

**THE EFFECTS OF ECONOMIC GLOBALIZATION ON GREENHOUSE GAS  
EMISSIONS: AN EMPIRICAL ANALYSIS**

**TOCHUKWU EMMANUEL IDEBA**  
Bachelor of Science, University of Nigeria, 2022

A Thesis Submitted in Partial Fulfilment of the Requirements of

**MASTER OF ARTS**

In

**ECONOMICS**

Department of Economics  
University of Lethbridge  
LETHBRIDGE, ALBERTA, CANADA

© Tochukwu Emmanuel Ideba, 2026

**THE EFFECTS OF ECONOMIC GLOBALIZATION ON GREENHOUSE GAS  
EMISSIONS: AN EMPIRICAL ANALYSIS**

Date of Defence: March 12, 2026

Dr. Pascal Ghazalian                      Professor                      Ph.D.  
Supervisor

Dr. Duane Rockerbie                      Professor                      Ph.D.  
Thesis Examination Committee Member

Dr. Stavroula Malla                      Professor                      Ph.D.  
Thesis Examination Committee Member

Dr. Amir Akbary                      Professor                      Ph.D.  
Chair, Thesis Examination Committee

## ABSTRACT

When a coin is flipped, there are only two possible outcomes: heads or tails. There is no consideration that the wind direction, or even the coin's weight, might influence the result. This is similar to the current discussion on economic globalization and GHG emissions, which is a key limitation of existing research. Studies argue whether economic globalization increases or decreases emissions, often failing to recognize that there are nuances associated with nations' absorption of economic globalization, and ultimately, how it affects the environment. Therefore, this study addresses this limitation by examining the effects of economic globalization on greenhouse gas emissions first globally, then on a subset of sub-Saharan Africa (SSA), accounting for how economic structures influence the environmental absorption of globalization. Using secondary panel data for 103 countries (2000–2023), the study employs the Fixed Effects Model as a benchmark and the Panel Corrected Standard Error (PCSE) model to account for contemporaneous correlation. The empirical results reveal that while economic globalization generally reduces emissions, there is also a significant global split. In developed countries, economic globalization reduces greenhouse gas emissions, while it exacerbates them in the developing world. Further findings reveal that increased per capita income is a necessary factor in reducing emissions. The central finding is the “structural neutrality” of SSA. In SSA, the net effects of trade openness and FDI are near-zero. Specifically, the SSA-specific mitigating factor cancels out the general pollution haven tendency found in other developing nations. This suggests that SSA is not a significant pollution haven, primarily due to its extractive economic profile rather than carbon-intensive manufacturing. The study concludes that because globalization is environmentally inert in SSA, governments should prioritize growth-enhancing policies which will facilitate the transition to higher income per capita levels necessary for environmental remediation. SSA governments must invest in renewable energy, quality infrastructure, and human capital.

## ACKNOWLEDGEMENTS

With a heart full of thanks and gratitude, I acknowledge God, who is the giver of wisdom, knowledge, and understanding. Without Him, I would not have come this far. He has seen me through thick and thin, pleasant and unpleasant situations. I am grateful for His undying love and grace.

How can this piece of expression be complete if I fail to recognize the master craftsman behind this empirical research? I would like to express my gratitude to Professor Pascal Ghazalian, my instructor and supervisor, in the most particular and sincere way possible. He gave meticulous, friendly, encouraging, educational, and intellectual assistance throughout the study process. Also, my appreciation goes to my committee members, Professor Duane Rockerbie and Professor Stavroula Malla, for their kind corrections and inputs that made this piece of work a success.

To my mum, Mrs. Patricia Ideba Nwafor, thank you for being a great support and strength in all ramifications. And to my beloved dad, Mr. David Ideba Nwafor. I say thank you for supporting both financially and emotionally. To my sister, Kelechi Chiamaka, and kiddies Ideba Oluebube, Ideba Ifeanyi, Ideba Favor, Ideba Amarachi, and Ideba Goodluck, I love you all. Words are not enough to express the gratitude in my heart. God bless you all.

## TABLE OF CONTENTS

Contents	Pages
TITLE PAGE.....	I
THESIS EXAMINATION COMMITTEE.....	ii
ACKNOWLEDGEMENTS.....	iv
TABLE OF CONTENTS.....	v
LIST OF FIGURES.....	vii
LIST OF TABLES.....	viii
LIST OF ABBREVIATIONS.....	ix
CHAPTER ONE: INTRODUCTION.....	1
1.1 Background of the Study.....	1
1.2 The Global Imperative for Environmental Sustainability.....	3
1.3 Economic Globalization: Definition and Evolution.....	7
1.4 The Empirical Debate of Economic Globalization and Greenhouse Emissions: Pollution Haven Vs Porter Hypothesis.....	11
1.5 Sub-Saharan Africa: A Critical Case Study.....	13
1.6 Objectives of the Study.....	15
1.7 Significance of the Study.....	17
CHAPTER TWO: LITERATURE REVIEW.....	20
2.1 Conceptual Literature.....	20
2.2 Theoretical Literature.....	26
2.3 Empirical Literature.....	35

2.4 Research Gap and Objectives .....	44
CHAPTER THREE: MODEL SPECIFICATION AND METHODOLOGY.....	48
3.1 Analytical Framework.....	48
3.2. Model Specification.....	53
3.3. Estimation Technique.....	55
3.4. Pre-Estimation Tests .....	56
3.5 Methods of Result Evaluation.....	60
3.6. Software Packages .....	62
CHAPTER FOUR: DATA AND DESCRIPTIVE STATISTICS.....	63
4.1. Data.....	63
4.2. Descriptive Statistics.....	67
CHAPTER FIVE: EMPIRICAL RESULTS .....	72
5.1 Global Empirical Results .....	74
5.2 Empirical Results for Sub-Saharan Africa (SSA).....	90
CHAPTER SIX: CONCLUSION.....	101
REFERENCES .....	106

## LIST OF FIGURES

Figure 1.1:Global GHG Emissions .....	5
Figure 1.2:Global Merchandise Trade and Economic Growth .....	10
Figure 1.3: Greenhouse Gas Emissions in Sub-Saharan Africa.....	15
Figure 2.1: Trends in FDI Openness and GHG Emissions in Developing Countries.....	33

## LIST OF TABLES

Table 3.1: A Priori Expectations of Parameters .....	60
Table 4.1: Nature and Sources of Data .....	63
Table 4.2: Descriptive Statistics.....	68
Table 4.3: CSD, panel unit root, and cointegration tests .....	70
Table 4.4: Pairwise Correlation.....	71
Table 5.1: Fixed Effects Models with LTOP and FDI .....	78
Table 5.2: Fixed Effect Models with FTI.....	79
Table 5.3: Random Effect Models with LTOP and FDI.....	80
Table 5.4: Random Effect Models with FTI .....	81
Table 5.5: Hausman Test Result.....	83
Table 5.6: Panel Corrected Standard Error (PCSE) Models with LTOP and FDI .....	86
Table 5.7: Panel Corrected Standard Error (PCSE) Models with FTI.....	90
Table 5.8: Fixed and Random Effect Models for Sub-Saharan Africa with LTOP and FDI....	93
Table 5.9: Panel Corrected Standard Error (PCSE) Models for SSA with LTOP and FDI .....	97
Table 5.10: Fixed and Random Effect Models for Sub-Saharan Africa (SSA) with FTI .....	99
Table 5.11: Panel Corrected Standard Error (PCSE) Models for SSA with FTI .....	100

## LIST OF ABBREVIATIONS

APEC	Asia Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
CLRM	Classical Linear Regression Model
CSD	Cross-sectional Dependence
ECOWAS	Economic Community of West African States
FDI	Foreign Direct Investment
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GLS	Generalized Least Squares
ICC	International Chamber of Commerce
IMF	International Monetary Fund
MENA	Middle East and North Africa
MNCs	Multinational Corporations
MNEs	Multinational Enterprises
NASA	National Aeronautics and Space Administration
NDC	Nationally Determined Contributions
PCSE	Panel Corrected Standard Error
SSA	Sub-Saharan Africa
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	The United Nations Development Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USMCA	United States-Canada-Mexico Agreement

WDI	World Development Indicators
WDI	World Development Indicators
WFP	World Food Program
WHO	World Health Organization
WMO	World Meteorological Organization
WTO	World Trade Organization

# CHAPTER ONE

## INTRODUCTION

### 1.1 Background of the Study

For decades, environmental economists have tirelessly worked towards achieving a sustainable global economy – one in which the well-being of future generations is prioritized, even as the needs of current global citizens are adequately met. This has not been an easy task, as the industrial revolution of the late 18<sup>th</sup> to early 20<sup>th</sup> centuries (which propagated the adoption of fossil-fuel reliant industrial machinery for production) left a severe legacy of environmental degradation that persists today (Anderson, 2024). This historical shift fundamentally altered the planet’s atmospheric composition, setting in motion a trajectory of climate change that now poses an existential threat.

Nicholas Stern, the former Chief Economist of the World Bank and currently chair of the Grantham Research Institute on Climate Change, outlined the costs of climate change in his 2006 report, the “Stern Review.” He acknowledged that climate change is an externality resulting from past economic activities, stating that “greenhouse gases represent the biggest market failure the world has ever seen” (Stern, 2006). Market failures often occur when future costs are not included in current production processes. As production and consumption grow and the global market expands, many economists argue that greenhouse gas emissions will also increase consistently (Kastratovic, 2019; Destek, 2020; Kalayci & Hayaloglu, 2024).

Stern famously estimated that if measures are not put in place to correct this failure, the overall costs and risks of greenhouse gas (GHG) emissions could be equivalent to losing “at least 5% of global GDP each year” and, with a broader range of risks, could rise to 20% of GDP (Stern, 2006). Unfortunately, the costs of global GHG emissions have largely followed these past projections and continue to increase, posing even greater threats to future generations. A report

by the International Chamber of Commerce (ICC) found that “climate-change-related extreme weather events” alone cause billions in economic losses annually, with the global economy losing over 2 trillion dollars in the past ten years (ICC, 2024). Beyond direct economic costs, climate change events were estimated to affect 1.6 billion people between 2014 and 2023 (ICC, 2024). Therefore, greenhouse gas emissions and climate change are not merely a future problem, as the Secretary General of the ICC notes, but a problem “felt in the here and now by the real economy” (ICC, 2024).

Despite the widespread acceptance of climate change as a critical market failure and the introduction of policies such as the COP21 and the Paris Agreement, which aim at internalizing these externalities, global GHG emissions continue to rise (see Figure 1.1). This indicates challenges in policy efficacy. Moreover, the fight against global warming has sparked debates over the drivers and effects of climate change, as well as suitable policies to combat it (McLaughlin, 2021). Some arguments underline that economic globalization could be instrumental in eradicating global GHG emissions, as it encourages a joint effort to enhance the speed of transition to a low-carbon economy, through the adoption and transfer of cleaner technologies (as the Paris Agreement proposes). However, critics argue that economic globalization results in environmental degradation through higher levels of production associated with the surge in global demand, noting that the effectiveness of technology transfer in mitigating transmissions depends heavily on the strength of environmental regulations.

While the overall phenomenon is well-documented, global studies offer mixed results, and the generalizability of these findings to regions facing distinct developmental challenges, institutional capacities, and environmental vulnerabilities remains underexplored. For instance, Sub-Saharan Africa (SSA), which presents a compelling case, is the weakest in adapting to and mitigating the implications of GHG emissions. This study aims to provide an updated empirical

structure by first analysing the overall effect of economic globalization, through international trade and Foreign Direct Investment (FDI), on greenhouse gas emissions. This analysis will provide a benchmark of the general trend against which specific regional findings can be compared, using SSA as a case study. By narrowing the focus, the study will explore how global effects differ in SSA, addressing existing ambiguities in the literature and offering new evidence on how and why these effects may vary. Since SSA is dependent on primary resource extraction industries, understanding this specific regional dynamic is necessary for targeted strategies for sustainable development.

## **1.2 The Global Imperative for Environmental Sustainability**

The concept of environmental sustainability, energy preservation, and climate change has been a topic of discussion for several decades. This topic focuses on the careful use and conservation of natural resources in a way that balances economic development and social progress with the protection of the environment. The goal is to ensure that the needs of the future generation are not compromised, even while the needs of the present generation are adequately met. The Brundtland Commission, a sub-organization of the UN, classifies these “needs” as access to clean water, food security, safe and adequate housing, basic healthcare and sanitation, social wellbeing, and economic security (UN, 1987). In the present generation, these needs are supposed to be met within the ecological limits of the planet. This means that current human consumption production processes must respect the Earth’s carrying capacity so that resources are not depleted at rates faster than they can regenerate, and that waste generation does not exceed the environment’s absorptive capacity.

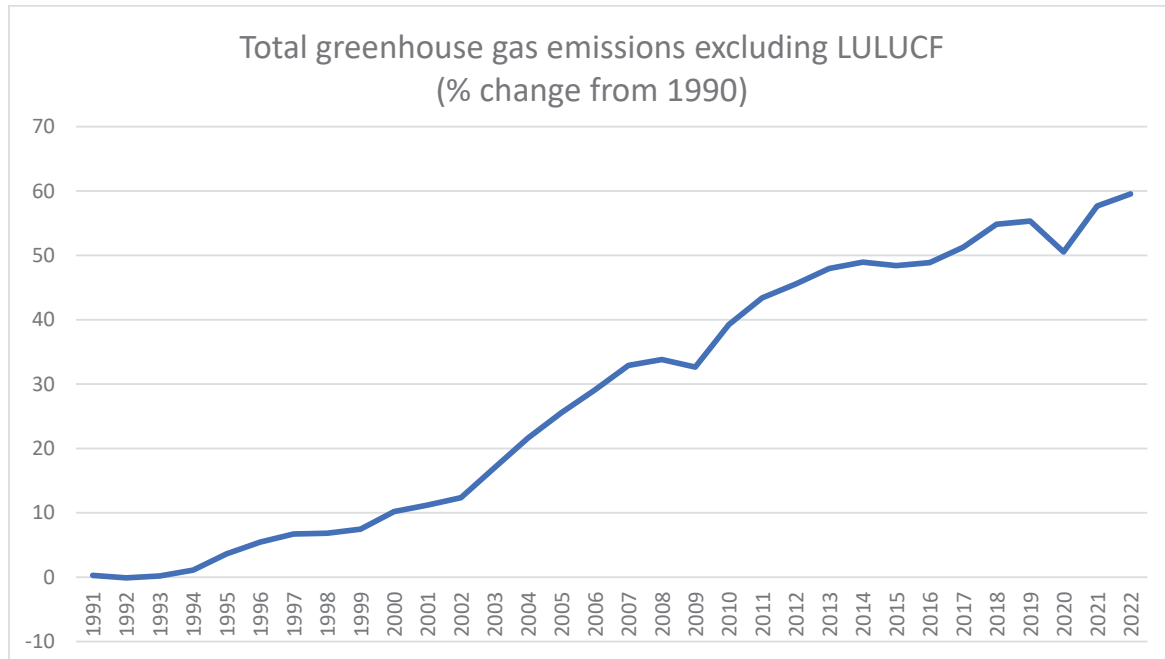
If these ecological boundaries are continually exceeded, the consequences for the planet and its inhabitants would be severe. The excessive accumulation of greenhouse gases (GHGs) in the atmosphere leads to rising global temperatures, typically referred to as global warming. Global warming results in extreme weather events, including prolonged heat waves, extreme

floods, droughts, storms, and rising sea levels (UN, 2015). Beyond these direct effects, environmental degradation severely impacts agriculture. For instance, pollution and GHG emissions grossly affect freshwater resources, which are essential for life and agriculture, thereby directly threatening global food security (Acheampong *et al.*, 2019; Filonchyk *et al.*, 2024).

Unfortunately, despite decades of scientific warnings and the clear articulation of these ecological boundaries, global GHG emissions levels, including carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O), continue to accelerate at an alarming rate. According to the World Meteorological Organization (WMO) (2024), “the globally averaged surface concentrations for carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O) reached new highs in 2023, with CO<sub>2</sub> at 420.0±0.1 ppm, CH<sub>4</sub> at 1934±2 ppb, and N<sub>2</sub>O at 336.9±0.1 ppb. These values constitute, respectively, increases of 151%, 265%, and 125% relative to pre-industrial (before 1750) levels.” It is safe to say that these increases represent a significant shift in the Earth’s atmospheric composition, and this will contribute even more to the Earth’s degradation in the future. CO<sub>2</sub>—the primary contributor to GHG emissions—is largely driven by industrial use of natural gas and fossil fuels, especially in cement production (WMO, 2024). The WMO further highlights that about half of the CO<sub>2</sub> generated from human activity is trapped in the atmosphere, while the rest is absorbed by the land and ocean. Methane is emitted from the integration of natural and human activity, including wetlands, involving about 40% of total methane emissions, and agriculture (*e.g.*, rice production, livestock rearing), involving a larger portion – about 60% (WMO, 2024). Approximately 7% of the Earth’s warming is accounted for by nitrous oxide, which is caused by previously trapped greenhouse gas emissions. To put these figures into perspective, Figure 1 shows that global GHG emissions have been increasing over time, with a sharp increase between 2000 and 2010. Moreover, 2020 saw a dip in GHG emissions because of the economic slowdown caused by the COVID-19

pandemic, after which GHG emissions increased again. Overall, global GHG emissions have been trending upward over time.

Figure 1.1: Global GHG Emissions



Source: Author's construct using data from the World Bank's World Development Indicator (WDI) database.

Consequently, the well-being of the present generation is consistently jeopardized by these environmental crises. According to the United Nations, about 3 billion people experience water shortages globally. A report from the United Nations Educational, Scientific, and Cultural Organization (UNESCO) estimates an increase in urban populations facing water shortages from 930 million in 2016 to between 1.7 and 2.4 billion people globally by 2050 (UNESCO, 2023). Meanwhile, the quality of the environment and food security are closely linked, as previously outlined. The World Food Program (WFP) reported that “a total of 1.9 million are in the grips of catastrophic hunger” (WFP, 2025). The report further highlighted that climate change is a major cause of the increase in global hunger as extreme weather conditions grossly affect agriculture and food security, urging that global hunger will continue to increase drastically if immediate action is not taken. The World Health Organization (WHO) highlighted

that globally, 1 in 11 people faced hunger, 1 in 5 in Africa, equivalent to 733 million people, according to a 2023 UN report (WHO, 2024).

These growing issues have prompted a global imperative for action among researchers and policymakers. At the United Nations Climate Change Conference (COP29) held in November 2024, countries of the world reaffirmed their commitment to COP21, which focuses on keeping the increase in average global temperature below 2°C and continuous efforts to further reduce it below 1.5°C. The goal is to achieve a global emission decline of 43% by 2030 and reach net-zero carbon emissions by 2050. This commitment is a testament to the global effort to reduce greenhouse gas emissions and build a planet capable of adapting to the ongoing climate change. Beyond global initiatives, various regions of the world have joined the fight against environmental degradation. An example is the Asia Pacific Ministerial Conference on Environment and Development, held every five years. This conference serves as a key platform bringing together various climate change and energy preservation bodies to address pressing environmental and development challenges in the region. Furthermore, the World Bank Group, recognized as the largest multilateral funder of climate investments in developing countries, has demonstrated significant commitment through its strategic Climate Change Action Plans. Its first plan (2016-2020) successfully delivered over \$83 billion in climate finance to developing countries, exceeding its target of 28% of total lending for climate-related investments (World Bank, 2020). This initiative also actively supported countries in enhancing their Nationally Determined Contributions (NDCs) under the Paris Agreement and implementing carbon pricing mechanisms. Building on this foundation, the World Bank Group has embarked on its new Climate Change Action Plan for 2021-2025, aiming to significantly increase climate finance, strengthen climate change adaptation efforts globally, and strategically align all financial flows with the transformative goals of the Paris Agreement.

Essentially, for countries at all stages of development, reducing the trajectory of global greenhouse gas emissions remains a matter of urgency.

### **1.3 Economic Globalization: Definition and Evolution**

To address this global imperative for environmental sustainability, there is a need for a deeper dive and a clear understanding of the major drivers of current global economic activity. Since it has been established that human actions (or inactions) contribute to the growing trend in global GHG emissions, we need to highlight how the interconnectedness of the global economy works in this regard. Economic globalization influences patterns of production, consumption, trade, and investment across borders, thereby holding significant implications for both environmental degradation and the potential for sustainable solutions. To fully grasp its role, it is essential to first define and trace the evolution of economic globalization itself.

Economic globalization, according to the United Nations, refers to the growing interrelationship among various countries and regions of the world because of increasing cross-border trade, the dissemination of information, communications, and technology, and the mobility of international capital (Shangquan, 2000; Ghazalian, 2025). Precisely, economic globalization fosters connections between countries through International Trade (the exchange of goods and services between countries through exports and imports) and the mobility of capital (through investments made by entities in one country into a business in another country).

The major facilitators and direct beneficiaries of economic globalization are multinational corporations (MNCs). These are companies that operate in multiple countries, typically having headquarters in their home countries (Pitelis & Sugden, 2000). In a study by Osibanjo *et al.* (2014), it is noted that “modern-day globalization is identified by the actions of multinationals.” This is because these corporations fast-track the flow of business, technologies, and investment

between the home countries and several host countries (Osibanjo *et al.*, 2014) by establishing global supply chains that span continents. The activities of MNCs range from resource extraction and manufacturing to transportation and waste management. According to Sparrow (2004), MNC activities are significant drivers of global energy consumption and, consequently, greenhouse gas emissions (Osibanjo, 2014). In this regard, their role in achieving environmental sustainability within a globalized world cannot be overemphasized.

To fully underscore the present-day dynamics of economic globalization and its environmental implications, it is necessary to trace the historical progression that has shaped its course. Distinct phases have marked the trajectory of economic globalization, each era bearing unique historical features. The “Age of Discovery” during the 15<sup>th</sup> to early 18<sup>th</sup> century marked the first wave of modern economic globalization (Vanham, 2019). European explorers discovered several trade routes, particularly to Asia, for spices, silk, and other essential goods. This era is also noted for the establishment of trading contacts and capital flow between the Old European territories (Africa, Asia, and Europe) and the New World (the Americas) (Wolfe, 2020). During this time, advancements in shipbuilding and navigation facilitated a rise in global trade and investment.

The second wave of economic globalization, often attributed to the mid-19<sup>th</sup> to early 20<sup>th</sup> century, was driven by the Industrial Revolution and a significant reduction in transportation and communication costs. During this period, advancements in steamships, the expansion of railway networks, and the expansion of worldwide telegraph networks facilitated an increase in global trade and investment. According to Vanham (2019), the effect of economic globalization was evident in its numbers: for a century, trade saw an average annual growth of 3%, propelling global merchandise trade from a modest 6% of global GDP to a substantial 14% by the eve of World War I in 1914 (Giovanni, 2018). Though this period was interrupted by the

disruptive forces of World War I, the subsequent economic instability of the Great Depression, and the impact of World War II, the transformation of the global economy is evident in the surge of international trade and its impact on global economic growth. Before 1870, worldwide merchandise trade represented a minor share of global output, remaining below 10% (Fouquin & Hugot, 2016). However, today, that figure has increased to around 25%, and this shows that the growth in global trade has not only been substantial but has also exceeded the rapid pace of economic growth in the last hundred years. Figure 2 below shows that global merchandise trade was increasing at a fast pace before the First World War in 1914. There was a sharp decline from 14% in 1913 to 11% in 1914. The downward trend continued and even declined further during World War II in 1945. After the Great War, merchandise trade started increasing at a fluctuating pace, experiencing some moments of slight decline.

The modern era of economic globalization, according to the World Trade Organization (WTO) (2024), became prominent after World War II, marking the third and most significant wave. This era aimed to rebuild post-war economies and foster international cooperation. It was fundamentally shaped by the establishment of the Bretton Woods system, which created key international institutions like the International Monetary Fund (IMF) and the World Bank, and laid the groundwork for the General Agreement on Tariffs and Trade (GATT) in 1948, which later evolved into the World Trade Organization (WTO). These institutions provided a framework for international trade and finance. In subsequent decades, several other multilateral and regional trade blocs were formed. These include the Economic Community of West African States (ECOWAS) in 1975, the United States-Canada-Mexico Agreement (USMCA) in 2020, and numerous bilateral free trade agreements. These blocs have been pivotal in the evolution and advancement of international trade through the removal of tariffs and other barriers to free trade. Beyond these policies, improvements in communication and transportation infrastructure have played a critical role in making international business transactions far more efficient. The

combined effect of these factors has created a modern globalized economy where international trade and investment are common phenomena. This is evident in Figure 1.2 below, which highlights the trend of merchandise trade after the Great War. Furthermore, the United Nations Conference on Trade and Development (UNCTAD) (2023) highlighted that global Foreign Direct Investment (FDI) was about 2.5 trillion dollars in 2015. After that, there have been several deficits, with “a strong rebound in 2020” (UNCTAD, 2023). Generally, the flow of FDI has remained above 1 trillion dollars since then.

