(4), 77.
- Xiaosong, W., & Siyuan, T. (2020). Institutional quality, foreign aid and economic growth in recipient countries. *China Economist*, 15(6), 68-83.
- Yahoo, M., & Othman, J.B. (2017). Carbon and energy taxation for CO₂ mitigation: a CGE model of the Malaysia. *Environment, Development and Sustainability*, 19, 239-262.
- Yang, S., & Park, S. (2020). The effects of renewable energy financial incentive policy and democratic governance on renewable energy aid effectiveness. *Energy Policy*, 145, 111682.
- Yang, X., Jiang, P., & Pan, Y. (2020). Does China's carbon emission trading policy have an employment double dividend and a Porter effect?. *Energy Policy*, 142, 111492.
- Yang, X., Wang, S., Zhang, W., Li, J., & Zou, Y. (2016). Impacts of energy consumption, energy structure, and treatment technology on SO₂ emissions: A multi-scale LMDI decomposition analysis in China. *Applied energy*, 184, 714-726.

- Yang, Z., Zhang, M., Liu, L., & Zhou, D. (2022). Can renewable energy investment reduce carbon dioxide emissions? Evidence from scale and structure. *Energy Economics*, 112, 106181.
- Yiew, T. H., & Lau, E. (2018). Does foreign aid contribute to or impeded economic growth. *Journal of International Studies* Vol, 11(3), 21-30.
- Yu, L., Gao, X., Lyu, J., Feng, Y., Zhang, S., & Andlib, Z. (2023). Green growth and environmental sustainability in China: the role of environmental taxes. *Environmental Science and Pollution Research*, 30(9), 22702-22711.
- Yüksel, S., & Mikhaylov, A. (2022). The effect of the carbon tax to minimize emission. In *Clean Energy Investments for Zero Emission Projects: An Analysis on How to Reduce the Carbon Footprint* (pp. 1-11). Cham: Springer International Publishing.
- Yunzhao, L. (2022). Modelling the role of eco innovation, renewable energy, and environmental taxes in carbon emissions reduction in E- 7 economies: evidence from advance panel estimations. *Renewable Energy*, 190, 309-318.
- Zafar, M. W., Shahbaz, M., Hou, F., & Sinha, A. (2019). From nonrenewable to renewable energy and its impact on economic growth: the role of research & development expenditures in Asia-Pacific Economic Cooperation countries. *Journal of cleaner production*, 212, 1166-1178.
- Zardoub, A., & Sboui, F. (2021). Impact of foreign direct investment, remittances and official development assistance on economic growth: panel data approach. *PSU Research Review*, (ahead-of-print).
- Zhang, J., Patwary, A. K., Sun, H., Raza, M., Taghizadeh-Hesary, F., & Iram, R. (2021). Measuring energy and environmental efficiency interactions towards CO₂ emissions reduction without slowing economic growth in central and western Europe. *Journal of environmental management*, 279, 111704.
- Zhou, Z., Zhang, W., Pan, X., Hu, J., & Pu, G. (2020). Environmental tax reform and the “double dividend” hypothesis in a small open economy. *International Journal of Environmental Research and Public Health*, 17(1), 217.
- Zhu, Y., Ghosh, M., Luo, D., Macaluso, N., & Rattray, J.S. (2018). Revenue Recycling And Cost Effective Ghg Abatement: An Exploratory Analysis Using A Global Multi-Sector Multi-Region Cge Model. *Climate Change Economics*, 09, 1840009.
- Zimmer, A., & Koch, N. (2017). Fuel consumption dynamics in Europe: Tax reform implications for air pollution and carbon emissions. *Transportation Research Part A: Policy and Practice*, 106, 22-50.