It is safe to say that economic globalization, driven by the trading and investment activities of multinational corporations, has restructured the contemporary global economy. However, the precise nature of its environmental consequences (Sparrow, 2004; Osibanjo, 2014), particularly its impact on greenhouse gas emissions, is a matter of ongoing academic and policy contention. The subsequent section will therefore explore this empirical debate.

Figure 1. 2: Global Merchandise Trade and Economic Growth



Source: Author’s construct using data from Fouquin & Hugot; *Centre d’Études Prospectives et d’Informations Internationales* (CEPII) National data (2016)

## **1.4 The Empirical Debate of Economic Globalization and Greenhouse Emissions: Pollution Haven Vs Porter Hypothesis**

Economic globalization, while recognized as a powerful tool for global economic growth, presents a hotly debated relationship with environmental sustainability. The discourse primarily revolves around two contrasting theoretical frameworks: the Porter Hypothesis and the Pollution Haven Hypothesis.

Some scholarly arguments often align with the Porter Hypothesis. This perspective posits that stringent environmental regulations can stimulate innovation and enhance competitiveness. In a globalized context, proponents argue that economic globalization could be instrumental in reducing global GHG emissions, as economic growth is often accompanied by broader environmental regulations and demands for environmentally friendly production processes. Consequently, multinational corporations (MNCs), as key players in the global economy, are increasingly adopting sustainable business practices in response to these regulatory pressures. Empirical evidence from various regions lends support to this view. For instance, Ahmed and Le (2021), in their investigation of six Association of Southeast Asian Nations (ASEAN) countries, found that trade globalization helps in mitigating CO<sub>2</sub> emissions. Similarly, Aluko *et al.* (2021), examining 27 industrial countries, revealed that economic globalization reduces environmental degradation. Further supporting this, Zaidi *et al.* (2019) demonstrated that globalization and financial development reduce carbon emissions in Asia Pacific Economic Cooperation (APEC) countries. In addition, Sarkodie & Strezov (2019), focusing on developing countries, found that FDI associated with the inflow of clean technology and safe environmental practices helps ameliorate GHG emissions. By engaging in international cooperation, joint research efforts, and open access knowledge systems, countries can utilize the experiences of others and enhance the speed of the transition to not just a low carbon but a

greener economy. This view suggests a “win-win” scenario where environmental protection and economic prosperity can be mutually reinforcing.

In contrast, critics argue that economic globalization results in environmental degradation through higher levels of production associated with the surge in global demand (Aluko *et al.*, 2021). This notion supports the Pollution Haven Hypothesis, which suggests that industries with high pollution abatement costs will tend to relocate their production facilities from countries with strict environmental regulations to those with more lenient ones, effectively creating “pollution havens.” While various trade participants have incorporated the Sustainable Development Goals of 2030 by including investments in clean energy in developing countries (UNCTAD, 2023), this international flow of capital also carries potential risks. Foreign Direct Investment inflows make it easier for emission-heavy industries to move from developed countries with stringent environmental policies to less developed countries, which are characterized by lax environmental policies. This creates an opportunity for these industries to continue the increase in global GHG emissions, but now within the boundaries of developing countries with more lenient environmental policies (Ghazouani, 2024). Empirical studies have provided evidence consistent with this hypothesis across different contexts. For example, Gaies *et al.* (2022) found that economic globalization exacerbates CO<sub>2</sub> emissions in 17 Middle East and North Africa (MENA) countries. Similarly, Destek (2020), in a study on Central and Eastern Europe, showed that economic globalization increases carbon emissions. Kim (2020)'s research on Korea revealed that FDI inflows have a long-term positive effect on GHG emissions, while Murshed (2023) confirmed that FDI increases carbon emissions in BRICS countries. Furthermore, Kalayci & Hayaloglu (2024) investigated the impact of globalization and trade openness on CO<sub>2</sub> emissions within NAFTA countries, finding a positive relationship between economic globalization, trade openness, and CO<sub>2</sub> emissions. This is coupled with the fact that in recent years, globalization and world trade have been dominated by power

asymmetries and trade imbalances. The argument is that developed countries mostly extract the benefits while shifting the economic costs – pollution, fossil fuel extraction, and natural gas burning – to communities with lesser power. Consequently, industries, particularly in developing nations, may prioritize output over environmental protection, leading to increased pollution and resource depletion (Aluko *et al.*, 2021).

Therefore, while economic globalization can promote sustainable investment flows and the transfer of cleaner technologies, careful consideration of its potential environmental consequences needs to be put in place. The effectiveness of technology transfer in mitigating emissions depends heavily on the strength of environmental regulations, the institutional quality of the host country, and the type of FDI, as most high-level corporations might choose to transfer fossil-fuel-powered technology to countries with abundant non-renewable energy resources. From the foregoing, the implications of economic globalization could be positive or negative. This situation has so far intensified the debate about the effects of economic globalization among researchers, policymakers, and activists in advanced and developing countries. The borderline is that the overall impact remains an important empirical question.

It is within this ambiguous empirical landscape that this study identifies a significant research gap. While the debate between the Pollution Haven and Porter Hypotheses has yielded varied insights across different global contexts, comparative and conclusive empirical evidence specifically tailored to regions with unique economic, institutional, and environmental realities remains underexplored.

### **1.5 Sub-Saharan Africa: A Critical Case Study**

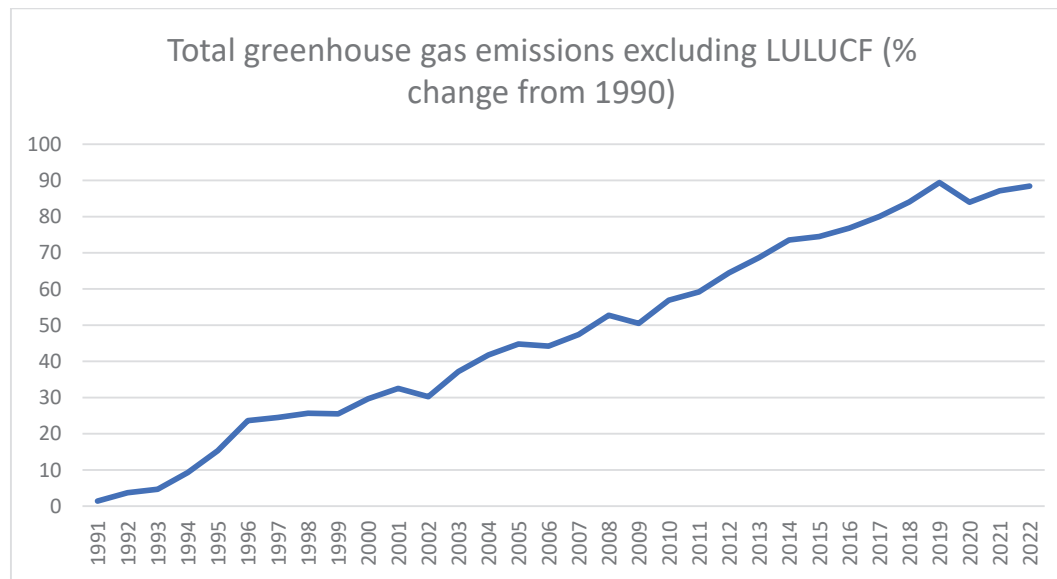
Sub-Saharan Africa (SSA) represents an interesting case in examining the relationship between GHG emissions and economic globalization. SSA faces complex challenges and opportunities regarding the effects of economic globalization. The benefits of economic globalization for

SSA are often expressed through greater market access for its products, job creation, and economic growth (WTO, 2024). Nevertheless, economic globalization also exposes SSA to various challenges related to income inequality, economic vulnerability, and environmental degradation.

The lax environmental regulations and policies in SSA, coupled with higher levels of corruption and inadequate infrastructure, create conditions that could lead to the formation of a pollution haven for heavy industries. This scenario posits that MNCs might exploit the opportunity to circumvent GHG emission costs tied to stringent environmental regulations in their home country and relocate production to SSA through their foreign affiliates. These unfavourable conditions in SSA may further exacerbate the implications of economic globalization for GHGs due to increased economic openness, rising demand, and higher production levels using fossil fuel energy (Yusuf *et al.*, 2020). Evidence from Figure 3 below shows that GHG emissions in SSA have been increasing over time, a trend that warrants investigation regarding its nexus with globalization.

Furthermore, SSA countries are generally highly dependent on primary resource extraction industries, and they are often characterized by a rapid pace of urbanization and industrialization. They also lack the technological and financial resources necessary to transition toward low-carbon energy resources. Despite the increase in GHG emissions in SSA, Acheampong *et al.* (2019) noted that the SSA region contributes less to global GHG emissions while also being the weakest in adapting to and mitigating its implications. This weakness has so far exposed the region to extreme climate change and worsened conditions in the aspect of food insecurity due to agricultural challenges (Adzawla *et al.*, 2019).

Figure 1. 3: Greenhouse Gas Emissions in Sub-Saharan Africa



Source: Author's construct using data from WDI

Understanding how economic globalization manifests its environmental impact in a region characterized by rapid development, evolving governance structures, and intense vulnerability to climate change is important for both regional policy formulation and the broader global discourse on sustainable development. It is for this reason that this study adopts SSA as a case study. Against this backdrop, this study will investigate the overall effect of economic globalization on greenhouse gas emissions and examine whether this effect is different in the case of SSA. The research findings will contribute to both the ongoing empirical debate and regional policy efforts for sustainable development.

### 1.6 Objectives of the Study

Environmental sustainability should be a topic of everyday discussion, accessible even to those unfamiliar with the jargon of climate change. Researchers have discovered that the environmental challenges we face today are a result of the actions of previous generations (Stern, 2006; IPCC, 2013; Anderson, 2024). Sadly, the present generation has continued and even intensified this trend. While the Industrial Revolution that occurred between the 18<sup>th</sup> and 20<sup>th</sup> centuries laid the foundation for large-scale burning of fossil fuels, its immediate

atmospheric consequences were less pronounced than those driven by the intensified activities of the current generation. These activities have significantly contributed to the increased concentration of greenhouse gas emissions in the Earth's atmosphere over centuries, directly resulting in a rise in the Earth's temperature. The planet is warming at an unprecedented rate, and this has been proven to alter the climate, leading to severe consequences such as heatwaves, rising sea levels, melting glaciers, wildlife extinction, food insecurity, displacement, and death (WHO, 2023).

Empirical projections indicate that climate change will lead to “approximately 250,000 additional deaths per year from just undernutrition, malaria, diarrhoea, and heat stress, between 2030 and 2050” (WHO, 2023). Currently, research indicates that about 37 percent of heat-related deaths are a result of “human-induced climate change” (WHO, 2023). Furthermore, the economic costs of climate change are projected to increase significantly if adequate measures are not put in place. The global cost of climate change impacts is projected to be between “\$1.7 trillion to \$3.1 trillion per year by 2050” (World Economic Forum, 2023). These challenges have prompted a global imperative to address rising GHG emissions. Central to this discourse is the role of economic globalization. However, there have been mixed empirical findings in this context, as highlighted in the preceding sections.

Considering the global imperative to ameliorate the level of GHG emissions, coupled with the growing empirical divide on the role of economic globalization, this study sets forth clear objectives to advance both academic understanding and policy formulation. The fundamental objective of this study is to empirically examine the relationship between economic globalization (as manifested through international trade and foreign direct investment) and greenhouse gas (GHG) emissions. This investigation will first model and observe this effect at a global scale, before narrowing its focus to SSA to ascertain how this relationship might differ

in this specific regional context. The empirical analysis will be structured to move from a general global understanding to a more specific examination of SSA, building upon a comparative methodological approach. The focus of the empirical analysis will lie on understanding the varying impacts of globalization on GHG emissions, considering several economic characteristics such as the Gross Domestic Product, resource use, including non-renewable energy consumption, among other control variables. The empirical analysis will evaluate two major hypotheses:

1. There is no significant overall effect of economic globalization, through international trade and FDI, on GHG emissions.
2. This effect does not significantly differ in the case of SSA.

### **1.7 Significance of the Study**

The global concern over greenhouse gas (GHG) emissions and climate change necessitates a clear understanding of their primary drivers. While economic globalization remains an important tool for global integration, its consistent effect on GHG emissions remains a subject of debate and mixed empirical evidence. Existing literature offers conflicting views, ranging from arguments that globalization exacerbates emissions by creating 'pollution havens,' to claims that it fosters cleaner production through technology transfer. This ambiguity represents a gap in comprehensive knowledge, and this has largely affected the design of effective and targeted strategies for environmental sustainability.

Addressing this ambiguity is an urgent global imperative, consistently highlighted by major international bodies. As previously highlighted, organizations like the UN, IPCC, World Bank, and IMF frequently emphasize the need for evidence-based strategies to mitigate GHG emissions and foster sustainable development. This study directly responds to this global call

by delving into the intricate and often conflicting relationship between economic globalization and GHG emissions.

The significance of this study, therefore, lies in its endeavour to bring clarity to these ambiguous and conflicting findings. This is achieved by moving from an initial global observation of the economic globalization-GHG emissions nexus to a detailed context-specific evaluation, using SSA as a case study. This methodological design, which will employ the Panel Corrected Standard Errors (PCSE) technique, designed to account for cross-country heterogeneity, potential endogeneity, and ensure robust standard errors, will ensure the credibility and reliability of the findings, thereby strengthening the empirical foundation of the debate.

The specific contributions of this research are enormous. Firstly, by examining the impact of economic globalization on GHG emissions in SSA, this study directly addresses a knowledge gap in a region like SSA, characterized by its unique developmental stage, resource dependency, and vulnerability to climate change. The research will translate empirical findings into actionable intelligence. Hence, this study will inform governments and regional bodies on policies that can guide strategic engagement with international trade and foreign direct investment to attract environmentally sound practices and technologies as well as contribute significantly to meeting climate action targets. By advancing a context-specific understanding, this research will directly aid in the formulation of effective strategies for a sustainable future, while significantly contributing to the bulk of existing literature on this subject matter.

For multinational corporations and local enterprises, this research will offer a clearer understanding of the environmental risks and opportunities associated with their operations. This will enable firms to make more responsible and economically viable choices, aligning with growing consumer and investor demand for corporate sustainability.

Furthermore, the health of our planet directly affects the well-being and quality of life of all its inhabitants. Without urgent and firm actions to protect Earth, a liveable future for our children and future generations is at risk. This is why, regardless of nationality or economic status, everyone must work together diligently in the fight for sustainability. By shedding light on how globalization influences climate change, this study will enhance public awareness regarding the environmental footprint of global economic activities.

Additionally, this research directly addresses a significant gap in the existing literature on sustainable development, particularly concerning developing regions like SSA. By offering robust empirical evidence derived from a carefully chosen methodology, it will contribute to refining existing theoretical frameworks within a region characterized by unique developmental stages, institutional capacities, and resource dependencies.

To carry out this empirical analysis, this study adopts annual secondary data from a panel of 103 countries selected from different regions of the world. The time series spans the years 2000 to 2023 (23 years), given the availability of data, which was sourced from the World Bank Group's World Development Indicators (WDI, 2023). The geographical scope of the study involves a global-level examination to understand the overall effects of economic globalization on GHG emissions across the panel of all selected countries worldwide. Subsequently, the study will narrow its focus to conduct a detailed analysis specifically for Sub-Saharan Africa and determine if the global effect significantly differs in this context. The dual-level analysis (global and SSA-specific) in this study will provide a methodological benchmark for future context-specific research in other diverse regions.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Conceptual Literature

##### 2.1.1 Economic Globalization

Globalization is a broad idea that spans across different fields of study. Many scholars define this term based on their specific fields. Some connect globalization to social, cultural, and political integration, while others see it through the lens of free trade and the mobility of investment. Danaeefard & Abbasi (2011) suggest that the meaning of globalization depends on the ideological background of the researcher. They mention that there are two opposing views on globalization—the “optimistic” and “pessimistic” perspectives. Supporters of the former are of the notion that globalization encourages peaceful, friendly, and close relationships between countries, while the latter argue that it traps poor countries in long-term poverty because they cannot compete effectively with their global counterparts (Danaeefard & Abbasi, 2011). From this, globalization has been a hot topic for debate among scholars, and Movius (2010) notes that “no single definition exists.” Nevertheless, for this study, this study examines various definitions of globalization from both supporters and critics, focusing especially on economic globalization.

Globalization, according to Dey (2007), is a more intensive social and cultural integration of individuals from different backgrounds, not merely the “marketing and selling” of products across borders. Through shared experiences, different nations, communities, and individuals are driven to accept and adopt ideas, methodologies, and knowledge that were once alien to them. These ideologies also include institutional and political systems, as noted by Thompson (2007), who recognized that if trade is one of the key aspects of the world’s increasing interconnectedness, then the transfer of commodities must happen “within some type of political-economic regime” (Thompson, 2007). Furthermore, Nyang (1998) relates

globalization to “a trend in world affairs” that connects people living in one part of the world with others located in a different part of the globe, recognizing the advancement in transportation mechanisms as one of its core drivers.

Cooper (2001) presents a contrasting view of globalization, noting that “African history reveals the inadequacy in the concept of globalization” (Cooper, 2001). In their study on the history of globalization in Africa, they highlighted that advocates of globalization often limit the concept to a “system of interconnection” or, as Nyang (1988) implies, a trend that “has penetrated the entire globe” without considering the limits of this interconnection (Cooper, 2001). The main criticism of the concept of globalization as an interconnection is towards the ideology that it is a two-way phenomenon. Empirical research has shown that many participants in the global stage do not always “get their way” (Cooper, 2001). Critics further contend that there are certain regions where trade and capital cannot freely flow. Moreover, many nations lack the necessary structure to properly absorb what is transferred to them, as well as the resources to sustain such connections (Cooper, 2001). This creates a win-lose scenario where some benefit from globalization at the expense of others. Supporting this notion, Betz & Hein (2023) contend that the “increasing precarious nature” of globalization leads to an imbalance in the global market, which ultimately creates a divide between citizens and policymakers. When this happens, there will be a “loss of trust in political institutions” (Betz & Hein, 2023).

While the dominant theme across these scholarly ideas is increased global interaction, with particular focus on the flows of knowledge, capital, goods, and services, the broader concept of globalization highlights the importance of human agency. This means that the concept carries moral and ethical considerations. Having explored the nature, impact, and reciprocity of this global interconnectedness, it is safe to say that the cross-border transfer of goods and services and the increasing mobility of investment are fundamentally enabled and made possible by

deeper social interaction. Social connections, through institutional regulation, communication, trust, and shared understanding (or lack thereof), are the bedrock upon which economic globalization is built. In the context of this study, the impact of economic globalization on greenhouse gas emissions is investigated. Ultimately, its impact on greenhouse gas emissions, particularly within the context of developing regions such as SSA, will reflect whether this “interconnection” presents mutual benefits or whether unequal power dynamics erode the “mutual benefits” that globalization promotes, leading to exploitation and, in this context, unequal environmental implications.

Building upon the established academic conversation, to capture the precise aim of this study, this study therefore defines economic globalization as the integration of nations across the world, driven by the expansion of economic activities, such as the free flow of goods, services, and direct investment, which, while fostering global interdependence, often operates within asymmetrical power structures that may lead to varied and sometimes unequal environmental consequences across different regions.

### **2.1.2 Greenhouse Gas Emissions**

Greenhouse gas emissions include any form of natural or human-induced gaseous component that has the capacity to absorb heat from the atmosphere and emit it back to the Earth’s surface. These gaseous components include carbon dioxide, methane, nitrous oxide, synthetic chemicals such as *sulphur hexafluoride*, and many other natural gases such as water vapour and ozone (United States Environmental Protection Agency, 2025).

The Intergovernmental Panel on Climate Change (IPCC) defines GHG emissions as:

“Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of radiation emitted by the Earth’s surface, by the atmosphere itself and by clouds” (IPCC, 2021).

From this definition, it is essential to note that greenhouse gases regulate the Earth's temperature at a specific level necessary to make the planet conducive for its inhabitants. This means that greenhouse gases are not inherently "harmful," instead, they are needed to keep the Earth warm enough to support life. The retention of heat in the Earth's surface balances climate conditions. However, over several decades, the emission of these gases has drastically increased above the necessary threshold. The effect is an exorbitant rise in the Earth's temperature, commonly referred to as "global warming." The National Aeronautics and Space Administration (NASA) reported that the current Earth's average temperature is at 15°C or approximately 59°F (NASA, 2024), highlighting that the past decade has been the warmest ever recorded. Global warming ultimately alters the climate composition, resulting in extreme weather events. Various studies have noted that the consistent increase in these emissions is a result of human activities. The UN highlighted that "the world is now warming faster than at any point in recorded history," noting that one of the largest contributors to global warming is the burning of fossil fuels. Electricity generation, transportation, and production processes are still largely driven by fossil fuel energy consumption, and this has increased over the years due to global economic growth.

With global economic growth comes the global expansion of markets, the growth of multinational corporations, and the industrialization of nations, which place immense demands on energy resources. Furthermore, there is a critical nexus where the pursuit of globalization directly influences the magnitude and composition of greenhouse gas emissions. For this reason, the UN, along with various international climate bodies, has been advocating for more sustainable energy use and transfer. The goal is to reduce reliance on fossil fuels and shift towards renewable energy sources. The central question that emerges, and which this study will investigate, is whether economic globalization is a self-perpetuating cycle of GHG emissions or a major driver of a more sustainable global economy.

### **2.1.3 Economic Globalization and Environmental Sustainability Nexus**

The difference in the link between economic globalization and greenhouse gas emissions suggests that different factors drive their relationship. On one hand, one of the factors that explains the relationship between economic globalization and greenhouse gas emissions is a high surge in global demand. People in one part of the world can now easily access products made thousands of miles away. This expansion of the global market naturally comes with an increase in consumption and production levels. However, this production typically requires energy, and currently, the global economy still relies heavily on fossil fuels. Furthermore, globalization necessitates an increase in logistics, which burns a great deal of fossil fuel. In this scenario, globalization can be regarded as an accelerator of economic activity, where the sheer volume of trade grows faster than any efforts to be sustainable. This ultimately leads to a positive relationship with GHG emissions (Kastratovic, 2019; Kalayci & Hayaloglu, 2024).

Another factor that drives this similar relationship is the lack of strong institutions, which often leads to a “power imbalance,” as previously mentioned. In a bid to attract foreign investment and boost GDP, some countries might offer themselves as low-cost production hubs. This gives room for heavily polluting MNCs to exploit the benefits of economic globalization by moving to such areas where there are lax environmental policies in favour of economic growth. This speaks loudly about the relationship between economic globalization and greenhouse gas emissions in developing countries. This is particularly relevant for SSA, where the urgent need to eliminate poverty can sometimes lead to a blind eye being turned toward the environmental costs of new industrial projects.

On the other hand, globalization can also be seen as a tool for environmental protection, creating a scenario where it leads to a decrease in emissions. This happens through the “flow of ideas and technology.” Advocates of economic globalization believe that MNCs facilitate

the transmission of green technology and sustainable production processes to developing countries, which saves them resources by avoiding reinventing the wheel. Also, these proponents argue that the strict environmental policy in the developed world, which aids the reduction in GHG emissions, also favours the developing countries, as MNCs are required by law to meet certain environmental standards in production both domestically and internationally. Furthermore, when a multinational corporation from a developed country sets up a facility in a developing nation, it often brings with it advanced machinery and smarter managerial practices that are far more efficient than the local alternatives. In this case, through economic globalization, countries can utilize the experiences of others and enhance the speed of the transition to not just a low-carbon but a greener economy by engaging in international cooperation, joint research efforts, and open access knowledge systems.

Furthermore, as international trade agreements become more sophisticated, they often include clauses that require all participants to meet certain environmental benchmarks to gain access to lucrative global markets. In this scenario, the interconnectedness of the world creates a form of “peer pressure” where countries are incentivized to clean up their production processes to remain competitive and maintain their social license to operate. This suggests a negative relationship, where globalization acts as a carrier for sustainability.

Ultimately, whether globalization helps or harms the environment depends on which of these scenarios is dominant. Is the global system being used to spread clean innovation, or is it being used to find the path of least resistance for carbon-intensive production? The answer to this question reflects the true nature of the “interconnection” and whether it truly offers mutual benefits or simply shifts the environmental burden to the most vulnerable.

## **2.2 Theoretical Literature**

Many ideas have been committed, in part or whole, to explain economic globalization and greenhouse gas emissions within the scope of international and environmental economics. This study will look at a few of these theories to see which ones better explain the facts in context.

### **A. Theories of Economic Globalization**

#### **2.2.1 The Theory of Comparative Advantage**

The theory of comparative advantage, propagated by David Ricardo in the early 19th century, is widely adopted in international economics. This theory emphasizes the importance of free trade among nations as a means of improving consumption and the overall standard of living. The idea is that since every country has a certain level of resource endowment, they can channel their resources to produce what they are most skilled at, focusing on the good with the lowest opportunity cost. Ricardo opined that this would lead to specialization and a more “*efficient utilization of resources*” in production (OECD, 2011). The outcome of this system would be high-quality, but cheaper goods that can be exchanged in the international market (Faccarello, 2015), which in turn improves the overall welfare of the trading nations. OECD (2011) notes that this theory is widely accepted as one of the fundamental explanations of international trade. While this theory provides a foundational justification for trade, it has been critiqued for its simplicity, as it assumes labour is the sole factor of production and does not account for other factors and externalities that might influence free trade (Fletcher, 2011).

#### **2.2.2 The Heckscher-Ohlin Model**

Developed by Eli Heckscher and his student Bertil Ohlin in the early 20th century, the Heckscher-Ohlin (H-O) model expands on the comparative advantage model. This theory introduces capital as another important factor of production, alongside labour. Based on their level of endowment, countries in international trade are categorized as either “*capital-rich*” or “*labour-rich*” (Lu, 2024). The theory predicts that a country will export goods that are

intensive in the factors it has in abundance and import goods that are intensive in the factors it has in scarcity (Blaug, 1992).

While the H-O model offers a more robust explanation for trade, its empirical validity has faced significant challenges. The famous "Leontief Paradox" found that the U.S., a capital-abundant country, exported labour-intensive goods and imported capital-intensive goods, which directly contradicts the model's assumptions. Subsequent research has attempted to reconcile this paradox by including more factors of production, such as human capital and technology (Lu, 2024). In the context of economic globalization and GHG emissions, this model provides a framework for understanding how the varied factor endowments of trading participants can influence their specialization, including nations that may have differing environmental footprints.

### **2.2.3 The Eclectic Paradigm (The OLI Model)**

The Eclectic Paradigm, proposed by John Dunning (1988), moves beyond simple trade theory to explain the motivations behind Foreign Direct Investment (FDI). Cruz (2020) argues that the OLI model is "*a more holistic perspective*" in analysing the moderating role of institutions in the attraction of FDI.

The theory posits that a firm will undertake FDI only if it possesses three sets of advantages: Ownership-specific (O), Location-specific (L), and Internalization (I). These explain why there are disparities in internal production and how these differences motivate international trade (Sharmiladevi, 2017). Studies have shown that firms seek ownership advantages to compete with local firms. This manifests during international trade if these firms have a "*competitive advantage*" (high brand reputation) of a certain product or resource, which cannot be replicated easily (Corporate Finance Institute, CFI, 2015). Through multinational corporations (MCNs), they transfer these products and resources to other foreign markets. However, the host countries

where these investments are to be made must present adequate geographical advantages, including access to affordable labour, access to raw materials, energy sources, and, more importantly, favourable regulations. Furthermore, the internalization advantages of producing in-house to protect intellectual property are also considered. Firms might choose to continue producing in their home countries and supplying to host countries. They can also choose to license their product design to the recipient countries (CFI, 2015).

#### **2.2.4 The New Trade Theory**

The New Trade Theory (NTT), primarily associated with Paul Krugman, builds on the foundation of comparative advantage by focusing on economies of scale and product differentiation (Chandra, 2022). The NTT explains why countries with similar factor endowments engage in significant trade with one another, a phenomenon known as intra-industry trade. This theory suggests that by specializing in a specific variety of a product, firms can achieve economies of scale and benefit from a larger global market, while consumers benefit from a greater diversity of goods. Empirical evidence has largely supported the NTT predictions, showing that economies of scale and consumer demand for variety are significant drivers of trade in the modern global economy (Chandra, 2022).

### **B. Theories of Environmental Sustainability**

#### **2.2.5 The Tragedy of the Commons**

The theory of the “Tragedy of the Commons” was propagated by William F. Lloyd in 1833 but was popularized by Garrett Hardin in 1968. It describes a situation in which individuals, acting independently and rationally in their self-interest, will deplete a shared, finite resource even when it is not in their long-term collective interest (Spiliakos, 2024). When there is a “common” good with little to no restrictions on its usage, individuals, driven by personal interests, tend to overuse this good with no regard for the potential harm its depletion could cause for future users or even to the environment. These individuals are often of the notion that

other users of the public good do not act in the best interest of the group; hence, they are convinced that their selfish actions are justified (Spiliakos, 2024). Hardin's original work argued for the necessity of either government regulation or private property rights to prevent such a tragedy. However, this theory has been significantly appraised and challenged by subsequent research. Most notably, Ostrom (1990) demonstrated through decades of empirical work that communities are often capable of developing effective systems of collective governance to sustainably manage common-pool resources without the need for state or private intervention.

### **2.2.6 The Environmental Kuznets Curve (EKC) Hypothesis**

The Environmental Kuznets Curve (EKC) hypothesis, named after Simon Kuznets (1955), provides insights into the interrelation between environmental quality and economic development (Huo *et al.*, 2022). It suggests an inverted U-shaped relationship between economic development and environmental degradation. Initial empirical studies in the early 1990s found evidence supporting this hypothesis for certain pollutants, suggesting that countries naturally become cleaner as they get richer.

The environmental aspect of the Simon Kuznets curve of 1955, as popularized by Gene Grossman and Alan Krueger's 1991 work on the environmental impacts of NAFTA, assesses environmental performance in the long run based on an inverted U-shaped curve. Based on his assumptions, in the beginning phase of development, resources are being consumed rapidly to facilitate production and growth while neglecting the environment. Consequently, this causes a rise in emissions; at this phase, higher income levels have been reached, but countries are now facing increasing pollution as resources are being depleted and waste is accumulating. Owing to this, there is a shift in focus due to increased environmental awareness; thus,

industries seek “*cleaner and greener*” technology to mitigate the damage made to the environment, resulting in improved environmental outcomes (Stern, 2004).

However, the EKC has been subject to extensive appraisal. A comprehensive review by Stern (2004) concluded that the evidence for a universally applicable EKC is weak and often depends on specific pollutants, periods, and countries. Furthermore, critics argue that the observed "inverted U" may simply reflect the offshoring of polluting industries from developed to developing countries, a phenomenon that is central to the Pollution Haven Hypothesis. This implies that a country's "cleaner" environment may come at the expense of another's, raising questions about the global effectiveness of the EKC as a pathway to sustainable development.

### **2.2.7 Environmental Economics**

Environmental economics applies economic principles to environmental issues, focusing on market failures, externalities, and the valuation of environmental goods. The field, which is a “*specialization of neoclassical economics*” (Morrissey, 2020), has evolved significantly to develop market-based policy instruments designed to internalize the external costs of pollution, such as carbon taxes, tradable permits, and subsidies for clean technologies (Morrissey, 2020; Nick *et al.* 2001). Empirical studies have appraised the effectiveness of these policies, showing mixed results. While some studies confirm their role in reducing emissions, others question their effectiveness due to price volatility and institutional interference. This ongoing appraisal highlights the practical challenges of translating economic theory into effective policy in a complex political and social landscape.

### **2.2.8 ESG (Environmental, Social, and Governance) Framework**

The ESG framework is a modern standard used to evaluate a company's performance beyond traditional financial metrics. It provides a structured way for investors, stakeholders, and

consumers to assess a firm's commitment to and management of a broader range of non-financial factors. The three core components are:

- Environmental (E): Measures a company's impact on the natural environment, including its carbon emissions, energy efficiency, waste management, and sustainable sourcing.
- Social (S): Assesses a company's relationships with its employees, suppliers, customers, and the communities in which it operates.
- Governance (G): Evaluates a company's leadership, executive compensation, internal controls, and shareholder rights.

The ESG framework posits that globalization, through the power of capital markets and investor pressure, can be a positive force for encouraging firms to adopt more environmentally and socially responsible practices, especially when their operations span multiple countries. However, the framework has also faced significant critical appraisal, with some scholars highlighting the risk of "*greenwashing*," where companies use ESG reporting to enhance their public image without making substantive changes to their operations (Laufer, 2003). This ongoing debate reflects the tension between corporate responsibility and market-driven incentives within a globalized economy.

### **2.2.9 Race to The Bottom Theory**

The "*Race to the Bottom*" theory suggests that in a globalized economy, countries will compete with one another by progressively lowering their environmental standards and regulations to attract foreign investment and gain a competitive edge in international trade. The increased mobility of capital gives multinational corporations the power to seek out locations with the most lenient regulations. This creates a powerful incentive for governments to weaken their environmental protections to avoid losing investment, leading to a worldwide decline in

environmental quality. In this context, globalization may facilitate the transfer of inferior resources from high-income countries to lower-income countries.

### **C. The Core Theoretical Debate on Economic Globalization and Environmental Sustainability Nexus**

#### **2.2.9 The Pollution Haven Hypothesis (PHH)**

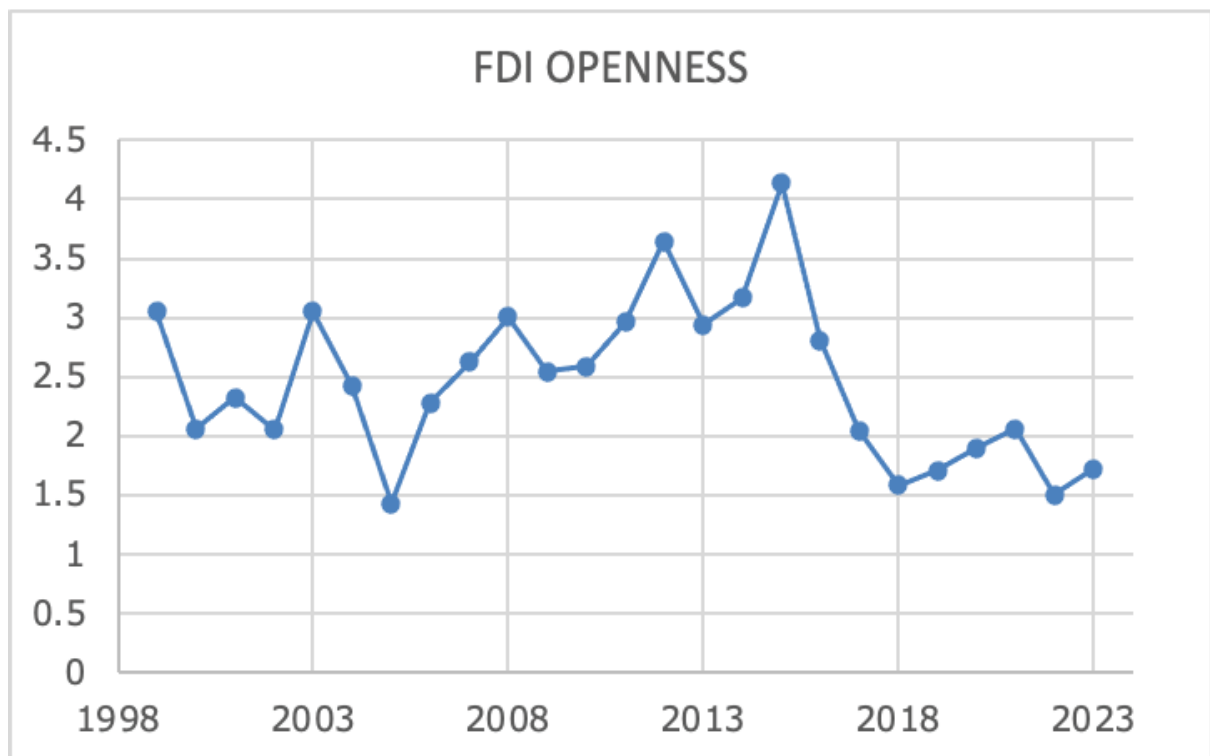
The pollution haven hypothesis, as earlier popularized by Brian Copeland and Scott Taylor in their 1994 paper “North-South trade and the environment,” postulated that developed countries with high pollution emissions from the economic activities of their industries tend to seek out countries with weaker environmental regulations and standards to minimize costs due to increased taxation on pollution degradation (Copeland & Taylor, 1994). According to Aminu *et al.* (2023), developing countries with greener pastures, cheap labour, and abundant resources in need of investments for further development, become a target for the pollution-intensive industries of the developed countries due to their less restrictive regulations, ultimately becoming a pollution haven for those environmentally detrimental industries. Moreover, in hopes of gaining external funding to stimulate economic success, developing countries willingly reduce their standards and accept the relocation of developed countries’ production industries to gain foreign direct investments, subsequently leading to increased degradation of the once “green” environment (Polloni-Silva *et al.*, 2021; Aminu *et al.*, 2023). This hypothesis has been a central point of debate in environmental economics.

Figure 2 below shows the trend in FDI openness (Panel A) as well as GHG emissions (Panel B) in developing countries. While FDI openness has been fluctuating over the years, experiencing periods of increase and decrease, GHG emissions have been on an increasing trend. This raises concerns about the environmental cost of attracting FDI for economic growth, as increased economic activity often translates to higher emissions, especially in developing countries that are dependent on natural energy resources. A typical example can be found in

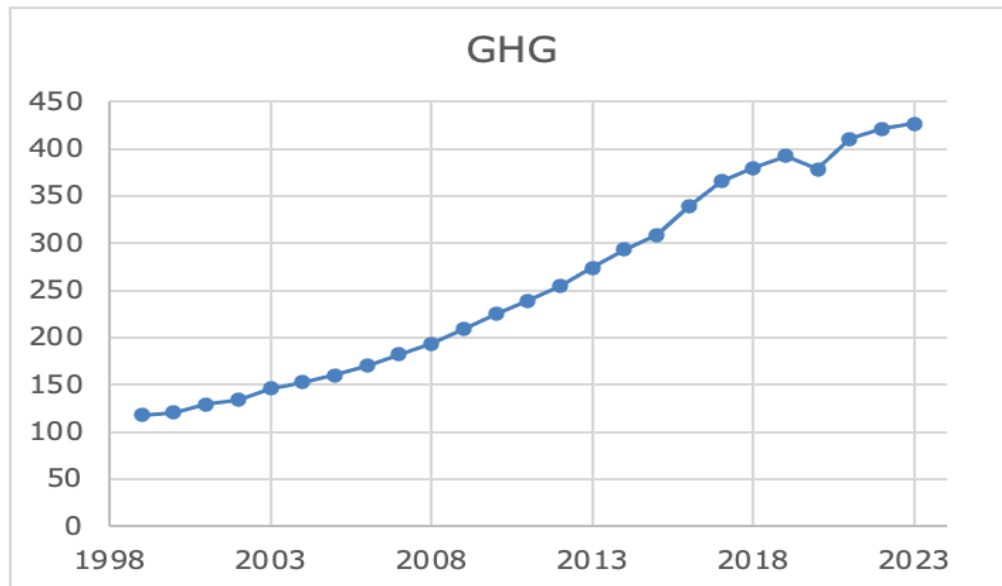
the oil and gas sector, where, due to oil spillages and gas flaring, the environment suffers significant damage. However, this sector accounts for a significant portion of FDI flows since its discovery due to open trade across borders becoming a resource curse for oil-dependent countries like Nigeria (Campbell, 2019). This is coupled with the fact that these countries are more prone to investors who are seeking to avoid stricter environmental regulations elsewhere. The case of Nigeria’s oil and gas sector exemplifies this notion. While FDI has flowed into this sector, it has also brought significant environmental damage through oil spills and gas flaring. Therefore, such investments, while boosting economic growth in the short term, could lead to long-term environmental degradation.

Figure 2.1: Trends in FDI Openness and GHG Emissions in Developing Countries

A: FDI Openness



## B: GHG emissions



Source: Author's construct using data from WDI.

### 2.2.10 The Porter Hypothesis (PH)

In contrast to the pollution haven hypothesis, the Porter hypothesis (Porter & Linde, 1995) laid out crucial arguments that the strict regulations in developed countries are in place to protect the environment and give external pressure to compel industries to be more efficient by stimulating the innovation of environmentally friendly technologies and products, eventually leading to the production of “greener” products utilizing sustainable resources that bring less burden on the environment. Several studies suggest the existence of the pollution-haven hypothesis in developing countries, but there is very limited potential for the occurrence of the Porter hypothesis, though the possibility still exists. Nonetheless, the Porter hypothesis shows the potential opportunities innovation brings, especially in renewable energy development with the introduction of solar and hydropower. Economic globalization has also made it easier for developing countries to adopt cleaner technologies from developed countries. This provides developing countries with the opportunity to make use of advanced technology without reinventing the wheel. The challenge lies in strategically attracting FDI that promotes sustainable practices, fosters innovation, and supports the transition to a low-carbon economy.

## **2.3 Empirical Literature**

In recent years, some studies have focused on the global economy and its impact on greenhouse gas emissions, focusing on individual countries and cross-country panel reviews. Each study either favours or refutes the underlying debate regarding economic globalization and emissions. This section reviews various studies conducted by researchers within and outside SSA, highlighting the scope of the study, the method employed, the findings, the conclusion, and the existing gap.

### **2.3.1 Review of Foreign Studies (Global and Cross-regional)**

Gaies *et al.* (2022) examined this relation within the context of 17 Middle East and North Africa (MENA) countries. By employing a panel autoregressive distributed lag model (ARDL) and the nonlinear autoregressive distributed lag model (NARDL), the study shows that economic globalization exacerbates CO<sub>2</sub> emissions. However, Ahmed and Le (2021) investigated the effect of trade globalization on CO<sub>2</sub> emissions in 6 Association of Southeast Asian Nations (ASEAN) countries by utilizing the fixed and random effect models. According to this study, trade globalization helps in mitigating CO<sub>2</sub> emissions. In another study specific to 27 industrial countries, Aluko *et al.* (2021) employed the augmented mean group technique to examine the relationship between globalization and environmental degradation. The study findings reveal that economic globalization reduces environmental degradation. Similarly, Zaidi *et al.* (2019) examined the effect of economic globalization and financial development on CO<sub>2</sub> emissions in Asia Pacific Economic Cooperation (APEC) countries by utilizing the Continuously Updated Bias-Corrected (CUP-BC) and Continuously Updated Fully Modified (CUP-FM) methods. The study findings show that globalization and financial development reduce carbon emissions. In addition, Sarkodie & Strezov (2019) investigated the impact of FDI on GHG emissions in developing countries, employing a panel data regression, and found that FDI associated with the inflow of clean technology and safe environmental practices helps ameliorate the emissions

of GHG in developing countries. Hossain *et al.* (2023) and Ge *et al.* (2022) also found that FDI could reduce carbon emissions by introducing environmentally friendly technology.

In contrast, a study by Destek (2020) examined the relationships among all dimensions of globalization and the environment in Central and Eastern Europe. By employing the Augmented Mean Group (AMG), the study shows that economic globalization increases carbon emissions. Kastratovic (2019) supports this notion in a study on the link between FDI in agriculture and GHG in developing countries. Using the system generalized method of moments, the empirical study revealed that FDI in agriculture increases CO<sub>2</sub> emissions in developing countries. Kalayci & Hayaloglu (2024) investigated the impact of globalization and trade openness on CO<sub>2</sub> emissions within NAFTA (North American Free Trade Agreement) countries using panel data analysis from 1990 to 2015. Their findings indicate a positive relationship between economic globalization, trade openness, and CO<sub>2</sub> emissions. Furthermore, their study provides evidence for a positive relationship between economic growth and CO<sub>2</sub> emissions in both linear and squared forms, suggesting a lack of support for the Environmental Kuznets Curve (EKC) hypothesis in this context.

In another study, Kim (2020) utilized the Autoregressive Distributed Lag (ARDL) model to explore how FDI impacts Korean GHG emissions. The findings of the study show that FDI inflows have a long-term positive effect on GHG emissions in Korea. Also, Murshed (2023) analysed the effect of FDI on carbon emissions in the context of BRICS (Brazil, Russia, India, China, and South Africa). Through the application of the panel regression, the study shows that FDI increases carbon emissions. Likewise, Ghazouani (2024), examining BRICS countries between 1990 and 2021, reveals a dynamic relationship where the influence of economic globalization on CO<sub>2</sub> emissions has shifted from positive to negative over time. Rauf *et al.* (2023) and Nasim *et al.* (2023) concluded that FDI harms environmental sustainability in

BRICS and South Asian countries, respectively, by increasing CO<sub>2</sub> emissions. Nguyễn & Phan (2025) offer a nuanced view, finding that while exports benefit sustainable development, imports are detrimental, and FDI's impact is complex.

Cristea *et al.* (2013) extensively analyzed how transportation directly contributes to GHG emissions in the world. The study involved a comparative analysis of output and international transportation of goods. The results indicate that the liberalization of tariffs in support of international trade increases GHG emissions generated through transport. This increase was also found to be more than the value of the trade itself. In a similar vein, Zhu & Van (2006) analyzed how the expansion of trading partners across Europe affects international trade and GHG emissions. Using a “comparative static general equilibrium model” to analyze this relationship, Zhu & Van (2006) discovered that international trade contributes positively to the economic development of European trading countries and is not directly linked to the increase in GHG emissions. However, the transportation of trading goods (especially when the mobility and production technology remain fixed) leads to an increase in GHG emissions.

Focusing on Pakistan, Ullah *et al.* (2022) employed ARDL techniques to investigate both symmetric and asymmetric relationships between globalization and GHG emissions. Their findings suggest a positive correlation between economic, social, and political globalization and GHG emissions in both the short and long run under a symmetric framework. However, the asymmetric ARDL model, which was deemed more robust, indicates that positive and negative shocks of economic and political globalization have corresponding positive and negative effects on GHG emissions in the long run.

### **2.3.2 Review of Domestic Studies (Empirical Evidence from SSA)**

Specifically addressing Sub-Saharan Africa (SSA), Sahar *et al.* (2023) investigated the sensitivity of climate change to overall, *de jure*, and *de facto* globalization, alongside

population, urbanization, and economic growth, using panel data from 1990 to 2018. Their findings, derived from novel panel cointegration and DCCE-MG techniques, reveal a significant positive long-run influence of overall globalization, its sub-dimensions, economic growth, and urbanization on climate change in SSA. Conversely, the population showed a negative long-run relationship with climate change. Also, Acheampong *et al.* (2019) utilized the fixed and random effect model to study the association between economic globalization and CO<sub>2</sub> emissions in SSA. According to the study, FDI is crucial in combating CO<sub>2</sub> emissions, while trade openness exacerbates CO<sub>2</sub> emissions.

Contrastingly, several studies on SSA countries find evidence that supports the Pollution Haven Hypothesis (PHH), suggesting that the region attracts environmentally intensive industries from more developed countries with stringent regulations. Amoah *et al.* (2023), for example, affirm that FDI inflows have a positive and significant effect on carbon emissions in 30 SSA countries, labelling the region a "pollution haven." This finding is supported by Boubacar *et al.* (2024), whose two-step GMM analysis of less developed African countries also found a positive link between FDI and CO<sub>2</sub> emissions, formally affirming the validity of the PHH for Africa. Similarly, Afolabi (2025) found a direct connection between FDI and CO<sub>2</sub> emissions and extended the argument to suggest that Bilateral Investment Treaties (BITs) also contribute substantially to environmental degradation in the region. Aminu *et al.* (2023) investigated the interaction effect of financial development on carbon emissions in SSA by utilizing the Fully Modified Ordinary Least Squares (FMOLS). While the study reveals that the interactive impact of financial development reduces environmental degradation, it also reveals that FDI helps intensify CO<sub>2</sub> emissions. Similarly, an earlier study by Yiadom *et al.* (2022) investigated the relationship between FDI and the environment in SSA. By employing the Augmented Mean Group (AMG), the study shows that FDI degrades the environment. In another study, Halliru *et al.* (2021) examined the relationship between FDI, economic growth, and the environment

in West Africa using a panel quartile estimator. The study reveals that FDI inflows induce carbon emissions. Similarly, a study by Gyamfi *et al.* (2021) confirms the findings of Halliru *et al.* (2021). In this study, Gyamfi *et al.* (2021) also employed the panel quartile technique to investigate the relationship between FDI and the SSA environment. However, in an earlier study, Kiviyiro & Arminen (2014) found a contradictory relationship between FDI and carbon emissions. By employing the ARDL model, the study findings reveal that FDI reduces carbon emissions in some SSA countries and increases them in other SSA countries. Using data from 38 SSA countries between 1980 and 2017 and employing second-generation panel data tests and the Hoechle estimation approach to account for spatial dependence, heteroscedasticity, and error autocorrelation, Bakata (2021) found that both overall globalization and its *de jure* and *de facto* aspects contribute positively to environmental pollution by increasing carbon dioxide (CO<sub>2</sub>) emissions in the region. Interestingly, Asongu & Nnanna (2021) investigated how governance modulates the effect of globalization on CO<sub>2</sub> emissions in SSA and identified critical thresholds of FDI and trade that, when interacting with various governance indicators, can either facilitate or hinder CO<sub>2</sub> mitigation. This presents a rather compelling argument that the impact of globalization on emissions in SSA is not uniform but is conditional on the prevailing governance structures. That is, the role of governance and policy is a key determinant of these outcomes. Duodu *et al.* (2021) found that FDI improves environmental quality in the long run in 23 SSA countries when complemented by effective policies and institutions for environmental sustainability (PIES), although its short-run effect is detrimental. This suggests that the ultimate impact of FDI depends on the regulatory environment. Amoah *et al.* (2023) also emphasize the importance of policy, recommending that SSA governments strengthen their regulatory frameworks for FDI to mitigate the positive link between FDI inflows and carbon emissions.

It is important to note that the relationship between economic globalization and environmental degradation is not always straightforward. For instance, Ewane & Ewane (2023) found a U-shaped relationship between FDI and emissions, with evidence for the "halo effect" (FDI initially reducing emissions) holding before a turning point, after which the PHH takes hold. This notion is supported by Ganda & Panicker (2025), who, in a study of 45 SSA countries, found that initial phases of FDI significantly lower carbon emissions, while later stages demonstrate a positive link. Other research finds evidence of a halo effect more broadly, with Nwabueze *et al.* (2023) supporting the Pollution Halo Hypothesis, particularly in some contexts.

Similar to FDI, studies on international trade within SSA tend to show a consistently negative impact on the environment. Andriamahery *et al.* (2022) found that trade significantly increases various emissions (N<sub>2</sub>O, CH<sub>4</sub>, and CO<sub>2</sub>) across all income groups within SSA. The study by Ewane and Ewane (2023) also revealed that while trade openness can reduce CO<sub>2</sub> emissions in the short run, it contributes to an increase in the long run. However, the mitigating role of policy and institutions is critical. Mpure *et al.* (2024) demonstrated that the adverse effects of both aggregate and disaggregated trade on environmental degradation are significantly reduced in the presence of strong environmental policies and institutions. This study, therefore, concludes that international trade cannot guarantee environmental sustainability without effective policies and calls for strengthening these institutions, particularly within the context of the African Continental Free Trade Area Agreement (AfCFTA).

Furthermore, Ganda & Panicker (2025) indicate that economic growth generates a positive relationship with environmental quality, which may contradict a straightforward EKC model. In a broader context, Akinlo & Dapa (2021) offer a different approach by examining the interaction of FDI and environmental degradation on poverty reduction. Their findings are

mixed depending on the poverty metric used, underscoring that the environmental impacts of FDI and trade cannot be isolated from their broader socio-economic consequences.

### **2.2.3 The Role of Energy Consumption and Energy Mix**

The nexus between economic globalizations and GHG emissions is highly influenced by energy consumption. Several studies highlight this connection, often focusing on how the energy mix moderates the environmental impact of other economic activities. For instance, Ideba *et al.* (2025), in their study of Nigeria, found that while access to clean fuels and technology insignificantly reduces greenhouse gas (GHG) emissions, access to electricity has a significant positive impact on emissions. They attribute this finding to Nigeria's predominantly fossil fuel-reliant energy mix. This means that while there might be availability of clean energy, it is often suffused by the predominant energy source. Similarly, Aquilas *et al.* (2024), examining 46 African countries, discovered that the manufacturing sector's negative effect on environmental sustainability can be reversed when manufacturing activities are powered by renewable energy. This finding suggests that renewable energy has the potential to drive industrial growth in Africa without harming the environment, while a reliance on non-renewable energy, even "clean" fossil fuels like natural gas, is not sustainable in the long run.

Other research reinforces the adverse effects of non-renewable energy reliance. Papadas (2024), using a quantile panel regression for N11 countries, found that while economic growth negatively impacts environmental sustainability, the consumption of renewable energy has a positive effect. Conversely, non-renewable energy consumption, along with trade openness, produces adverse outcomes. Fatima *et al.* (2021), focusing on Vietnam, also validated the hypothesis of energy consumption-induced pollution emissions. Shifting focus to Australia, Voumik *et al.* (2023) observed a cointegration among economic growth, foreign direct investment (FDI), trade openness, urbanization, and energy usage. Their findings show that

economic growth, FDI, and trade openness all have a positive and significant impact on energy usage in the long run, and the study advocates for a paradigm shift from fossil fuels to renewable energy sources to ensure sustainable energy usage. Xuan (2025) further supports this, showing in a study on Japan that while trade and FDI contribute to GDP, the adoption of renewable energy has a significant negative relationship with CO<sub>2</sub> emissions.

#### **2.3.4 Economic Growth and Environmental Sustainability**

Hossain *et al.* (2023) found support for the EKC hypothesis in 32 Asian economies, where economic growth eventually helps reduce carbon emissions after a certain point. Similarly, Lee *et al.* (2020) found that economic growth in recipient countries of Korean Official Development Assistance (ODA) has the potential to mitigate environmental degradation once they reach a certain level of economic development. However, other studies find a more consistently positive relationship between growth and emissions. Osadume (2021)'s study on West Africa revealed a significant positive impact of economic growth on carbon emissions in both the short and long run. This finding aligns with Teklie & Yagmur (2023) in their GMM analysis of 52 African economies. Hussain & Zhou (2022), investigating 92 Belt and Road Initiative countries, also found that economic growth, along with other factors, significantly increases energy demand and CO<sub>2</sub> emissions.

Furthermore, Hanvoravongchai & Paweenawat (2025), analyzing seven ASEAN countries, found that economic growth and trade openness positively impact CO<sub>2</sub> emissions, while FDI shows an inverse relationship. Bahera *et al.* (2024), studying East Asia–Pacific nations, found a robust long-term relationship between carbon emissions and output volatility, suggesting that environmental degradation can negatively impact economic stability. Similarly, Papadas (2024) indicates that economic growth has a negative impact on environmental sustainability, especially at higher levels of resource consumption.

### 2.3.5 The Role of Foreign Aid and Development Assistance

The role of foreign aid and development assistance in environmental sustainability has been a topic of intense debate. Several studies investigate whether these inflows facilitate cleaner development or exacerbate existing environmental problems. Farooq (2022), studying Asian economies, found that while foreign aid mitigates CO<sub>2</sub> emissions (by promoting the development of cleaner industrial technology), FDI enhances them. However, they also noted that foreign aid can deteriorate governance, which in turn reduces government control over industrial emissions. When there is weak governance, there will be less-stringent environmental policies; hence, the influx of polluting industries is inevitable. In a similar vein, Siddiqui *et al.* (2024), analyzing BRICS economies, found that foreign aid has a beneficial moderating effect on the relationship between environmental sustainability and globalization, as well as technological innovation.

Other studies offer mixed but generally positive findings. Huo *et al.* (2022), using adjusted net savings as a measure of environmental sustainability, found that foreign aid, along with financial development and trade openness, makes a positive contribution to environmental sustainability. Lee *et al.* (2020) also found that Official Development Assistance (ODA) has a direct and indirect mitigation impact on CO<sub>2</sub> emissions in recipient countries. Focusing on Pakistan, Perveen & Khan (2021) confirmed a positive and highly significant relationship between ODA and sustainable development.

In the context of Sub-Saharan Africa, Wang *et al.* (2022)'s study of 37 countries found that ODA reshapes the urbanization-environment nexus. Their findings show that as ODA crosses a certain threshold, its effect on carbon emissions first increases and then weakens, indicating that ODA helps to alleviate environmental pressure during the urbanization process. While Stauder (n.d.) found a statistically insignificant but negative association between ODA and

CO2 emissions in 118 aid-receiving countries, the study also confirmed a significant positive association between FDI and emissions.

### **2.3.6 The Role of Manufacturing Sector Activities**

Aquilas *et al.* (2024) found a negative and significant effect of manufacturing value added on environmental sustainability in 46 African countries. However, this effect turned positive when the sector's activities were powered by renewable energy. Similarly, Nasim *et al.* (2023), in their study of South Asian countries, found that industrial value added has a negative relationship with CO2 emissions. This suggests that industrial growth is not necessarily linked to increased emissions in this context, although their study also found FDI and population growth to be harmful to the environment.

However, Singh *et al.* (2024), in their research on 34 countries, found that manufacturing value added had a positive impact on environmental sustainability, but also diminished it alongside FDI and economic development. Brunel & Levinson (2021) offered a distinct perspective by decomposing US manufacturing GHG emissions. Their study found no evidence of carbon leakage, either offshoring to or from the US, suggesting that stringent air pollution regulations have not caused firms to relocate to 'pollution havens' and that the US has not become one itself due to less strict climate regulations.

## **2.4 Research Gap and Objectives**

The existing empirical literature on the nexus between economic globalization and greenhouse gas (GHG) emissions presents a diverse and often contradictory picture. Studies examining different regions have yielded mixed results. For instance, some research indicates that economic globalization exacerbates carbon dioxide (CO2) emissions in the Middle East North Africa (MENA) region (Gaies *et al.*, 2022) and Central and Eastern Europe (Destek, 2020), while others suggest that it mitigates emissions in the Association of South East Asia (ASEAN)

countries (Ahmed & Le, 2021), industrial nations (Aluko *et al.*, 2021; Zaidi *et al.*, 2019), and through the inflow of clean technology via Foreign Direct Investment (FDI) in developing countries (Sarkodie & Strezov, 2019). However, studies focusing on FDI in agriculture and specific countries like Korea and BRICS (Brazil, Russia, India, China, and South Africa) reveal that FDI can also increase carbon emissions (Kastratovic, 2019; Kim, 2020; Murshed, 2023). Moreover, the role of international trade and transportation in GHG emissions has been highlighted, with some studies showing a positive link (Cristea *et al.*, 2013) and others finding no direct link but emphasizing the impact of transportation (Zhu & Van, 2006).

This thesis will proceed by examining whether the effects of FDI on GHG emissions exhibit variations in the case of SSA. These differences could arise due to the concentration of inward FDI in resource-extractive industries in SSA countries and due to the institutional challenges and the weaker environmental regulations and enforcement mechanisms. The initial empirical literature produced varying results when examining the effects of FDI on GHG emissions in SSA. While some studies suggest that FDI can reduce CO<sub>2</sub> emissions (Acheampong *et al.*, 2019; Kiviyiro & Arminen, 2014), others find that it intensifies emissions (Aminu *et al.*, 2023; Yiadom *et al.*, 2022; Halliru *et al.*, 2021; Gyamfi *et al.*, 2021). Notably, most studies in SSA primarily focus on the impact of FDI, often overlooking the broader nature of economic globalization and the comprehensive measurement of GHG emissions.

Therefore, this thesis aims to address several critical gaps in the existing literature. First, this study provides a broader perspective by analyzing the impact of economic globalization on GHG emissions using a global panel dataset encompassing 103 countries. This approach is different from prior studies that predominantly concentrate on specific regions or country groupings. By first examining the economic globalization and GHG emissions nexus on a global scale, this research will establish a baseline understanding of the overall trends and

dynamics at play. This global analysis will serve as a comparative framework for a more nuanced interpretation of the findings specific to SSA. By dissecting the global patterns and then narrowing the focus to the unique context of SSA, this study aims to provide a more insightful understanding of the complex relationship between economic globalization and GHG emissions.

In addition to the geographic scope, another notable gap within the SSA literature is its focus on the impact of FDI on carbon emissions. While FDI is a good measure of globalization, there is a need to incorporate trade as well. Moreover, SSA presents a more nuanced case study due to its rapid economic growth, which is also largely driven by its increasing integration into the global market. This study contributes to the existing literature on this subject by employing variables like Trade Openness and FDI inflow that best capture the broad nature of economic globalization, going beyond previous studies that only focus on one aspect of globalization. Instead of focusing on one of the greenhouse gases, this study will employ total greenhouse gas emissions, encompassing carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O), to provide a broader picture of the environmental impact.

Most studies reviewed employ panel regressions that fail to account for cross-sectional dependency. Hence, this study addresses this methodological gap by employing the Panel Corrected Standard Error (PCSE) estimator, being the first study within the context of SSA to adopt this model. The PCSE accounts for cross-sectional dependency and other econometric issues, such as possible contemporaneous correlation, heteroscedasticity, and autocorrelation that might exist in the model of analysis, which conventional panel regression analysis fails to do.

Given that there are several empirical gaps in the study of the relationship between economic globalization and GHG emissions, particularly in SSA, this thesis aims to provide adequate answers to the following research questions:

1. What is the overall effect of economic globalization, through international trade and FDI, on GHG emissions?
2. Does this effect differ in the case of SSA?

By addressing these gaps, this study aims to provide policymakers in SSA with a deeper understanding of how to balance the growth associated with FDI and International trade with environmental sustainability.

## CHAPTER THREE

### MODEL SPECIFICATION AND METHODOLOGY

#### 3.1 Analytical Framework

Research has shown that economic globalization increases greenhouse gas (GHG) emissions through the “pollution haven hypothesis.” When there are weaker environmental laws in certain countries, they will be made attractive destinations (havens) for polluting, resource-extractive, and energy-intensive industries. In this regard, economic globalization, through trade and foreign direct investment (FDI) flows, often involves the transfer of “dirty exports” (Brandi *et al.*, 2020). Institutional weaknesses and dependence on primary extractive resource exports create a “location advantage” for polluting firms seeking to relocate production outside of regions with stricter environmental laws.

Furthermore, several studies have shown that despite the proposed benefits of economic globalization, the emissions-increasing forces of the Pollution Haven Hypothesis are still prevalent (Yiadom *et al.*, 2022). Sultana *et al.* (2023) discovered that with globalization comes an increase in energy demand from overall economic expansion and consumption. As countries engage more in international trade, the sheer volume of production and transportation activities, that is, the global supply chain, grows, leading to higher energy consumption and thus higher emissions (Shao *et al.*, 2021; Namahoro *et al.*, 2021, among others, as cited in Sultana *et al.*, 2023). In a study on the nexus between globalization and GHG emissions in the European Union, Vlahinić *et al.* (2021) revealed a “significant positive relationship,” which also supports the notion that globalization increases emission levels.

In contrast, advocates of economic globalization are of the notion that it is a key factor in the reduction of GHG emissions. This school supports the “Porter hypothesis,” which entails that globalization is a mechanism for the transfer of “clean technology.” FDI, particularly from

developed economies, often brings advanced, cleaner production techniques and better managerial practices into host countries (Sarkodie & Strezov, 2019). Multinational corporations often adhere to higher environmental standards set by their home countries, standardizing these clean practices globally. Furthermore, the “halo effect” comes into play as well. In support of this hypothesis, Wu *et al.* (2022) evidenced that the effect of globalization on the environment comes in three distinct ways, with one of them being the “technical effect.” Here, globalization significantly helps in the reduction of emissions when it facilitates the transfer of “technical know-how,” which will, in turn, assist host countries in the production of greener products (Wu *et al.* 2022). In this case, globalization ensures that there is always a strict streamlining of the traded goods to ensure that the local economies are protected. This is achieved through strong trade agreements.

Trade agreements often include environmental protection clauses, which push firms toward higher standards to maintain access to lucrative and safe markets, hence reducing GHG emission levels. Recently, there has been an increasing number of environmental provisions in preferential trade agreements (PTAs) (Brandi *et al.* 2020). This supports the Porter Hypothesis, where global competition and rising standards spur innovation in clean technology (Porter, 1995). The study by Brandi *et al.* (2020) provides empirical evidence indicating that these provisions actively help to decrease “dirty” exports and, simultaneously, promote “green” exports from developing nations. The evidence suggests that by setting and enforcing higher environmental standards, PTAs can be used as a targeted policy tool to counter the potential effects of the Pollution Haven Hypothesis, thus creating a win-win trade-off for economic development and environmental protection. However, it is necessary to note that the environmental impact of economic globalization might differ in developing and advanced nations, respectively (Wu *et al.*, 2022).

It is no news that a vast majority of the world's economies, especially developing countries, still rely on raw exports (Brandi *et al.* 2020). The United Nations in 2015 noted that resource extraction makes up about 40 percent of world trade. Zhong & Su (2023) buttressed this point, stating that the exports in natural resources reached 3730 billion USD in 2018, most of which were fossil fuels (65%) and non-ferrous metals (22%). They further identified, through the study's empirical results, that trade liberalization increases resource exports by at least 24%. Xia *et al.* (2022) acknowledge that developing countries are home to enormous quantities of fossil fuels. The environmental costs of extracting these fuels for exports include pollution, improper waste management, and resource depletion, all of which contribute to the overall increase in GHG emissions. However, this extraction is inevitable because if there are attempts to decrease energy extraction and consumption, economic expansion will be delayed. Chienwattanasook *et al.* (2021) note that developing countries are often more focused on boosting economic growth and eliminating poverty by any means. In this regard, policymakers put very few efforts into enhancing sustainable development. In their study, Chienwattanasook *et al.* (2021) found that globalization has a statistically significant positive effect on emission levels in developing countries. Gaies *et al.* (2022) support this notion in their study, which showed that trade globalization significantly increases CO2 emissions in developing countries. Given that these "resource-dependent" countries also often lack proper environmental governance, especially when it comes to trade agreements, profit-maximizing multinational companies (MCNs) often leverage this vulnerability.

Regardless, research has shown that certain "environmentally safe" trade agreements inevitably help developing countries by promoting green exports and decreasing "dirty" ones. These environmental standards are often driven by the demands of advanced economies. This can be regarded as a benefit conditional on meeting the North's terms. Nevertheless, the global argument that trade openness decreases emissions is valid here because mechanisms for

environmental mitigation do exist within globalization, just that it is often specific to advanced economies.

Muhammad & Khan (2021) investigated the impact of globalization, among other environmental factors, on emission levels. The empirical analysis was disaggregated into developed (31 countries) and developing (155 countries). Interestingly, the study found that economic globalization and fuel exports significantly reduce emissions in developing countries. On the other hand, in developed countries, fuel exports, economic growth, and economic globalization increase emissions (Muhammad & Khan, 2021). Similarly, Xia *et al.* (2022), in a comparative study on the globalization-environmental degradation nexus in developed and developing countries, found a combined effect: there existed a positive and statistically significant association between globalization and emissions. In contrast, Farooq *et al.* (2022), using a global panel analysis spanning across 180 countries, found that overall, globalization mitigates environmental degradation.

While globalization brings the benefits of specialization (Comparative Advantage), the current nature of trade (often involving the export of raw, carbon-intensive goods and imports of manufactured goods) means the aforementioned “technique effect” (cleaner production) has not yet overcome the dominant “scale effect” (focus on economic expansion). This suggests that the global environmental-improving “Halo” effect is entirely outweighed by the emissions-increasing forces of the Pollution Haven Hypothesis in developing nations. (Yiadom *et al.*, 2022). The environmental cost of increased production and shipping is not being mitigated by structural shifts or clean technologies in developing nations.

According to Ullah *et al.* (2022), “*before addressing the issue of environmental degradation, a country’s development is unavoidable.*” The study highlights that while issues of climate disruption affect all levels of the world economy, lower-income regions will be impacted more

greatly (Ullah *et al.* 2022). This supports the EKC hypothesis, which entails that at the initial levels of economic development (rise in income per capita), environmental degradation increases, but decreases as the country starts to get wealthier (after a certain income threshold). However, the truth is that many countries are still on the increasing slope of the EKC, where economic activity, driven by trade in raw materials and primary production, precedes the capacity to invest in cleaner technologies. But, as the EKC hypothesis suggests, as countries continue to develop, that is, as GDP per capita grows, they can afford to forgo pollution-intensive resources and invest in environmental protection. In a study of globalization, human capital, and emissions nexus, Jahanger (2021) found evidence of the EKC hypothesis in a panel of 78 developing countries.

Mpure *et al.* (2024) demonstrate that whether international trade (FDI and total trade openness) is good or bad for the developing nations' environment is entirely conditional on the policies and institutions for environmental sustainability (PIES). As Campbell (2003) noted, exposure to competition forces firms to innovate. When these environmental provisions in agreements are put in place, they might start to apply a regulatory push that will force countries to adopt cleaner technologies to remain competitive in global value chains.

It is a fact that environmental degradation and global warming are a heavy threat to both current and future generations. Theories have been proposed in this regard; environmental scientists, policy analysts, business leaders, and the public have been putting their respective cents in on this topic of global concern. Climate change symposiums are constantly organized, with more efforts aimed towards mitigating the risks of global warming. This is especially relevant in these recent times, when we are witnessing the harsh effects of climate change and global warming. With more extreme weather events constantly claiming the lives of millions, discussions on this subject grow more precarious, largely because people do not have adequate

empirical evidence to understand why these disasters occur. This is why studies such as this are very necessary. Empirical studies like this, backed by strong econometric modelling and in-depth analyses, provide the necessary quantifiable evidence that will properly provide context to the bulk of theories and assumptions on this subject.

### 3.2. Model Specification

The following are the basic empirical models to tackle the first objective of this research (effects of economic globalization on GHG emissions) and the second objective of this research (whether there are differing implications for SSA), respectively. Equation 1 is the model for the first objective of this study. It identifies the relationship between economic globalization and GHG emissions on a general basis. Equation 2 and 3 look at the moderating effect of development on how economic globalization affects GHG emissions. Furthermore, equation 4 and 5 will be employed to determine if a global split exists between developed and developing countries before looking at SSA case within developing nations. To achieve the second objective of this study, equation 6 and 7 will be utilized to determine the marginal effect of economic globalization on GHG emissions in SSA.

$$LTGE_{it} = \alpha_1 LTOP_{it} + \alpha_2 FDI_{it} + \alpha_3 NRE_{it} + \alpha_4 LR GDP_{it} + \alpha_5 LPOP_{it} + \theta_i + \theta_t + \mu_{it} \quad (1)$$

$$LTGE_{it} = \alpha_1 LTOP_{it} + \alpha_2 FDI_{it} + \theta_1 LTOP_{it} \times LR GDPPC_{it} + \theta_2 FDI_{it} \times LR GDPPC_{it} + \alpha_3 NRE_{it} + \alpha_4 LR GDP_{it} + \alpha_5 LPOP_{it} + \vartheta_i + \vartheta_t + \varepsilon_{it} \quad (2)$$

$$LTGE_{it} = \alpha_1 LTOP_{it} + \alpha_2 FDI_{it} + \theta_1 LTOP_{it} \times LR GDPPC_{it} + \theta_2 FDI_{it} \times LR GDPPC_{it} + \alpha_3 NRE_{it} + \alpha_4 LR GDP_{it} + \alpha_5 LR GDPPC_{it} + \vartheta_i + \vartheta_t + \varepsilon_{it} \quad (3)$$

$$LTGE_{it} = \alpha_1 LTOP_{it} + \alpha_2 FDI_{it} + \theta_1 LTOP_{it} \times DING_{it} + \theta_2 FDI_{it} \times DING_{it} + \alpha_3 NRE_{it} + \alpha_4 LRGDP_{it} + \alpha_5 LPOP_{it} + \vartheta_i + \vartheta_t + \varepsilon_{it} \quad (4)$$

$$LTGE_{it} = \alpha_1 LTOP_{it} + \alpha_2 FDI_{it} + \theta_1 LTOP_{it} \times DING_{it} + \theta_2 FDI_{it} \times DING_{it} + \alpha_3 NRE_{it} + \alpha_4 LRGDP_{it} + \alpha_5 LRGDPPC_{it} + \vartheta_i + \vartheta_t + \varepsilon_{it} \quad (5)$$

$$LTGE_{it} = \beta_1 LTOP_{it} + \beta_2 FDI_{it} + \delta_1 LTOP_{it} \times DING_{it} + \delta_2 FDI_{it} \times DING_{it} + \delta_3 LTOP_{it} \times SSA_{it} + \delta_4 FDI_{it} \times SSA_{it} + \beta_3 NRE_{it} + \beta_4 LRGDP_{it} + \beta_5 LPOP_{it} + \vartheta_i + \vartheta_t + \varepsilon_{it} \quad (6)$$

$$LTGE_{it} = \beta_1 LTOP_{it} + \beta_2 FDI_{it} + \delta_1 LTOP_{it} \times DING_{it} + \delta_2 FDI_{it} \times DING_{it} + \delta_3 LTOP_{it} \times SSA_{it} + \delta_4 FDI_{it} \times SSA_{it} + \beta_3 NRE_{it} + \beta_4 LRGDP_{it} + \beta_5 LRGDPPC_{it} + \vartheta_i + \vartheta_t + \varepsilon_{it} \quad (7)$$

where:

*TGE* = Total Greenhouse Gas Emission (kt *CO*<sub>2</sub>-eq)

*TOP* = Trade Openness (Volume of trade to GDP ratio)

*FDI* = Foreign Direct Investment Openness (FDI net inflow as a proportion of GDP)

*NRE* = Non-Renewable Energy Consumption (Percent of total energy use)

*RGDP* = Real Gross Domestic Product

*RGDPPC* = Real Gross Domestic Product per Capita

*FTI* = Freedom to Trade Internationally

*POP* = Population

*L* = Nature Log

$DING = \begin{cases} 1 & \text{for all Developing country} \\ 0 & \text{otherwise} \end{cases}$

$SSA = \begin{cases} 1 & \text{for all SSA} \\ 0 & \text{otherwise} \end{cases}$

$\theta_i$  &  $\vartheta_i$  = country-specific effect

$\theta_t$  &  $\vartheta_t$  = time-specific effect

$\mu_{it}$  &  $\varepsilon_{it}$  = error terms

$i = 1, 2, \dots, N$  [ $N=103$ ]

$t = 1, 2, \dots, T$  [ $T=23$  years (2000-2022)]

### 3.3. Estimation Technique

To achieve the objectives of this study, this study will employ the Fixed Effect model, Random Effect model, and the Panel Corrected Standard Error (PCSE) model.

To begin with, this study will adopt the Fixed Effects model as the baseline model. The Fixed effect model deals with the issue of unobserved heterogeneity that results in potential endogeneity problems. Endogeneity is one of the most critical issues in econometrics. One of the core assumptions of the Classical Linear Regression Model (CLRM) is strict exogeneity of the independent variables. As established in econometric principles, the ideal estimation environment demands that all explanatory variables be strictly exogenous. This implies that the factors driving changes in the independent variables are statistically independent of all unobserved factors captured in the error term ( $\varepsilon_{it}$ ). When this assumption is violated, the estimation process becomes compromised, yielding coefficients that are biased and inconsistent, even with large sample sizes. Also, this study will employ the Random Effects model as an alternative to the Fixed Effects model and later determine which one is appropriate by using the Hausman test.

Furthermore, to provide a robust framework for analysis, this study adopts the Panel Corrected Standard Error (PCSE) model. When researchers conduct panel analyses, the common problems they face are heteroskedasticity, autocorrelation, and cross-sectional dependency among cross-sectional units. To address this issue, Beck & Katz (1995) introduced the PCSE model, which produces a robust standard error that is efficient relative to the standard error

produced by Generalized Least Squares (GLS). The PCSE addresses the issue of underestimated standard errors, which, according to Beck & Katz (1995), underestimated the standard errors by 50%-300%. The PCSE model corrects the standard error by replacing it with the variance-covariance matrix ( $\Omega$ ), which accounts for possible contemporaneous correlation that might exist between cross-sectional units and corrects for autocorrelation and heteroscedasticity. According to Adeleye *et al.* (2023), the PCSE is a static panel data model suitable for long-run analysis.

In the context of this thesis, the PCSE model is warranted, given the varying environmental and economic conditions across countries. GHG emissions and FDI often follow global and regional trends and exhibit persistence over time. For instance, FDI inflows could exhibit varying environmental effects across countries, leading to significant econometric concerns about heteroskedasticity, while autocorrelation is expected in GHG emissions throughout time periods.

This study will proceed as follows:

- (a) Ascertain if cross-sectional dependency exists between the units.
- (b) Based on the result of (a), conduct a first or second-generational unit root test.
- (c) Based on the result of (a), conduct a first- or second-generation co-integration test.
- (d) Estimate the model using the Fixed Effect model, Random Effect model, and the Panel Corrected Standard Error (PCSE) model.

### **3.4. Pre-Estimation Tests**

#### **3.4.1. Cross-sectional dependence (CSD) analysis**

Cross-sectional dependence describes a situation where cross-sectional units (countries, individuals) are interrelated. In other words, it is a situation when variables or residuals of cross-sectional units are correlated. In this situation, shocks in one cross-sectional unit can be traced to events in the other. Cross-sectional dependence occurs due to structural and

geographical linkage, common shocks, and spillover effects, among other things. This test is necessary as it helps determine the best (first or second generational) panel unit root and co-integration test to employ (Jianguo *et al.*, 2022). When cross-sectional interdependence exists between variables of cross-sectional units, it is appropriate to use second-generation panel unit root and co-integration tests like the Cross-sectionally Augmented Im-Pesaran–Shin (CIPS) unit root test and the Westerlund cointegration test, which account for cross-sectional dependency (Pesaran, 2020). However, when cross-sectional dependency fails to exist between cross-sectional units, it is appropriate to use the first generational panel unit root and co-integration test, like the Im-Pesaran-Shin (IPS) unit root test and the Pedroni co-integration test, which assumes cross-sectional dependency. To test for cross-sectional dependence, this study will employ the final version of Pesaran (2020). The CSD test is given below:

$H_0$ : No Cross-sectional dependence

$H_1$ : Cross-sectional dependence

$$CSD_{Test} = \sqrt{\frac{2T}{N(N-1)}} \left( \sum_{i=1}^{N-1} \sum_{j=i+1}^N \widehat{\rho}_{ij} \right) \quad (3)$$

where:

$T$ = Time period

$N$ = Cross-sectional Unit

$\widehat{\rho}_{ij}$ = Correlation between variables of I and j cross-section

In this context, it is important to note that this test is applicable to small sample sizes and for any combination of N and T (Pesaran, 2020).

### 3.4.2. Panel Unit Root Analysis

After conducting the cross-sectional dependency test, the first-generational or second-generational panel unit root test will be employed to ascertain the stationarity of the variables employed in this study. This study will either use the first or the second generational panel unit root test, depending on the cross-sectional unit root test result. In situations where there is no

cross-sectional dependency between units, this study will employ the Im-Pesaran-Shin (IPS) unit root test, which does not account for contemporaneous correlation between units. However, if cross-sectional dependency is detected among the cross-sectional units based on the result of the CSD test, this study will utilize the cross-sectionally Augmented Im-Pesaran-Shin (CIPS), which was first introduced by Pesaran (2007). The cross-sectionally augmented Im-Pesaran-Shin was built from the cross-sectionally Augmented Dickey-Fuller (CADF).

Interestingly, the Cross-sectionally Augmented Dickey-Fuller (CADF) extends the Augmented Dickey-Fuller (ADF) unit root test by adding the cross-sectional average of the dependent variable as an independent variable. Furthermore, it first differences off the cross-sectional average of the dependent variable as an independent variable. By doing this, the cross-sectionally Augmented Im-Pesara-Shin (CIPS) takes care of the contemporaneous correlation between units. The hypothesis of this is stated below:

$H_0$ : The series is not stationary.

$H_1$ : The series is stationary.

Mathematically, the test statistic of CIPS is derived from the CADF, as shown below:

$$Y_{it} = \alpha_{it} + \beta_i Y_{i,t-1} + \gamma_{1i} \bar{y}_{i,t-1} + \gamma_{2i} \Delta \bar{y}_t + \sum_{j=1}^{\rho} \delta_{ij} \Delta y_{i,t-j} + \varepsilon_{it} \quad (4)$$

where:

$Y_{it}$ =The value of the variable for cross-section i at time t

$\bar{y}_t = \frac{1}{N} \sum_{i=1}^N y_{it}$ : The cross-sectional average at time t

$\Delta y_{it} = y_{it} - \Delta y_{i,t-1}$

$\rho$ : The lag order for the autoregressive terms

$\varepsilon_{it}$ = The error term

The CIPS is given as:

$$CIPS = \frac{1}{N} \sum_{i=1}^N CADF_i \quad (5)$$

Where:

$N$ : The number of cross-sectional units

$CADF_i$ : The CADF statistic for cross-section  $i$

### 3.4.3. Panel Cointegration Analysis

A co-integration test will be employed to determine whether a long-run relationship exists among the variables employed in this study. Moreover, co-integration among the variables guarantees the use of a long-run model like the panel-corrected standard error (Adeleye *et al.*, 2023).

However, this study will employ a co-integration test based on the result of the CSD test. When there is no cross-sectional dependency between units, this study will employ the Pedroni co-integration test, which does not account for contemporaneous correlation between units. However, in the case of a detected cross-sectional dependency among the cross-sectional units based on the result of the CSD test, this study will utilize the Westerlund co-integration test, which accounts for cross-sectional dependency (Pesaran, 2020). The hypotheses of this test are stated thus:

$H_0$ : No cointegrating relationships among the variables.

$H_1$ : At least one cointegrating relationship among the variables.

### 3.4.4. Hausman Test

One of the most common issues that arises in panel regression analysis is the problem of endogeneity. The problem arises when one of the explanatory variables is correlated with the individual-specific error component  $u_{it}$ . In this case, the parameter of the model becomes biased and inconsistent even in a large sample size. This problem is mostly prevalent in the case of Random effect model.

Therefore, the Hausman test is utilized to determine whether the random effect is appropriate or not. That is, the individual-specific error is uncorrelated with any of the independent

variables. In a case where there is a correlation, the Fixed effect model becomes the appropriate model. The null and alternative hypotheses are stated below.

$H_0$ : Random effect is appropriate ( $u_{it}$  is not correlated with the  $X'_{it}$ s)

$H_1$ : Fixed effect is appropriate ( $u_{it}$  is correlated with the  $X'_{it}$ s)

### 3.5 Methods of Result Evaluation

#### 3.5.1 The Economic Criteria

The magnitude of the relationship and the signals of the relationship, or a priori expectations, will be used to evaluate the estimated findings. This means that the outcome will be evaluated to see if the parameter estimates' signs are consistent with economic theory, as well as the size of the association between each explanatory variable and the dependent variable. The expected signs of the parameters of this research model in accordance with reality or theory are shown in the table below for clarity:

Table 3.1: A Priori Expectations of Parameters

Parameters	Explanation	Expected Sign
$\alpha_1$	( $\alpha_1 > 0$ ). $\alpha_1$ is expected to have a positive association with total greenhouse gas emission (TGE). This means that an increase in trade openness will cause an increase in total greenhouse gas emissions, which results in environmental degradation.	+
$\alpha_2$	( $\alpha_2 > 0$ ). $\alpha_2$ is expected to show a positive association with the dependent variable, total greenhouse gas emission. By implication, an increase in foreign direct investment (FDI) will cause total greenhouse gas emissions (TGE) to increase, which results in environmental degradation.	+

$\alpha_3$	$(\alpha_3 > 0)$ . $\alpha_3$ is expected to exhibit a positive association with the dependent variable, total greenhouse gas emission. By implication, an increase in non-renewable energy consumption (NRE) will cause total greenhouse gas emissions (TGE) to increase, which results in environmental degradation.	+
$\alpha_4$	$(\alpha_5 > 0)$ . $\alpha_5$ is expected to show a positive relationship. This implies that an increase in real GDP (RGDP) will increase TGE.	+
$\alpha_5$	$(\alpha_8 > 0)$ . $\alpha_8$ is expected to exhibit a positive relationship. This means that an increase in population (POP) will increase TGE.	+

Source: Author's Conceptualization (2025)

### 3.5.2. The Statistical Criteria

#### The Student T-test

This test is used to determine the statistical significance of each of the model's explanatory variables at a specific level of significance, usually 5%. With  $n-k$  degrees of freedom, the t-test confirms whether the mean of each explanatory variable is statistically distinct at a 5% significance level. The t-test is beneficial in two ways: first, it exposes the nature of the influence that an explanatory variable has on the dependent variable independently, and second, it aids the researcher in deciding whether to reject the study's null hypothesis. The statistical significance of each explanatory variable in the model will be determined using the probability value (p-value) of the t-statistic in this empirical study.

#### The F-test

This test is used to determine the model's overall statistical significance (*i.e.*, whether the joint value of all the explanatory variables in the model is statistically different from 0 or not). At a defined significance level, usually 5%, the F-test follows the f-distribution with  $(n-k)$  degrees of freedom. The F-statistic is compared to the f-critical value, or the F-statistic's probability

value (p-value) is used to determine whether to reject or fail to reject the null hypothesis ( $H_0$ ). To determine the statistically significant property of the joint explanatory variables in the model, this study uses the p-value of the F-statistic at a significance level of 5%.

### **The Coefficient of Multiple Determinations**

The  $R^2$ , in simple terms, is a numerical measure of the variation in the explained variable (TGE) caused by the variations in the explanatory variables used in the model. In other words,  $R^2$  measures the changes in the dependent variable caused by the changes in the explanatory variables.  $R^2$  is a measure of goodness-of-fit (*i.e.*, it shows how well the regression line fits the data).  $R^2$  lies between 0 and 1, mathematically expressed as  $0 \leq R^2 \leq 1$ .

### **3.6. Software Packages**

The statistical program that will be utilized in the computation and modification of data for this investigation is Microsoft Excel 16.0. All essential tests and estimations for this empirical study will be done using STATA econometrics software. Both packages were chosen because they have appealing user interfaces, are intuitive to use, are mathematically simple to use, and, most importantly, are suitable for the estimation procedures and tests utilized in this empirical study.

## CHAPTER FOUR

### DATA AND DESCRIPTIVE STATISTICS

#### 4.1. Data

This study uses annual secondary data from 103 countries. The time series spans the years 2000 to 2022 (23 years). The data and its sources are summarized in the table below:

Table 4.1: Nature and Sources of Data

Variable	Acronyms	Data Source
Total Greenhouse Gas Emission	TGE	World Development Indicators (WDI)
Trade Openness	TOP	World Development Indicators (WDI)
Foreign Direct Investment	FDI	World Development Indicators (WDI)
Non-Renewable Energy Consumption	NRE	World Development Indicators (WDI)
Real GDP	RGD	World Development Indicators (WDI)
Real GDP Per Capita	RGDPPC	World Development Indicators (WDI)
Freedom to Trade Internationally	FTI	Fraser Institute

Source: Author's Conceptualization (2025)

**Total Greenhouse Gas Emissions (GHG):** These are gases like carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O), which are found in the atmosphere and can trap heat, which helps regulate the temperature of the Earth. However, excessive trapping of heat by GHG causes the greenhouse effect, which results in climate change.

**Trade Openness:** According to Yanikkaya (2003), one of the easiest measures of a country's openness or trade liberalism is trade openness, as it measures a country's involvement in global trade relative to its economic activity. A more quantitative approach suggests that it is the ratio of a country's aggregate trade, both imports and exports, to its gross domestic product. The idea of openness of trade advocates economic interconnectedness, suggesting a barrier-free flow of capital goods and labour services within the global economy. A series of controversial

reports have been released on the effect of trade openness on greenhouse gas emissions; nevertheless, rational expectations offer both positive and negative views on trade openness empirically. Mpuure *et al.* (2024) present arguments on the impact of greenhouse gas emissions on international trade in 24 Sub-Saharan African countries and validate that trade openness significantly reduces emissions in the presence of environmentally sustainable policies and institutions. In opposition, an earlier study by Yılmaz (2023) argues using a Vector Error Correction Model that energy consumption from trade activities increases CO<sub>2</sub> emissions positively and significantly in 30 Sub-Saharan African countries.

**Foreign Direct Investment Openness:** This refers to the degree to which a country's policies and regulations allow and encourage foreign direct investment (FDI)—a direct investment by a foreign investor residing in one country into a business of interest in another country. FDI refers to the acquisition or establishment of a business by a foreign investor in a country known as the host country. Foreign direct investment entails having an active voice in the management of the business. Also, it involves having a 10% share of the business and a long-term relationship with the business. While FDI is a primary mechanism through which economic globalization occurs, FDI openness quantifies the degree of participation in this global flow of trade and investment and whether this openness to investments from foreign countries contributes to higher levels of GHG emissions. Based on rational expectations, this variable can either have a positive or negative effect on total greenhouse gas emissions. This is because of the conflicting conclusions on how FDI affects greenhouse gas emissions. Gyamfi *et al.* (2021) employed FDI to investigate the relationship between FDI and carbon emissions. The study reveals that FDI inflows induce carbon emissions. However, in an earlier study, Kiviyiro & Arminen (2014) found a contradictory relationship between FDI and carbon emissions. By employing the ARDL model, the study findings reveal that FDI reduces carbon emissions in some SSA countries and increases them in other SSA countries.

**Freedom to Trade Internationally:** Freedom to trade internationally is a component of the Economic Freedom of the World (EFW) Index released by the Fraser Institute. This variable measures how free a country is in trading with other countries. In other words, the variable reflects how a country embraces economic globalization by capturing how free a country is to international trade and investment. The metric is robust and encompasses diverse indicators of economic globalization, like tariffs, Nontariff barriers to trade, regulatory barriers, and financial openness. The index is measured on a scale of 0 to 10. Countries that are more open to international trade are given a higher score close to ten, while countries with a lot of trade restrictions receive a lower score close to zero. Based on the debate on how economic globalization affects greenhouse gas emissions, this variable can either have a positive or negative relationship with total greenhouse gas emissions. To see the effect of economic globalization on greenhouse emission from another indicator's perspective, this metric will be used to replace trade openness and FDI to re-estimate equations 1 to 7.

**Non-Renewable Energy Consumption:** This refers to the total energy usage of non-renewable energy sources like fossil fuel resources (crude oil, petroleum, natural gas, coal, diesel, and uranium nuclear energy) that help in the production of output (Awodumi & Adewuyi, 2020). Non-renewable energy exists in finite quantities and cannot be readily replenished or reused within a short time. In other words, fossil fuel energy consumption formed over millions of years from organic carbon materials, whose consumption has lethal environmental consequences in the form of climate change and pollution due to the amount of greenhouse gases emitted. Most researchers agree that non-renewable energy consumption is a key factor behind total greenhouse gas emissions, as its extraction, burning, or processing emits high concentrations of powerful greenhouse gases (like carbon dioxide, methane, and nitrous oxide), bringing about climate change and global warming. Utilizing the second-generation panel co-integration methods among 8 SSA countries, Vural (2020) ascertained that non-renewable

energy significantly increases greenhouse gas emissions in the long term. In a similar context, Adedoyin *et al.* (2021) propose uncertainty in previous validations as results from estimating 32 SSA countries using the one-step system GMM, revealing that though non-renewable energy consumption increases CO<sub>2</sub> emissions when moderated with economic policy uncertainty, which disrupts economic activities, its effects bring about a reduction in carbon emissions.

**Real Gross Domestic Product:** The IMF noted that GDP “measures the monetary value of final goods and services produced in a country in a given period, say a quarter or a year” (IMF, 2024). “Real” GDP, in this context, is adjusted for inflation – that is, the price changes are accounted for within a particular year. Hence, it represents the overall scale of economic activity (IMF, 2024). According to Balatsky *et al.* (2015), real GDP represents the “economic size” of a country. In their study on “resource demand growth and sustainability due to increased world consumption,” they found that “larger economies” tend to require more energy use, which contributes to GHG emissions. In this regard, real GDP, as an indicator of economic size, captures the “scale effect” of economic expansion on GHG emissions (He *et al.*, 2021). The study further reported that “economic growth” (real GDP) increases GHG emissions. However, while it may seem like increased economic growth is a catalyst for GHG emissions, there are some opposing views. For instance, Kounis *et al.* (2023), in their study titled “The Decoupling of Emissions and Economic Growth,” highlighted that as an economy continues to grow into a more advanced society, it will get to a point where GDP growth is “separated from growth in GHG emissions.” Hence, when this growth stage is coupled with technological advancement and sustainable economic practices, there will be a negative relationship between GDP and GHG emissions.

**Real Gross Domestic Product per Capita:** According to the World Bank (2025), “GDP per capita is gross domestic product divided by midyear population.” It provides an average

measure of a country's economic output per person, which is a main indicator of the level of development. Aziz *et al.* (2024), in their study on "the effectiveness of environmental protection policies on greenhouse gas emissions," analyzed the ratio of GDP per capita (a proxy for "affluence") to GHG emissions in Canada. The study revealed that real GDP per capita positively impacts GHG emissions in Canada. In a different research, Han *et al.* (2024) decomposed "high uncertainty in greenhouse gas mitigation pathways in emerging regions" and found that among the various factors that drive uncertainty in the proportion of GHG emissions in emerging regions, GDP per capita has the strongest impact.

**Population:** This refers to the total number of people inhabiting a given city or country at a particular point in time. It also could mean the number of a given sex and/or age bracket living in a defined territory at a given point in time. Population growth is often linked with higher demand for consumable goods, and as a country's population grows, so does its demand for manufactured goods. As a result, the use of fossil fuel energy, which is a vital component in the manufacturing process, also skyrockets, causing a further increase in greenhouse gas emissions. This effect only becomes less when a country has integrated or advanced in the use of green energy in its production processes. It is expected that as the population of a country increases, its greenhouse gas emissions also increase.

#### **4.2. Descriptive Statistics**

This section describes the panel dataset utilized in this study by examining the mean, minimum and maximum values, dispersion, and the pairwise correlation.

Table 4.2: Descriptive Statistics

Variable	Type	Mean	Std. Dev.	Min	Max	Observations
TGE	overall	380.5481	1315.486	1.7567	15175.6	N = 2369
	between		1279.81	2.537826	10974.13	n = 103
	within		328.3385	-5350.845	4582.015	T = 23
TOP	overall	81.89867	47.49509	2.69883	437.327	N = 2360
	between		45.49103	24.09808	361.6187	n = 103
	within		14.16333	23.50292	161.0376	T-bar = 22.9126
FDI	overall	6.399073	27.88482	-296.013	452.221	N = 2360
	between		17.26235	-0.38528	151.1863	n = 103
	within		21.93831	-381.718	346.0827	T = 23
FTI	overall	7.343996	1.289288	1.75	9.7	N = 2257
	between		1.248506	3.832857	9.476087	n = 103
	within		0.4653576	4.802692	9.238997	T-bar = 21.9126
NRE	overall	68.50073	27.48702	4.59	100	N = 2369
	between		27.26018	7.401739	99.99826	n = 103
	within		4.395784	46.91552	89.24726	T = 23
RGDP	overall	6.20E+11	2.02E+12	2.70E+09	2.10E+13	N = 2369
	between		1.96E+12	6.91E+09	1.71E+13	n = 103
	within		4.90E+11	-5.24E+12	7.96E+12	T = 23
POP	overall	5.87E+07	1.83E+08	281205	1.43E+09	N = 2369
	between		1.83E+08	323310	1.35E+09	n = 103
	within		1.31E+07	-1.38E+08	2.29E+08	T = 23
RGDPPC	overall	16217.09	19310.19	287.391	99677.5	N = 2369
	between		19180.86	458.6016	81303.48	n = 103
	within		2897.634	-102.0051	57304.9	T = 23

Source: Author's construct using STATA's output

Table 4.2 shows the descriptive statistics for the variables employed in this study. The dataset covers 103 countries observed for 23 years. For some variables like FTI and TOP, the average observed years is less than 23 which means that some observations were missing and this panel is considered unbalanced panel.

The average Total Greenhouse Gas (TGE) emission level and Trade openness (TOP) are 380.55 kt  $CO_2$ -eq (Kiloton of carbon dioxide equivalent) and 81.89, respectively. Also, the average FDI net inflow as a proportion of GDP is 6.4. The negative minimum value shows that some countries witnessed more outflow than inflow in some years. Furthermore, the average Real GDP and Real GDP per capita are 620 billion dollars and 16,217.09 dollars, respectively. The table also shows that the average Non-renewable energy consumption (NRE) is 68 percent of total energy use. The average population is also given as 58.7 million people. It can also be observed from the table that the average score for Freedom to trade internationally is relatively high.

Moreover, the between-country standard deviation for TGE and TOP is far higher than the within-country standard deviation, suggesting a high variation of emissions and Trade openness across countries. That is, some countries pollute more than others, and some are more open to trade than others. Similarly, freedom to trade internationally (FTI), Non-renewable energy use (NRE), Real GDP (RGDP), Real GDP per capita (RGDPPC), and Population (POP) vary more across countries as expected. However, FDI inflow variables are more within countries over time.

Table 4.3: CSD, panel unit root, and cointegration tests

Variables	Pesaran (2004) CD-Test		Pesaran (2007) CIPS (@ Level)		Pesaran (2007) CIPS (@ First difference)		integrated Order
	Statistic	P-value	Statistic	P-value	Statistic	P-value	
LTGE	63.622	0.000	3.9958	1.0000	-34.0167	0.0000	I(1)
LTOP	54.038	0.000	-0.9885	0.1615	-28.9835	0.0000	I(1)
FDI	23.616	0.000	-15.4983	0.0000	-47.2958	0.0000	I(1)
FTI	32.711	0.000	-7.8811	0.0000	-32.3592	0.0000	I(1)
NRE	6.931	0.000	7.0201	1.0000	-31.7153	0.0000	I(1)
LRGDP	282.384	0.000	3.2458	0.9994	-34.4206	0.0000	I(1)
LPOP	234.904	0.000	5.8280	1.0000	-5.5571	0.0000	I(1)
LRGDPPC	192.321	0.000	2.5966	0.9953	-26.0692	0.0000	I(1)
Westerlund (2007) cointegration test (with LTOP & FDI)							
Statistic = -3.0840							
P-value= 0.0010							
Westerlund (2007) cointegration test (with FTI)							
Statistic = -5.1836							
P-value= 0.0000							

Source: Author's construct using STATA's output

Table 4.3 above depicts the results of the pre-estimation test carried out in this study. From the table, it is clearly shown that the p-value of the CD-test carried out for each variable is less than 0.05, and as such, this study fails to accept the null hypothesis of cross-sectional independence and concludes that the panel is cross-sectional dependent. This indicates that a shock in one country is more likely to spread to other countries. The table also shows that the variables employed became stationary after differencing them once. Furthermore, the

Westerlund (2007) cointegration test suggests a long-run relationship among the variables utilized.

Table 4.4: Pairwise Correlation

	TGE	TOP	FDI	FTI	NRE	RGDP	POP	RGDPPC
TGE	1							
TOP	-0.182	1						
FDI	-0.0405	0.2529	1					
FTI	-0.0123	0.3566	0.1305	1				
NRE	0.1572	0.2491	0.0887	0.2694	1			
RGDP	0.8152	-0.1892	-0.0426	0.1339	0.1493	1		
POP	0.7957	-0.2027	-0.0461	-0.1358	0.0942	0.4795	1	
RGDPPC	0.0706	0.2893	0.0557	0.593	0.2343	0.2755	-0.0968	1

Source: Author's construct using STATA's output

From Table 4.4 above, Trade openness, Foreign direct investment, and Freedom to Trade Internationally have a negative association with Total Greenhouse Gas Emission. Meanwhile, Non-renewable energy, Real GDP, Population, and Real GDP per capita have a positive association with Total Greenhouse Gas Emission. Evidently, the regressors show no sign of strong multicollinearity given that none of the correlation coefficients between the regressors is greater than 0.80.

## CHAPTER FIVE

### EMPIRICAL RESULTS

The empirical analyses are presented and discussed in this section, in line with the underlying theoretical and empirical discourse. Before diving into the findings, it is essential to understand the methodological steps taken and the justification of their use to ensure the reliability of the results. The initial analysis was conducted using the Fixed Effects (FE) and Random Effects (RE) models, which served as the benchmark analysis. A benchmark model (or reference model) is a standard or baseline regression model used as a point of comparison for evaluating more complex or specialized models. It offers simplicity and the most fundamental explanation of the relationship between the dependent variable and the core independent variables. The baseline fit allows researchers to confirm that the basic, non-conditional relationships hold true before introducing more complicated models. To confirm the best model to adopt, the Hausman Test was conducted, which subsequently confirmed that the Fixed Effects model, which accounts for unobservable, time-invariant characteristics unique to each country, was the most appropriate baseline estimation.

However, in a globalized world, economies are not isolated. Shocks, policy decisions, and economic trends in one country often affect others, leading to a phenomenon known as cross-sectional dependence or contemporaneous heterogeneity, as evidenced in Table 4.3. This is why the Panel Corrected Standard Error (PCSE) model was adopted as the main analytical technique of this study. The PCSE, which is an advanced FE model, corrects for this interdependence, providing more reliable standard errors and, consequently, more trustworthy conclusions about the true impact of economic globalization on emissions. As Castle & Hendry (2022) argue, reliable modelling of complex, nonstationary processes, such as climate and economic time

series, requires methods that account for abrupt shifts and the interlinked nature of the data-generating processes, which the PCSE is designed for.

This section is divided into four major categories: the theoretical framework, presentation and discussion of regression results for the global analysis, as well as presentation and discussion of regression results for SSA.

The theoretical framework provides a detailed structure upon which the objectives of this study were built. It showcases the global debate on the economic globalization and GHG emissions nexus, drawing insights from the broad body of literature on the “pollution haven” and “Porter” hypotheses. This framework appraises evidence-based research findings on how economic globalization reinforces either of the two hypotheses in developed and developing nations. From this appraisal, a direct link is found. For the world, the emissions-increasing forces of the pollution haven hypothesis seemingly overwhelm the impact of the Porter hypothesis. Scholars explained this through the Environmental Kuznets Curve (EKC) hypothesis. Since studies have shown that the Porter hypothesis is mostly evident in developed nations, while developing countries are still largely “pollution havens,” the EKC theory, in this context, entails that developing nations are still in the early stages of the curve. A vast majority of developing economies rely on the export of raw materials, with resource extraction accounting for approximately 40% of world trade (65% of which is fossil fuels). This resource dependence ensures that increased globalization (trade liberalization) inherently increases carbon-intensive production, pollution, and resource depletion. Developing countries, focused on economic growth and poverty elimination, are highly incentivized to exploit these resources. The theoretical framework, thus, deduces that for these nations, “*development is unavoidable*” before environmental degradation can be effectively addressed, placing them squarely on the increasing slope of the EKC.

Based on this framework, this study is expected to find a positive global relationship (Vlahinić *et al.* 2021) and the dominance of the scale effect (meaning that the relationship is conditional on the income level: RGDP per capita). This ushers in the second category in this section, which is the empirical results for the dataset that covers the global analysis (a panel of 103 countries disaggregated into developed and developing nations).

Furthermore, the evidence deduced from the framework presents the need for disaggregation. Some studies provide conflicting results (Muhammad & Khan, 2021, finding different effects for developed vs. developing countries). For a reliable conclusion, especially in the event of structural differences, there should be a disaggregated analysis to account for the unique policy environment of developing nations. The third category, therefore, presents the empirical results of sub-Saharan Africa (a panel of 49 SSA countries), a region characterized by institutional weakness and high resource dependency, providing the necessary focused analysis to test the framework's deductions.

### **5.1 Global Empirical Results**

The empirical analysis investigates the nexus between economic globalization (through FDI and Trade Openness) and GHG emissions globally. In this section, the empirical regression involves a panel of 103 countries, disaggregated into developed and developing nations. Tables 5.1 and 5.2 present the benchmark results of the fixed effects regression model. While Table 5.1 details the nexus between economic globalization, disaggregated into trade openness and foreign direct investment, table 5.2 involves a composite index—FTI, which means freedom to trade internationally. FTI combines tariffs, nontariff barriers to trade, regulatory barriers, and financial openness to generate a single economic globalization index for a more direct analysis.

The log of total GHG emissions is the dependent variable. Panels (i) to (viii) are different model specifications. In the table, each cell across the respective panels contains the estimated

coefficients for each independent variable across the different model specifications (panels). The values in parentheses below the coefficients are the standard errors, which measure the precision of the estimated coefficients. The asterisk sign is used to denote the levels of significance, where \* denotes significance at the 10% level, \*\* at the 5% level, and \*\*\* at the 1% level.

Tables 5.1 ((i) and (ii)) and 5.2 (i) establish the fundamental relationships using the FE estimator, which controls for unobserved time-invariant country-specific heterogeneity. The coefficients on LR GDP are positive across the panels in the two tables and are respectively significant at the 1% level (\*\*\*). This implies that an increase in RGDP increases greenhouse gas emissions globally. This confirms the scale effect earlier established in the theoretical framework, where higher aggregate global economic output is the primary driver of increased total GHG emissions. Furthermore, the coefficients on NRE are also positive and significant at the 1% level. This validates that reliance on non-renewable sources strongly correlates with increased emissions. Most importantly, in the initial specifications, the direct effect of trade openness (LTOP) is found to be significantly negative at the 1% level (i), and FDI is statistically insignificant (ii). FTI is found to be statistically insignificant as well ((iii), Table 5.2).

Furthermore, a dummy variable approach ((vii) and (viii)) is utilized, where the binary variable DING (Developing Countries =1, Developed Countries = 0) is interacted with LTOP and FDI. The coefficient on this interaction term (LTOP×DING, FDI×DING) represents the difference in the slope of the globalization effect between developing and developed countries. The “difference in slope” arises when an interaction term between a continuous variable and a dummy (binary) variable is included in a regression model. It is the formal way to test whether the relationship (the slope) between the continuous variable and the dependent variable is significantly different across the two groups defined by the dummy variable. When DING is

multiplied by a continuous variable like LTOP (log of trade openness), the resulting coefficient represents the difference in the marginal effect of LTOP between the two groups. A significant slope coefficient is the statistical proof that the relationship between trade openness and GHG emissions is not uniform globally; rather, it is contingent on a country's development status.

In model (viii), the base coefficient for LTOP (where DING = 0) is negative (-0.154) and significant at the 1% level. This base coefficient represents the starting point, which in this case, is the effect of trade openness on GHG emissions in developed countries. By intuition, increased trade openness is associated with lower GHG emissions in developed nations. This aligns with the Porter Hypothesis, where higher-income countries benefit from importing cleaner, more efficient technologies due to their stringent environmental policies. Furthermore, the interaction term (LTOPxDING) acts as an adjustment that only applies to developing countries. This adjustment is referred to as the marginal effect of the difference in slope. This implies that being a developing country changes the environmental impact of trade by a certain amount, which, according to the results in model (viii) is +0.165. To get the actual impact of trade on a developing country, we must then combine the base effect with this marginal adjustment (+0.165) to get a net figure:  $-0.154$  (Base Effect) +  $0.165$  (Adjustment) =  $+0.011$ . This positive difference of 0.165 is so strong that it completely overrides the negative base effect (-0.154), resulting in a net positive impact of LTOP on GHG emissions in developing countries (0.011). This means that for these nations, trade is still associated with a rise in emissions. This supports the Pollution Haven Hypothesis (PHH). Under the PHH, trade liberalization in developing nations attracts foreign firms seeking lower environmental compliance costs, leading to an increase in pollution-intensive production and, consequently, higher emissions.

Conversely, while the base coefficient for FDI (developed countries) is negative, the interaction term  $FDI \times DING$  is statistically insignificant, suggesting no measurable differential impact of FDI between the two groups. However, the FTI results in Table 5.2 show a significant negative coefficient of FTI, with a positive marginal effect of the interaction term.

Beyond the basic relationship between the dependent and independent variables, the analysis of the Fixed Effects (FE) model introduces the examination of the interactions between economic globalization and Real GDP per Capita. This is to test how the income level mediates the impact of globalization. Here, the focus is on model (v) in Tables 5.1 and 5.2, respectively, which captures the direct relationship between economic globalization and GHG emissions, as well as the moderating effect of real GDP per capita. In model (v), the coefficients on LTOP and FDI are significantly positive at the 1% level (0.201 and 0.002, respectively). This implies that globally, as trade openness and FDI increase, GHG emissions increase. However, in Table 5.2 (model (v)), FTI is found to be statistically insignificant. Furthermore, the interaction term  $LTOP \times LRGDPPC$  is significantly negative (-0.061) at the 1% level. This implies that the positive marginal effect of trade openness on GHG emissions weakens as a country's income level rises. Similarly, the interaction term  $FDI \times LRGDPPC$  is significantly negative at the 1% level (-0.001). These findings suggest that richer economies are better equipped to mitigate the environmental costs of globalization, possibly due to stricter environmental regulations, shifts in comparative advantage towards cleaner service sectors, or the ability to demand and adopt cleaner, more efficient imported technologies.

In summary, the Fixed Effects benchmark models consistently demonstrate that the impact of economic globalization on GHG emissions is heterogeneous, being conditioned both by a country's development status, particularly concerning trade openness (viii), and its income level (v). While the FE model provides consistent estimates by controlling for time-invariant

heterogeneity, the analysis must confirm model efficiency and robustness. Therefore, the analysis proceeds to the Random Effects (RE) model for efficiency comparison, followed by the Hausman test to determine the most appropriate model.

Table 5.1: Fixed Effects Models with LTOP and FDI

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
<i>LTOP</i>	-0.033*** (0.006)	-0.036*** (0.006)	-0.011** (0.005)	-0.013*** (0.005)	0.201*** (0.026)	0.224*** (0.028)	-0.156*** (0.012)	-0.154*** (0.013)
<i>LRGDP</i>	0.377*** (0.014)	0.369*** (0.015)	0.312*** (0.012)	0.726*** (0.017)	0.572*** (0.032)	0.735*** (0.016)	0.342*** (0.012)	0.732*** (0.016)
<i>LPOP</i>	0.185*** (0.013)	0.191*** (0.013)	0.182*** (0.010)		0.077*** (0.016)		0.174*** (0.010)	
<i>FDI</i>		-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.002*** (0.001)	0.002*** (0.001)	-0.000* (0.000)	-0.000* (0.000)
<i>NRE</i>			0.007*** (0.000)	0.007*** (0.000)	0.007*** (0.000)	0.007*** (0.000)	0.006*** (0.000)	0.006*** (0.000)
<i>LRGDPPC</i>				-0.411*** (0.024)		-0.127*** (0.039)		-0.385*** (0.024)
<i>LTOPXLRGDPPC</i>					-0.061*** (0.007)	-0.067*** (0.008)		
<i>FDIXLRGDPPC</i>					-0.001*** (0.000)	-0.001*** (0.000)		
<i>LTOPXDING</i>							0.169*** (0.013)	0.165*** (0.014)
<i>FDIXDING</i>							0.000 (0.000)	0.000 (0.000)
<i>Number of obs.</i>	2360	2351	2351	2351	2351	2351	2351	2351
<i>Number of Groups</i>	103.000	103.000	103.000	103.000	103.000	103.000	103.000	103.000
<i>R<sup>2</sup></i>	0.880	0.878	0.891	0.891	0.901	0.900	0.656	0.667
<i>F</i>	1255.02 1	945.691	1443.108	1428.914	1086.618	1078.175	1125.815	1108.872

Note: The dependent variable is the log of total greenhouse gas emission (*LTGE*); Standard errors in parentheses; *DING* =Dummy variable for developing countries (developing=1, developed=0); \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

Table 5.2: Fixed Effect Models with FTI

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
<i>FTI</i>	-0.001 (0.002)	0.005** (0.002)	0.003 (0.002)	0.003 (0.002)	-0.011 (0.012)	-0.005 (0.012)	0.021*** (0.004)	0.021*** (0.004)
<i>LRGDP</i>	0.524*** (0.010)	0.346*** (0.016)	0.308*** (0.012)	0.706*** (0.019)	0.281*** (0.026)	0.708*** (0.019)	0.311*** (0.012)	0.708*** (0.018)
<i>LPOP</i>		0.211*** (0.015)	0.179*** (0.011)		0.193*** (0.016)		0.179*** (0.011)	
<i>NRE</i>			0.008*** (0.000)	0.008*** (0.000)	0.008*** (0.000)	0.008*** (0.000)	0.008*** (0.000)	0.008*** (0.000)
<i>LRGDPPC</i>				-0.388*** (0.026)		-0.405*** (0.037)		-0.389*** (0.026)
<i>FTIXLRGDI</i>					0.004 (0.003)	0.002 (0.003)		
<i>FTIXDING</i>							-0.022*** (0.005)	-0.022*** (0.005)
<i>Number of obs.</i>	2257	2257	2257	2257	2257	2257	2257	2257
<i>Number of Groups</i>	103.000	103.000	103.000	103.000	103.000	103.000	103.000	103.000
<i>R</i> <sup>2</sup>	0.806	0.883	0.884	0.881	0.885	0.882	0.862	0.856
F	1284.875	1003.404	1648.545	1621.693	1319.425	1297.076	1336.172	1314.781

Note: The dependent variable is the log of total greenhouse gas emission (*LTGE*); Standard errors in parentheses; *DING* =Dummy variable for developing countries (developing=1, developed=0); \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

The Random Effects (RE) models (i-viii) assume that the unobserved, country-specific effects are uncorrelated with the independent variables. If this assumption holds, the RE estimator is preferred over the FE estimator because it is more efficient (produces smaller standard errors). Tables 5.3 and 5.4, respectively, show that the significance, direction, and theoretical implications remain similar to the FE models. The high consistency suggests that the estimates are quite reliable and less sensitive to the specific treatment of the country-specific unobserved error.

Table 5.3: Random Effect Models with LTOP and FDI

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
<i>LTOP</i>	- 0.032*** (0.006)	-0.036*** (0.006)	-0.013** (0.005)	-0.015*** (0.005)	0.212*** (0.025)	0.233*** (0.028)	-0.161*** (0.012)	-0.159*** (0.012)
<i>LRGDP</i>	0.387*** (0.013)	0.382*** (0.013)	0.305*** (0.011)	0.768*** (0.015)	0.583*** (0.031)	0.771*** (0.014)	0.336*** (0.011)	0.770*** (0.014)
<i>LPOP</i>	0.191*** (0.011)	0.195*** (0.011)	0.202*** (0.009)		0.086*** (0.015)		0.192*** (0.009)	
<i>FDI</i>		-0.000 (0.000)	-0.000* (0.000)	-0.000 (0.000)	0.002*** (0.001)	0.002*** (0.001)	-0.000* (0.000)	-0.000* (0.000)
<i>NRE</i>			0.007*** (0.000)	0.007*** (0.000)	0.006*** (0.000)	0.006*** (0.000)	0.006*** (0.000)	0.006*** (0.000)
<i>LRGDPPC</i>				-0.460*** (0.021)		-0.156*** (0.038)		-0.431*** (0.021)
<i>LTOPXLRGDPPC</i>					-0.064*** (0.007)	-0.070*** (0.008)		
<i>FDIXLRGDPPC</i>					-0.001*** (0.000)	-0.001*** (0.000)		
<i>LTOPXDING</i>							0.174*** (0.013)	0.169*** (0.013)
<i>FDIXDING</i>							0.000 (0.000)	0.000 (0.000)
<i>Number of obs.</i>	2360	2351	2351	2351	2351	2351	2351	2351
<i>Number of Groups</i>	103.000	103.000	103.000	103.000	103.000	103.000	103.000	103.000
<i>R<sup>2</sup></i>	0.880	0.878	0.897	0.898	0.904	0.904	0.906	0.906
<i>Wald chi – squared statis</i>	4509.35	4530.62	8103.89	8034.35	8553.61	8484.75	8835.34	8710.55

Note: The dependent variable is the log of total greenhouse gas emission (*LTGE*); Standard errors in parentheses; *DING* =Dummy variable for developing countries (developing=1, developed=0); \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

Table 5.4: Random Effect Models with FTI

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
<i>FTI</i>	-0.003 (0.002)	0.005** (0.002)	0.003* (0.002)	0.003* (0.002)	-0.019 (0.012)	-0.014 (0.012)	0.022*** (0.004)	0.022*** (0.004)
<i>LRGDP</i>	0.557*** (0.010)	0.365*** (0.014)	0.296*** (0.011)	0.770*** (0.015)	0.255*** (0.025)	0.773*** (0.016)	0.297*** (0.012)	0.773*** (0.015)
<i>LPOP</i>		0.215*** (0.011)	0.210*** (0.009)		0.230*** (0.014)		0.211*** (0.010)	
<i>NRE</i>			0.007*** (0.000)	0.007*** (0.000)	0.007*** (0.000)	0.007*** (0.000)	0.007*** (0.000)	0.007*** (0.000)
<i>LRGDPPC</i>				-0.468*** (0.022)		-0.503*** (0.033)		-0.469*** (0.022)
<i>FTIXLRGDPPC</i>					0.006* (0.003)	0.005 (0.003)		
<i>FTIXDING</i>							-0.023*** (0.005)	-0.023*** (0.005)
<i>Number of obs.</i>	2257	2257	2257	2257	2257	2257	2257	2257
<i>Number of Groups</i>	103.000	103.000	103.000	103.000	103.000	103.000	103.000	103.000
<i>R<sup>2</sup></i>	0.808	0.885	0.895	0.895	0.896	0.895	0.896	0.895
<i>Wald chi – squared Statistic</i>	3040.64	3901.35	7556.70	7436.31	7561.98	7435.25	7661.20	7540.32

Note: The dependent variable is the log of total greenhouse gas emission (*LTGE*); Standard errors in parentheses. *DING* =Dummy variable for developing countries (developing=1, developed=0); \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

The Hausman test is a statistical hypothesis test used in econometrics to determine if a model's regressors are correlated with the error term, a condition known as endogeneity. Endogeneity is one of the most critical issues in econometrics. One of the core assumptions of the Classical Linear Regression Model (CLRM) is strict exogeneity of the independent variables. As established in econometric principles, the ideal estimation environment demands that all explanatory variables be strictly exogenous. This implies that the factors driving changes in the independent variables are statistically independent of all unobserved factors captured in the error term. When this assumption is violated, the estimation process becomes compromised, yielding coefficients that are biased and inconsistent, even with large sample sizes. The Hausman Test is most used in panel data analysis to decide between a fixed effects model and a random effects model.

The Hausman test relies on the following hypotheses:

- $H_0$ : The Random Effects model is appropriate (*i.e.*, the unobserved individual effects are uncorrelated with the regressors).
- $H_1$ : The Fixed Effects model is appropriate (*i.e.*, the unobserved individual effects are correlated with the regressors).

Decision Rule: Reject  $H_0$  if the p-value of the  $\chi^2$  Statistic is less than 0.05. This suggests endogeneity is present; hence, the fixed effects model should be adopted because it accounts for the correlation. Otherwise, fail to reject, and adopt the random effects model.

The presence of endogeneity in this study has been empirically identified through the Hausman Test, given that the p-value in Table 5.5 is below the 5% significance level, hence the null hypothesis of uncorrelation is rejected. This correlation violates the exogeneity assumption of CLRM. To address this confirmed endogeneity, therefore, the Fixed Effects model is the appropriate and consistent estimator for this analysis.

However, as earlier noted, the FE does not typically account for cross-sectional dependence (contemporaneous correlation of errors across countries), which is highly likely in an analysis like this that involves a large panel dataset of several countries that operate on an integrated global scene. Moreover, the evidence of cross-sectional dependence has been confirmed by the CD-Test in Table 4.3. Therefore, this analysis transitions to the Panel Corrected Standard Errors (PCSE) model, which is an advanced Fixed Effects model specifically designed to address cross-sectional dependence and heteroskedasticity, thereby producing more reliable standard errors and p-values than the standard FE model.

Table 5.5: Hausman Test Result

$\chi^2$ Statistic	59.33
Probability Value	0.0000

The PCSE models in Table 5.6 provide the most robust estimates for the global relationship between economic globalization and GHG emissions. The analysis follows a sequential (general to specific) procedure, building complexity from the basic relationship (i), through adding control variables (ii, iii, iv), to the specific interaction effects (v, vi, viii).

Initially, model (i) establishes the unconditional, clear, significant positive scale effect of trade openness on emissions. Here, the coefficient for trade openness (LTOP) is positive (0.033) and statistically significant. This finding is consistent with some literature supporting the PHH (Destek, 2020) and reflects the increased emissions associated with the transportation of goods in international trade (Cristea *et al.*, 2013). Model (ii) extends the analysis by introducing FDI to assess its initial, unconditional impact alongside trade. The coefficient for FDI is significantly negative (-0.001), providing early, robust evidence for the Porter Hypothesis. This suggests that, even when trade may slightly increase emissions, FDI flows are associated with cleaner technologies and practices. This supports findings in the literature (Sarkodie & Strezov, 2019; Hossain *et al.*, 2023). Crucially, the introduction of FDI slightly increases the positive effect of LTOP (from 0.033 to 0.040). This slight change suggests that the two forms of globalization operate distinctly on the environment.

Furthermore, in models (i) and (ii), LRGDP has a significant coefficient of 0.554, meaning that a percent increase in RGDP will lead to an increase in emission levels by about 0.554%. This finding aligns with most studies (Osadume, 2021; Hussain & Zhou, 2022), confirming that global economic growth is the primary force intensifying emissions. The following models introduce control variables. For instance, the inclusion of NRE (Non-Renewable Energy) in

Model (iii) onwards confirms its positive and significant impact. By intuition, as the consumption of non-renewable energy increases, GHG emissions increase drastically. This finding is consistent with the studies by Papadas (2024) and Fatima *et al.* (2021), which attribute high emissions to a reliance on fossil fuel-heavy energy mixes.

The inclusion of NRE causes the base effect of LTOP to turn negative (-0.016) in models (iii) and (iv). This shift is theoretically important, as it suggests that once the pollution strictly attributable to non-renewable energy consumption is controlled for, the remaining net effect of trade openness is slightly mitigating. This can be attributed to compositional effects or technology adoption that outweighs the transportation effect. The FDI coefficient remains significantly negative (-0.001), further reinforcing the evidence for the Porter Hypothesis, even after accounting for the energy mix. The progression from Model (i) through (iii) demonstrates that the relationship between globalization and emissions is complex, with trade's effect being sensitive to the inclusion of the energy mix control, while FDI's mitigating effect remains stable.

The analysis further disaggregates the focus into developed and developing nations by introducing a dummy variable "DING," where developed nations = 0, and developing nations = 1. From Table 5.6, in model (viii), it is observed that the interaction terms are significant. This fundamentally alters the interpretation of the globalization variables, demonstrating that the environmental consequences are heterogeneous and structurally dependent on a country's status.

The interaction term LTOP×DING in Panel (viii) reveals a significant structural break regarding trade. The base coefficient for LTOP (developed countries) is negative (-0.085). This indicates that for advanced economies, increased openness to trade results in lower emissions. On the other hand, the interaction term LTOP×DING is significantly positive (0.126). This

interaction term is the marginal effect that represents the “slope adjustment” for developing nations. By adding the adjustment to the base, we get a net slope of +0.041 ( $-0.085+0.126$ ) in developing countries. The positive marginal effect of the interaction term (0.126) is large enough to completely reverse the slope. This outcome provides strong evidence for the Pollution Haven Hypothesis regarding trade, confirming that trade openness mitigates emissions in the developed world while shifting into a polluting force in developing countries. This heterogeneity directly explains the conflicting findings in the literature, reconciling studies that found exacerbation in specific developing regions (Gaies *et al.*, 2022) with those that found mitigation in industrial nations (Aluko *et al.*, 2021).

Complementing this, the analysis of income level (Model v) demonstrates that a country’s wealth level mediates the environmental consequences of both LTOP and FDI. The coefficients on both  $LTOP \times LRGDPPC$  (-0.064) and  $FDI \times LRGDPPC$  (-0.003) are significantly negative. These results demonstrate that the positive (or polluting) marginal effect of both LTOP and FDI weakens as a country’s income per capita rises. This supports the argument that higher income thresholds enable countries to demand better environmental quality and implement the effective policies and institutions necessary to counter the adverse effects of globalization, a mechanism emphasized by literature regarding policy’s role in mitigating environmental degradation (Mpure *et al.*, 2024; Duodu *et al.*, 2021). As earlier discovered from the theoretical framework, emissions tend to increase at the initial stages of a country’s development. These findings support the EKC hypothesis, which suggests that as the income level continues to grow, emissions will start to decrease.

The PCSE models affirm that the environmental impact of economic globalization is conditional and demands policies that recognize the structural vulnerability of developing nations to trade-related pollution.

Table 5.6: Panel Corrected Standard Error (PCSE) Models with LTOP and FDI

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
<i>LTOP</i>	0.033*** (0.005)	0.040*** (0.005)	-0.016*** (0.004)	-0.016*** (0.004)	0.228*** (0.036)	0.212*** (0.032)	-0.085*** (0.008)	-0.085*** (0.008)
<i>LRGDP</i>	0.554*** (0.007)	0.554*** (0.008)	0.448*** (0.007)	0.939*** (0.003)	0.736*** (0.034)	0.938*** (0.003)	0.536*** (0.008)	0.958*** (0.004)
<i>LPOP</i>	0.192*** (0.003)	0.191*** (0.003)	0.214*** (0.003)		0.088*** (0.015)		0.184*** (0.002)	
<i>FDI</i>		-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	0.014*** (0.005)	0.014*** (0.005)	-0.001*** (0.000)	-0.001*** (0.000)
<i>NRE</i>			0.005*** (0.000)	0.005*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)
<i>LRGDPPC</i>				-0.491*** (0.006)		-0.219*** (0.030)		-0.425*** (0.005)
<i>LTOPXLRGDPP</i>					-0.064*** (0.009)	-0.060*** (0.008)		
<i>FDIXLRGDPPC</i>					-0.003*** (0.001)	-0.003*** (0.001)		
<i>LTOPXDING</i>							0.126*** (0.007)	0.126*** (0.006)
<i>FDIXDING</i>							0.001 (0.001)	0.001 (0.001)
<i>Number of obs.</i>	2360	2351	2351	2351	2351	2351	2351	2351
<i>Number of Groups</i>	103.000	103.000	103.000	103.000	103.000	103.000	103.000	103.000
<i>R<sup>2</sup></i>	0.891	0.892	0.913	0.913	0.915	0.915	0.919	0.919
<i>Wald chi – squared statistic</i>	333869.43	266846.41	1597594.31	1655059.77	1425106.59	1383189.23	2072468.71	1927154.95

Note: The dependent variable is the log of total greenhouse gas emission (*LTGE*); Standard errors in parentheses; *DING* =Dummy variable for developing countries (developing=1, developed=0); \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

The analysis further introduces the FTI (freedom to trade internationally) variable in Table 5.7 to assess the total, combined effect of economic globalization.

Table 5.7 introduces the FTI composite index, alongside the control variables. The coefficient for the FTI index is significantly negative across all the panels. This finding establishes firstly that, unconditionally, overall economic globalization significantly reduces global GHG emissions. This suggests that the efficiency gains, technological transfer, and potential compositional shifts associated with both trade liberalization and FDI flows, even when

combined, outweigh any potential emissions. This provides strong support for the Porter hypothesis when considering globalization as a single, comprehensive factor.

The control variables maintain their significant roles: LRGDP remains positive across all models. This asserts the continued dominance of the scale effect on emissions. Furthermore, NRE is also positive, confirming that the predominant reliance on fossil fuels in the global energy mix is a significant driver of global emission levels (Papadas, 2024; Fatima *et al.*, 2021). The consistency of these control variables across models (i) through (iv) reinforces the stability of the model's structure.

The introduction of the developing country dummy (DING) and its interaction term (FTIXDING) in Panels (vii) and (viii) is essential for testing the hypothesis of a structural break in the globalization-emissions nexus. The DING variable is set to 1 for developing countries and 0 for developed countries.

The divergence between the signs of the disaggregated Trade Openness (LTOP) variable and the aggregated FTI index after the introduction of the binary DING variable is a notable finding of this study. The impact of overall economic globalization (FTI) in developed countries (the base effect) is captured by the FTI coefficient, which is significantly negative (-0.085) in Panel (vii) and (-0.086) in Panel (viii). This corresponds with the negative base coefficient of LTOP (-0.085) in Table 5.6(viii). This suggests that, like trade volume, institutional freedom initially is associated with lower emission levels for advanced economies (the Porter Hypothesis).

However, the signs differ with the interaction terms, which capture the relationship between economic globalization and GHG emissions in developing countries. In the global models, in Table 5.6 (vii and viii), trade volume often exhibits a polluting tendency in developing regions (with a net slope of 0.041), and the FTI index displays a negative (-0.061) but statistically

insignificant effect. This divergence is rooted in the distinct aspects of globalization that these metrics capture. Because the marginal difference in slope (0.025) is insignificant, the data suggest that there is no statistically “different” slope for developing countries when it comes to the freedom to trade. This implies that while trade openness has a slope that changes significantly based on development status, the effect of institutional freedom is ultimately absorbed by other domestic factors.

For developed nations, where there is greater freedom in trade and investment, there will be lower domestic GHG emissions, which, according to the theoretical framework, is due to higher environmental standards and technological advancement. Although the magnitude of the mitigating effect is slightly reduced in developing countries, the robust conclusion is that the overall “Pollution Halo” effect of economic globalization holds universally when using the combined FTI measure. LTOP serves as a proxy for trade intensity or volume, typically calculated as the ratio of total trade to GDP. In the developing world, high trade volume frequently triggers the Scale Effect, where the sheer expansion of production, resource extraction, and transportation activities increases emissions, particularly when integration is tied to carbon-intensive primary commodities. This explains the positive marginal effect recorded (0.041). Conversely, FTI is a measure of institutional quality and economic freedom. As part of the Fraser Institute’s Economic Freedom Index, a high FTI score denotes a country that has reduced tariffs, eliminated non-tariff barriers, and maintained high financial openness.

This finding challenges simple Pollution Haven interpretations for overall globalization, suggesting that the benefits of cleaner technology and efficiency are widespread, even if slightly muted in the developing world.

The analysis of income level (LRGDPPC) provides a complementary perspective on how economic status influences environmental outcomes. The coefficient for LRGDPPC itself is

highly significant and negative (-0.396 in Panel (iv) and -0.350 in Panel (viii)). This suggests that an increase in per capita income leads to an approximately 0.396% decrease in GHG emissions. This supports the EKC hypothesis, indicating that beyond a certain level, further increases in per capita income leads to a reduction in GHG emissions.

The mediation is further tested by the FTIXLRGDPPC interaction term in Panels (v) and (vi). This term is statistically insignificant. This suggests that the effect of the FTI index does not systematically change with a country's income level, contrasting with the findings when LTOP and FDI were disaggregated. Since the FTI's effect is already established as universally mitigating, the lack of significance here implies that this mitigation is a global standard, achieved independent of income variations, unlike the strong income dependence observed when the component effects of trade and FDI were analyzed separately.

In essence, while the LRGDPPC variable confirms that higher income generally reduces emissions, the structural analysis shows that the FTI's mitigating effect is stable across both development status and income per capita, reinforcing the conclusion that overall economic globalization is a universal environmental benefit when measured as a single composite index.

Table 5.7: Panel Corrected Standard Error (PCSE) Models with FTI

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
<i>FTI</i>	-0.161*** (0.008)	-0.081*** (0.006)	-0.069*** (0.005)	-0.069*** (0.005)	-0.062*** (0.019)	-0.070*** (0.021)	-0.085*** (0.023)	-0.086*** (0.024)
<i>LRGDP</i>	0.883*** (0.004)	0.671*** (0.006)	0.559*** (0.008)	0.954*** (0.002)	0.574*** (0.047)	0.954*** (0.003)	0.615*** (0.010)	0.963*** (0.003)
<i>LPOP</i>		0.136*** (0.002)	0.172*** (0.003)		0.166*** (0.020)		0.152*** (0.004)	
<i>NRE</i>			0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.003*** (0.000)	0.003*** (0.000)
<i>LRGDPPC</i>				-0.396*** (0.007)		-0.398*** (0.050)		-0.350*** (0.009)
<i>FTIXLRGDPPC</i>					-0.002 (0.006)	0.000 (0.006)		
<i>FTIXDING</i>							0.024 (0.021)	0.025 (0.022)
<i>Number of obs.</i>	2257	2257	2257	2257	2257	2257	2257	2257
<i>Number of Groups</i>	103.000	103.000	103.000	103.000	103.000	103.000	103.000	103.000
<i>R<sup>2</sup></i>	0.882	0.910	0.925	0.925	0.925	0.925	0.926	0.926
<i>Wald Statistic</i>	$\chi^2$ 54151.38	179478.5 2	1844048. 76	1933495. 57	2316122. 97	2433272.2 4	2704532.6 8	2861971.4 5

Note: The dependent variable is the log of total greenhouse gas emission (*LTGE*); Standard errors in parentheses; *DING* =Dummy variable for developing countries (developing=1, developed=0); \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

## 5.2 Empirical Results for Sub-Saharan Africa (SSA)

The analysis now transitions from the global model to the specific regional focus on Sub-Saharan Africa (SSA). This addresses the second research question concerning whether the effects of economic globalization differ in the case of SSA.

Table 5.8 presents the Fixed Effects (FE) and Random Effects (RE) models as preliminary benchmarks before the final PCSE model. The table uses a hierarchical interaction approach. For clarity, *LTOP* and *FDI* are the base terms (for developed countries, *DING*=0.). *LTOPXDING* and *FDIXDING* are the interaction terms that capture the difference for all developing countries (including SSA). *LTOPXSSA* and *FDIXSSA* capture the difference specific to the SSA countries within the developing group. The Fixed Effects (FE) models (i) and (ii) control for unobserved time-invariant heterogeneity across countries, providing

consistent estimates for the SSA region. The Random Effects (RE) models (iii) and (iv) yield very similar results to the FE models, suggesting that the conclusions are robust to the model specification.

In Table 5.8, across all four panels (i – iv), the core economic drivers maintain their expected influence on GHG emissions. The Non-Renewable Energy (NRE) coefficient is consistently positive (0.006 across all panels). This confirms that the current fossil fuel-heavy energy mix is the single largest contributor to environmental degradation in the region. Similarly, LRGDP is significantly positive (0.340 to 0.773), confirming the dominant scale effect where economic growth, irrespective of region, increases emissions. Population (LPOP) is also positively associated with emissions (0.176 to 0.194), reflecting the demand-side pressure of population growth. Furthermore, when introduced in Panels (ii) and (iv), the income level (LRGDPPC) shows a significantly negative coefficient (-0.387 in (ii), -0.43 in (iv)). This supports the Environmental Kuznets Curve (EKC) hypothesis even in this specific regional context, suggesting that higher income levels mitigate pollution.

The overall impact of globalization in SSA is calculated by summing the three relevant coefficients: the base (Developed), the developing differential (DING), and the SSA differential (SSA).

For LTOP, the base effect (developed countries) is strongly negative (-0.155) in model (ii). This is offset by the significant positive differential for developing countries (LTOPXDING at 0.163) in (ii). The SSA-specific differential (LTOPXSSA) is insignificant (0.014), indicating that trade's impact in SSA is not statistically different from the rest of the developing world. The net effect of LTOP in SSA is therefore approximately:  $(-0.155+0.163+0.014\approx 0.022)$  positive. This outcome robustly supports the Pollution Haven Hypothesis (PHH) for trade in

SSA, where trade openness increases emissions, driven by the structural characteristics common to all developing nations.

For FDI, the base effect is negligibly negative (-0.000). The FDIXDING differential is also negligibly positive (0.000), largely neutralizing the base effect for the general developing world. However, the SSA-specific differential (FDIXSSA) is significantly negative in Panel (iii) (-0.001) and slightly positive in Panel (iv) (0.001) at the 5% level of significance. This mixed result, with coefficients of extremely small magnitude (around 0.001) and marginal significance, suggests that the net effect of FDI on GHG emissions in SSA is neutral. This finding strongly contrasts with the high FDI-induced PHH claims often made for the region in the literature. This suggests that the existence of the PHH in SSA is not significantly driven by FDI inflows. The next step will be to confirm the robustness of these findings using the PCSE method.

Table 5.8: Fixed and Random Effect Models for Sub-Saharan Africa with LTOP and FDI

	(i)	(ii)	(iii)	(iv)
<i>LTOP</i>	-0.155*** (0.012)	-0.154*** (0.013)	-0.160*** (0.012)	-0.159*** (0.012)
<i>FDI</i>	-0.000* (0.000)	-0.000* (0.000)	-0.000* (0.000)	-0.000* (0.000)
<i>LTOPXDING</i>	0.163*** (0.014)	0.162*** (0.014)	0.168*** (0.014)	0.167*** (0.014)
<i>FDIXDING</i>	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)
<i>LTOPXSSA</i>	0.014 (0.011)	0.006 (0.011)	0.015 (0.011)	0.007 (0.011)
<i>FDIXSSA</i>	-0.001* (0.000)	-0.001* (0.000)	-0.001** (0.000)	0.001* (0.000)
<i>NRE</i>	0.006*** (0.000)	0.006*** (0.000)	0.006*** (0.000)	0.006*** (0.000)
<i>LRGDP</i>	0.340*** (0.012)	0.735*** (0.016)	0.334*** (0.011)	0.773*** (0.014)
<i>LPOP</i>	0.176*** (0.010)		0.194*** (0.009)	
<i>LRGDPPC</i>		-0.387*** (0.024)		-0.435*** (0.021)
<i>Number of obs.</i>	2351	2351	2351	2351
<i>Number of Groups</i>	103.000	103.000	103.000	103.000
<i>R<sup>2</sup></i>	0.658	0.667	0.907	0.907
<i>F/ Wald <math>\chi^2</math> Statistic</i>	877.193	863.138	8884.06	8749.38

Note: The dependent variable is the log of total greenhouse gas emission (*LTGE*); Standard errors in parentheses; *DING* =Dummy variable for developing countries (developing=1, developed=0); *SSA* =Dummy variable for Sub-Saharan Africa countries (Sub-Saharan Africa country=1, otherwise=0); \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ ; The Wald  $\chi^2$  Statistic is for the Random effect models in columns (iii) and (iv).

The analysis now turns to the Panel Corrected Standard Error (PCSE) Models for Sub-Saharan Africa. The PCSE technique is the most methodologically robust for this panel data, as it accounts for cross-sectional dependence and heteroskedasticity, thus providing the most reliable standard errors and conclusions regarding the SSA region, which is the second key objective of this study. Globally, the PCSE models showed a significant structural divide: the global developing world experienced a net polluting effect of trade openness (PHH), while

developed countries benefited from a “pollution halo.” Before going into the SSA results, and thus, identifying how they differ from the global model, a summary of the global findings is presented.

The global PCSE models strongly support the notion that the environmental effect of globalization is heterogeneous and income-dependent (panel viii in Table 5.6), as noted by Wu *et al.* (2022) and Brandi *et al.* (2020). The results for Trade Openness affirm the global structural divide. The base mitigating effect in developed countries (-0.085), presented in panel (viii), Table 5.6, supports the Pollution Halo Hypothesis advocated by Sarkodie & Strezov (2019). However, the significant positive marginal effect of the interaction variable (LTOPXDING = 0.126) leads to a net polluting effect in developing nations (0.041). This validates the Pollution Haven Hypothesis (PHH) and aligns with studies like Gaies *et al.* (2022) and Destek (2020), which found that economic globalization exacerbates emissions in developing regions. The final finding supports the consensus that the “scale effect,” driven by an expansion in economic output (increase in RGDP) and the forces of the pollution-emitters, outweighs the “technique effect” in the developing nations’ context (Yiadom *et al.*, 2022). The interaction terms with LRGDPPC (Table 5.6, Panel vi) demonstrate how rising income mediates the globalization effect: The coefficients on both LTOP×LRGDPPC (-0.060) and FDI×LRGDPPC (-0.003) are significantly negative. This confirms that the environmental consequences of both trade and FDI improve (become more mitigating) as a country’s income per capita increases. Higher income facilitates the adoption of effective environmental policies and investments in cleaner technologies, strengthening the Pollution Halo effects of globalization.

The SSA PCSE models in Table 5.9 (panel vi) introduce SSA-specific marginal effects (LTOPXSSA and FDIXSSA), allowing precise differentiation between the SSA region and the

rest of the developing world. The findings show that the environmental consequences of globalization differ substantially in SSA compared to the general developing country experience.

The net effect of LTOP in SSA is calculated by summing the base effect, the developing country differential (LTOPXDING), and the SSA-specific differential (LTOPXSSA). While the general developing country differential (LTOPXDING) is highly significant and positive (0.089) in panel (vi), the SSA-specific differential (LTOPXSSA) is also significant, but negative (-0.023). This strong SSA-specific mitigating effect effectively neutralizes the overall pollution haven tendency of the developing group. The net effect of LTOP in SSA is determined by summing the three relevant coefficients from Panel (vi): Net LTOP Effect in SSA =  $(-0.060)+(0.089)+(-0.028) = 0.001$ .

The magnitude of the net effect of 0.001 is very low, though positive. The strong negative marginal effect specific to SSA (-0.028) is large enough to cancel out the general positive effect of trade openness (0.089) on GHG emission in the developing world (that is, the PHH tendency). This simply implies that trade openness in SSA is not a primary source of GHG pollution. This neutrality directly refutes the strong PHH identified by studies such as Andriamahery *et al.* (2022) and Acheampong *et al.* (2019), which concluded that trade openness exacerbates CO2 emissions in SSA. The findings of this study, which controls for global heterogeneity, suggest that SSA's primary commodity-export structure, which is not as carbon-intensive as manufacturing, shields it from the full force of the global trade PHH. The environmental impact is therefore more about local resource extraction than global carbon leakage.

Furthermore, the net effect of FDI in SSA is calculated as the sum of its three components, which are all found to be statistically insignificant (Panels ii to vi): Net FDI Effect in SSA =

$(-0.000) + (0.000) + (0.000) = 0.000$ . The net effect of 0.000 is statistically insignificant. FDI in SSA is neither a pollution haven nor a pollution halo; it is environmentally inert. This finding rejects the strong PHH for FDI in SSA as claimed by Amoah *et al.* (2023), Aminu *et al.* (2023), and Halliru *et al.* (2021). It also contradicts the simple Halo effect found in some studies (Acheampong *et al.*, 2019; Hossain *et al.*, 2023). The results of this study provide empirical evidence for the neutrality hypothesis, supporting the theoretical argument that FDI concentrated in isolated extractive sectors (oil, mining) does not generate significant national GHG externalities, that is, it neither transfers clean technology widely nor establishes large polluting domestic industries.

The analysis confirms the role of non-globalization drivers, providing a clear focus for policy in SSA. First, the strong negative coefficient on LRGDPPC (-0.439 in Panel (vi)) aligns with the EKC hypothesis (Hossain *et al.*, 2023; Jahanger, 2021), confirming that economic development itself is essential for long-term environmental mitigation. Development provides the financial capacity to invest in policies, as suggested by Mpure *et al.* (2024) and Duodu *et al.* (2021). Furthermore, the significant positive coefficient of Non-Renewable Energy (NRE) (0.004) confirms the literature (Papadas, 2024; Fatima *et al.*, 2021) that the fossil fuel energy mix is the primary driver of emissions. The findings of Aquilas *et al.* (2024) that access to electricity and industrial growth are polluting due to the reliance on fossil fuels are strongly supported. The overall policy implication is that SSA governments should focus their climate mitigation efforts primarily on domestic energy transition (decarbonization) and strengthening environmental governance to manage the localized impacts of extractive industries, rather than relying on trade or FDI restrictions, which are environmentally neutral but vital for economic growth.

Table 5.9: Panel Corrected Standard Error (PCSE) Models for SSA with LTOP and FDI

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
<i>LTOP</i>	-0.079*** (0.009)	-0.079*** (0.008)	-0.053*** (0.013)	-0.058*** (0.013)	-0.067*** (0.012)	-0.060*** (0.012)
<i>FDI</i>	-0.001*** (0.000)	-0.001*** (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000*** (0.000)	-0.000*** (0.000)
<i>LTOPXDING</i>	0.159*** (0.006)	0.158*** (0.006)	0.078*** (0.014)	0.080*** (0.014)	0.095*** (0.014)	0.089*** (0.014)
<i>FDIXDING</i>	-0.001 (0.001)	-0.001* (0.001)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
<i>LTOPXSSA</i>	-0.141*** (0.019)	-0.138*** (0.018)	-0.027*** (0.010)	-0.025** (0.010)	-0.023** (0.009)	-0.028*** (0.010)
<i>FDIXSSA</i>	0.010*** (0.003)	0.010*** (0.003)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)
<i>NRE</i>	0.004*** (0.000)	0.004*** (0.000)	0.005*** (0.000)	0.005*** (0.000)	0.004*** (0.000)	0.004*** (0.000)
<i>LRGDP</i>	0.561*** (0.009)	0.966*** (0.004)	0.469*** (0.017)	0.925*** (0.011)	0.515*** (0.016)	0.946*** (0.006)
<i>LPOP</i>	0.177*** (0.003)		0.206*** (0.007)		0.194*** (0.008)	
<i>LRGDPPC</i>		-0.408*** (0.006)		-0.439*** (0.016)		-0.427*** (0.016)
<i>Number of obs.</i>	2351	2351	2351	2351	2351	2351
<i>Number of Groups</i>	103.000	103.000	103.000	103.000	103.000	103.000
<i>R<sup>2</sup></i>	0.921	0.921	0.956	0.953	0.990	0.989
<i>Wald chi-squared chi – squared Statistic</i>	2687959.67	2413220.38	20077.87	15291.27	93397.90	130189.57

Note: The dependent variable is the log of total greenhouse gas emission (*LTGE*); Standard errors in parentheses; *DING* =Dummy variable for developing countries (developing=1, developed=0); *SSA* =Dummy variable for Sub-Saharan Africa countries (Sub-Saharan Africa country=1, otherwise=0); Model i and ii while iii and iv are ar(1) corrected. Also, v and vi are psar(1) corrected; \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

The analysis now extends the investigation of globalization to include the Freedom to Trade Internationally (FTI) index (Tables 5.10 and 5.11. As earlier noted, the FTI is a comprehensive measure of globalization that combines financial flows (like FDI) and trade openness (like LTOP), providing a singular, aggregated view of their joint impact, which is essential for

determining if the overall integration of a country into the global economy is environmentally sustainable.

The Global PCSE Models with FTI provide the foundational understanding of how this composite measure impacts GHG emissions. The base FTI (developed countries) coefficient is consistently negative across all models in Table 5.7 (-0.086 in Panel (viii)). This confirms that for high-income economies, overall globalization, when measured by FTI, results in a net Pollution Halo effect, aligning with the initial findings for both LTOP and FDI. In contrast, the FTIXDING interaction term, which captures the difference for the general developing world, is statistically insignificant. This suggests that for the general developing world, the net effect of FTI is approximately the base effect, meaning overall financial and trade integration is either neutral or slightly mitigating, even in developing countries. Furthermore, the FTIXLRGDPPC interaction term is significantly negative (-0.002 in Panel (v), Table 5.7). This reinforces the core principle of the EKC hypothesis, showing that as income per capita increases, the environmental benefits of globalization are structurally strengthened.

The analysis of SSA PCSE Models with FTI confirms the unique structural position of the region established in the LTOP/FDI analysis. In the fully controlled model in Table 5.11 (Panel (vi)), the coefficients for FTI, FTIXDING, and FTIXSSA are all insignificant. The Net Effect of FTI in SSA is therefore approximately:  $(-0.007) + (0.001) + (0.003) \approx -0.002$ . This result is consistent, serving as the definitive conclusion for the overall impact of globalization in SSA. This refutes the overall PHH narrative for the region and reinforces the conclusion that SSA's primary environmental threat lies in its domestic energy choices, given that NRE is still statistically positive (0.005). Furthermore, the scale of growth (LRGDP = 0.976) is a highly significant positive driver of emissions.

Table 5.10: Fixed and Random Effect Models for Sub-Saharan Africa (SSA) with FTI

	(i)	(ii)	(iii)	(iv)
<i>FTI</i>	0.021 <sup>***</sup> (0.004)	0.021 <sup>***</sup> (0.004)	0.022 <sup>***</sup> (0.004)	0.022 <sup>***</sup> (0.004)
<i>FTIXDING</i>	-0.025 <sup>***</sup> (0.005)	-0.025 <sup>***</sup> (0.005)	-0.025 <sup>***</sup> (0.005)	-0.025 <sup>***</sup> (0.005)
<i>FTIXSSA</i>	0.010 <sup>**</sup> (0.004)	0.011 <sup>**</sup> (0.004)	0.008 <sup>*</sup> (0.004)	0.009 <sup>*</sup> (0.004)
<i>NRE</i>	0.008 <sup>***</sup> (0.000)	0.008 <sup>***</sup> (0.000)	0.007 <sup>**</sup> (0.000)	0.007 <sup>**</sup> (0.000)
<i>LRGDP</i>	0.312 <sup>***</sup> (0.012)	0.704 <sup>***</sup> (0.019)	0.299 <sup>***</sup> (0.012)	0.770 <sup>***</sup> (0.016)
<i>LPOP</i>	0.177 <sup>***</sup> (0.011)		0.209 <sup>***</sup> (0.010)	
<i>LRGDPPC</i>		-0.383 <sup>***</sup> (0.026)		-0.465 <sup>***</sup> (0.022)
<i>Number of obs.</i>	2257	2257	2257	2257
<i>Number of Groups</i>	103.000	103.000	103.000	103.000
<i>R<sup>2</sup></i>	0.863	0.857	0.897	0.897
<i>F/ Wald chi – squared Statistic</i>	1116.788	1099.190	7671.96	7551.89

Note: The dependent variable is the log of total greenhouse gas emission (*LTGE*); Standard errors in parentheses; *DING* =Dummy variable for developing countries (developing=1, developed=0); *SSA* =Dummy variable for Sub-Saharan Africa countries (Sub-Saharan Africa country=1, otherwise=0); \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ ; The Wald  $\chi^2$  Statistic is for the Random effect models in columns (iii) and (iv).

Table 5. 11: Panel Corrected Standard Error (PCSE) Models for SSA with FTI

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
<i>FTI</i>	-0.090*** (0.023)	-0.090*** (0.024)	-0.007 (0.008)	-0.009 (0.008)	-0.005 (0.007)	-0.007 (0.007)
<i>FTIXDING</i>	0.046** (0.021)	0.046** (0.022)	0.004 (0.008)	0.004 (0.008)	-0.001 (0.007)	0.001 (0.007)
<i>FTIXSSA</i>	-0.045*** (0.009)	-0.045*** (0.009)	0.001 (0.004)	0.002 (0.004)	0.001 (0.004)	0.003 (0.004)
<i>NRE</i>	0.004*** (0.000)	0.004*** (0.000)	0.005*** (0.000)	0.005*** (0.000)	0.005*** (0.000)	0.005*** (0.000)
<i>LRGDP</i>	0.620*** (0.010)	0.973*** (0.003)	0.471*** (0.021)	0.942*** (0.010)	0.513*** (0.015)	0.976*** (0.005)
<i>LPOP</i>	0.154*** (0.004)		0.212*** (0.007)		0.201*** (0.007)	
<i>LRGDPPC</i>		-0.355*** (0.008)		-0.445*** (0.019)		-0.438*** (0.017)
<i>Number of obs.</i>	2257	2257	2257	2257	2257	2257
<i>Number of Groups</i>	103.000	103.000	103.000	103.000	103.000	103.000
<i>R<sup>2</sup></i>	0.927	0.927	0.957	0.955	0.990	0.989
Wald $\chi^2$ Statistic	3771948.44	4036688.36	17592.14	16053.84	93576.98	120978.11

Note: The dependent variable is the log of total greenhouse gas emission (*LTGE*); Standard errors in parentheses; *DING* =Dummy variable for developing countries (developing=1, developed=0); *SSA* =Dummy variable for Sub-Saharan Africa countries (Sub-Saharan Africa country=1, otherwise=0); Model i and ii while iii and iv are ar(1) corrected. Also, v and vi are psar(1) corrected; \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

## CHAPTER SIX

### CONCLUSION

#### 6.1 Conclusion

The necessity of achieving environmental sustainability while pursuing robust economic growth is a paramount and much-discussed theme in the literature on economic globalization and environmental sustainability. This is especially the case for developing countries that must contend with the dual challenge of eliminating poverty and mitigating greenhouse gas (GHG) emissions. As a structurally vulnerable geo-economic region, Sub-Saharan Africa (SSA) requires empirical analysis to move beyond the conflicting theoretical debates, that is, specifically, whether economic globalization results in a mitigating Pollution Halo or an exacerbating Pollution Haven.

This thesis investigates the effects of economic globalization, measured by trade openness (LTOP), foreign direct investment (FDI), and Freedom to Trade Internationally (FTI), on GHG emissions across a panel dataset of 103 countries, disaggregated into developed and developing countries, and a subset of SSA countries. To address the issue of cross-sectional dependence common in global panel data, the Panel Corrected Standard Error (PCSE) model was adopted as the main estimation technique.

The empirical results reveal that economic globalization reduces greenhouse gas emissions in general. However, the result also shows a significant structural global split. To capture the distinct effect of economic globalization on GHG emissions in developed and developing nations, a dummy (binary) variable was introduced, which represents developed = 0 (the base effect) and developing = 1 (the net difference in slope). In developed nations, economic globalization, which is captured by a negative base coefficient for LTOP (-0.085) and FTI (-0.086), acts as a mitigating force. This implies that economic globalization reduces GHG

emissions in advanced economies. However, for the general developing world, the marginal effect of the difference in slope (LTOPXDING) is 0.126. This positive marginal effect outweighs the mitigating base effect, resulting in a net slope of 0.041 for developing countries. This confirms that economic globalization, through trade openness, exacerbates GHG emissions in developing nations, triggering a Pollution Haven effect, where the “Scale Effect” of industrial expansion outweighs technological gains.

Central to this dynamic is the role of income level. The results consistently show a strong mitigating effect when Real GDP Per Capita (RGDPPC) is interacted with LTOP (-0.064), FDI (-0.003) and FTI (-0.002). This confirms the Environmental Kuznets Curve (EKC) hypothesis, suggesting that as countries achieve higher income levels, they gain the institutional and financial capacity to adopt cleaner production techniques.

Essentially, the empirical results reveal that the environmental consequences of globalization differ substantially in SSA compared to the general developing world. The key finding of this thesis is the demonstration of structural neutrality in SSA. Specifically, when the focus is narrowed to SSA, the model introduces a final adjustment that pulls the slope back down. The results indicate that the SSA-specific marginal effect of trade (LTOPXSSA = -0.028) cancels out the surcharge of the general developing nations (LTOPXDING = 0.089). This result brings back the net impact of trade openness and FDI in SSA to near-zero (0.001 and 0.000, respectively). This finding rejects the notion that SSA is a significant pollution haven for trade or FDI. This implies that, for the general developing world, trade is considered a positive driver of emissions, whereas the SSA region is neutral on this effect.

This neutrality suggests that SSA has not yet entered the carbon-intensive manufacturing stage that plagues other developing regions, but it also hasn't yet reached the high-income level where trade becomes an active tool for environmental cleaning. RGDP per capita is found to

be negative (-0.439), which confirms the presence of the EKC hypothesis, suggesting that as the region continues to develop and income levels further increase, there will be a significant reduction in GHG emissions. Summarily, these results emphasize that the GHG emissions challenge in SSA is not primarily driven by economic globalization. Instead, the findings show the dominance of other domestic factors, such as the negative effect of the income level, the consistently significant positive coefficient of non-renewable energy (0.004), and the positive effect of economic growth.

## **6.2 Policy Recommendations**

This thesis provides information to the governments of SSA countries regarding the policy shift necessary to address climate change. Since globalization is environmentally inert, policies should be prioritized that lead to higher levels of economic growth and trade liberalization. These policies will facilitate the rise in income per capita necessary to reach the “turning point” of the EKC, providing the financial resources required for environmental remediation

The findings in this thesis suggest that the imperative for SSA is the need for a sustained investment in decarbonization and green infrastructure. For SSA countries to achieve sustainable development, governments should invest in renewable energy sources and the provision of quality infrastructure, including transportation systems, information and communication networks, and school and training systems, to boost human capital. These policies will significantly reduce the high elasticity relative to NRE.

Furthermore, governments must strengthen Policies and Institutions for Environmental Sustainability (PIES) to mitigate the localized ecological damage caused by extractive FDI and raw material trade, which defines the region’s structural neutrality. This is because more developed infrastructure and improvements in economic institutions would boost returns on foreign investment in domestic markets and increase the overall productivity necessary for

achieving the emission-reducing income levels suggested by the EKC hypothesis. By adopting this policy suggestion, SSA countries can finally trigger the “Technique Effects” of globalization that have remained dormant due to the region’s current extractive economic structure.

### **6.3 Strengths and Limitations of the Study**

A major contribution of this study to the literature on this subject matter is the use of the PCSE model, which provides more reliable estimates than standard regression models by accounting for contemporaneous correlation and heteroscedasticity across a diverse global panel. Additionally, by disaggregating economic globalization into volume-based metrics (LTOP) and institution-based metrics (FTI), the study offers a nuanced view of how freedom to trade differs from trade intensity. Furthermore, the primary strength of this study lies in its unique analytical structure. By looking at the broad global context before narrowing the focus to Sub-Saharan Africa, the research provides a comprehensive baseline that highlights how regional realities diverge from global trends. The adoption of a difference in slope approach allows for a precise econometric identification of how the relationship between globalization and the environment rotates based on a country’s development status. This methodological approach ensures that the identified structural neutrality of SSA is not merely an observation but a statistically isolated phenomenon.

Nevertheless, there are still some limitations which future research, while building upon the findings of this study, can address.

### **6.4 Areas of Future Research Focus**

Building on the findings of this thesis, future research should investigate more deeply into the Freedom to Trade Internationally (FTI) index and its individual components. While the aggregated FTI showed a mitigating base effect, its interaction terms in robust models suggest

a complex relationship that warrants further disaggregation. Research could focus on how specific sub-components—such as regulatory trade barriers, black-market exchange rates, or capital controls—individually affect GHG emissions. Furthermore, investigating the role of the African Continental Free Trade Area (AfCFTA) in shifting SSA’s composition effect from primary commodities to manufacturing will be vital. Future studies could also move toward sectoral analysis to determine if specific industries within the region are hiding localized pollution havens that are obscured by the national-level neutrality found in this study.

## REFERENCES

- Acheampong, A. O., Adams, S., & Boateng, E. (2019). Do globalization and renewable energy contribute to carbon emissions mitigation in Sub-Saharan Africa? *The Science of the Total Environment*, 677, 436–446. <https://doi.org/10.1016/j.scitotenv.2019.04.353>
- Adedoyin, F. F., Ozturk, I., Agboola, M. O., Agboola, P. O., & Bekun, F. V. (2021). The implications of renewable and non-renewable energy generating in Sub-Saharan Africa: The role of economic policy uncertainties. *Energy Policy*, 150(0301-4215), 112115. <https://doi.org/10.1016/j.enpol.2020.112115>
- Adeleye, B. N., Akam, D., Inuwa, N., James, H. T., & Basila, D. (2023). Does globalization and energy usage influence carbon emissions in South Asia? An empirical revisit of the debate. *Environmental Science and Pollution Research*, 30(13), 36190–36207. <https://doi.org/10.1007/s11356-022-24457-9>
- Afolabi, L., Ejumedia, P. E., Oduyoye-Ejumedia, A. O., Kabanda, R., & Madichie, N. O. (2025). Unravelling the link between bilateral investment treaties and environmental sustainability in sub-Saharan african countries. *Insight on Africa*, 17(1), 7-29, <https://doi.org/10.1177/09750878241241792>
- Ahmed, Z., & Le, H. P. (2021). Linking Information Communication Technology, trade globalization index, and CO2 emissions: evidence from advanced panel techniques. *Environmental Science and Pollution Research*, 28(7), 8770–8781. <https://doi.org/10.1007/s11356-020-11205-0>
- Akinlo, T., & Dada, J.T. (2021). The moderating effect of foreign direct investment on environmental degradation-poverty reduction nexus: evidence from sub-Saharan African countries. *Environment, Development and Sustainability*, 15764–15784, <https://doi.org/10.1007/s10668-021-01315-1>
- Aluko, O. A., Opoku, E. E. O., & Ibrahim, M. (2021). Investigating the environmental effect of globalization: Insights from selected industrialized countries. *Journal of Environmental Management*, 281, 111892. <https://doi.org/10.1016/j.jenvman.2020.111892>
- Aminu, N., Clifton, N., & Mahe, S., (2023). From Pollution to prosperity: Investigating the Environmental Kuznets curve and pollution-haven hypothesis in sub-Saharan Africa’s industrial sector. *Journal of Environmental Management*, 342, 118147. <https://doi.org/10.1016/j.jenvman.2023.118147>
- Amoah, J. O., Alagidede, I. P., & Sare, Y. A. (2023). Impact of foreign direct investment on carbon emission in Sub-Saharan Africa: The mediating and moderating roles of industrialization and trade openness. *Cogent Business & Management*, 10(3). <https://doi.org/10.1080/23311975.2023.2266168>
- Anderson, K. (2024). “What was the Industrial Revolution’s environmental impact?” Greenly. Retrieved 20 June 2025, from <https://greenly.earth/en-gb/blog/ecology-news/what-was-the-industrial-revolutions-environmental-impact>

- Andriamahery, A., Danarson, J. H., & Qamruzzaman, M. (2022). Nexus between trade and environmental quality in sub-saharan Africa: Evidence from panel GMM. *Frontiers in Environmental Science*, 10, 986429 <https://doi.org/10.3389/fenvs.2022.986429>
- Aquilas, N. A., Ngangnchi, F. H., & Mbella, M. E. (2024). Industrialization and environmental sustainability in Africa: The moderating effects of renewable and non-renewable energy consumption. *Heliyon*, 10(4), <https://doi.org/10.1016/j.heliyon.2024.e25681>
- Asongu, S. A., & Nnanna, J. (2021). Globalization, governance, and the green economy in sub-Saharan Africa: Policy Thresholds. *World Affairs*, 184(2), 176–212. <https://www.jstor.org/stable/27066276>
- Awodumi, O. B., & Adewuyi, A. O. (2020). The role of non-renewable energy consumption in economic growth and carbon emission: Evidence from oil producing economies in Africa. *Energy Strategy Reviews*, 27(2211-467X), 100434. <https://doi.org/10.1016/j.esr.2019.100434>
- Aziz, N., Hossain, B., & Lamb, L. (2024). The effectiveness of environmental protection policies on greenhouse gas emissions. *Journal of Cleaner Production*, 450, 141868. <https://doi.org/10.1016/j.jclepro.2024.141868>
- Bakata, H. (2021). Globalization and Environmental Pollution in Sub-Saharan Africa. *African Journal of Economic Review*, 9(1), 191- 213.
- Balatsky, A.V., Balatsky, G.I., & Borysov, S. (2015). Resource Demand Growth and Sustainability Due to Increased World Consumption. *Sustainability*, 7(3), 3430-3440. <https://doi.org/10.3390/su7033430>
- Beck, N., & Katz, J. N. (1995). What To Do (and Not to Do) with Time-Series Cross-Section Data. *American Political Science Review*, 89(3), 634–647. <https://doi.org/10.2307/2082979>
- Behera, C., Mohanty, R. K., Priyadarsini, B. T., & Patnaik, D. (2024). Nexus between CO2 emission, renewable energy, trade openness and foreign direct investment, and output volatility. *Economic Change and Restructuring*, 57(5), 155, <https://doi.org/10.1007/s10644-024-09736-4>
- Blaug, M. (1992). The Heckscher-Ohlin Theory of International Trade. In M. Blaug (Ed.), *The Methodology of Economics: Or, How Economists Explain* (2nd ed., pp. 185-191). Cambridge University Press. <https://doi.org/10.1017/CBO9780511528224.013>
- Boubacar, S., Sarpong, F. A., & Nyantakyi, G. (2024). Shades of sustainability: decoding the impact of foreign direct investment on CO2 emissions in Africa's growth trajectory. *Environment, Development and Sustainability*, 1-34, <https://doi.org/10.1007/s10668-024-04656-9>
- Brandi, C., Schwab, J., Berger, A., Morin, J. (2020). Do environmental provisions in trade agreements make exports from developing countries greener? *World Development*, 129, 104899 <https://doi.org/10.1016/j.worlddev.2020.104899>

- Campbell, J. (2019). Nigeria is oil-dependent, not oil-rich. *Africa in transition, Africa program, and Nigeria on the brink, 1*.
- Campbell, N. (2003). Does trade liberalization make the Porter hypothesis less relevant? *International Journal of Business and Economics*, 2(2), 129-140.
- Castle, J., & Hendry, D. (2022, January 28). Econometrics for Modelling Climate Change. *Oxford Research Encyclopedia of Economics and Finance*. Retrieved 3 Dec. 2025, from <https://oxfordre.com/economics/view/10.1093/acrefore/9780190625979.001.0001/acrefore-9780190625979-e-675>.
- Chandra, R. (2022). Paul Krugman, New Trade Theory and New Economic Geography. Endogenous Growth in Historical Perspective, 221-249, [http://dx.doi.org/10.1007/978-3-030-83761-7\\_8](http://dx.doi.org/10.1007/978-3-030-83761-7_8)
- Chienwattanasook, K., Chavaha, C., Lekhawichit, N., & Jermstiparsert, K. (2021). The impact of economic growth, globalization, and financial development on CO2 emissions in ASEAN countries. *Academy of Strategic Management Journal*, 20(3). <https://wb.yru.ac.th/xmlui/handle/yr/5719>
- Cooper, F. (2001). What is the concept of globalization good for? An African historian's perspective. *African affairs*, 100(399), 189-213. <https://doi.org/10.1093/afraf/100.399.189>
- Copeland, B. R., & Taylor, M. S. (1994). North-South Trade and the Environment. *The Quarterly Journal of Economics*, 209(3), 755-787. <https://doi.org/10.2307/2118421>
- Corporate Finance Institute, CFI. (2015). Eclectic Paradigm: An economic and business method for analysing the attractiveness of making a foreign direct investment, <https://corporatefinanceinstitute.com/resources/management/eclectic-paradigm/>
- Cristea, A., Hummels, D., Puzello, L., & Avetisyan, M. (2013). Trade and the greenhouse gas emissions from international freight transport. *Journal of Environmental Economics and Management*, 65(1), 153-173. <https://doi.org/10.1016/j.jeem.2012.06.002>
- Cruz, C., Floriani, D.E., & Amal, M. (2020). The Eclectic Paradigm as a Comprehensive Model to Analyze Subnational Determinants of FDI. *International Journal of Emerging Markets*, 1746-8809, DOI 10.1108/IJOEM-07-2019-0517
- Danaeefard, H., & Abbasi, T. (2011). Globalization and Global Innovations. *The Systemic Dimension of Globalization*, InTech. doi: 10.5772/732
- Destek, M. A. (2020). Investigation on the role of economic, social, and political globalization on the environment: evidence from CEECs. *Environmental Science and Pollution Research*, 27(27), 33601–33614. <https://doi.org/10.1007/s11356-019-04698-x>
- Dey, S. R. (2007). Globalization and Its Real Benefits. *Critical Perspectives on International Business*, 75-84
- Dunning, J. (1988). The eclectic paradigm of international production: a restatement and some possible extensions. *Journal of International Business Studies*, 9(1-31), 1-30.

- Duodu, E., Kwarteng, E., Oteng-Abayie, E. F., & Frimpong, P. B. (2021). Foreign direct investments and environmental quality in sub-Saharan Africa: the merits of policy and institutions for environmental sustainability. *Environmental Science and Pollution Research*, 28(46), 66101-66120, <https://doi.org/10.1007/s11356-021-15288-1>
- Ewane, E. B., & Ewane, E. I. (2023). Foreign direct investment, trade openness and environmental degradation in SSA countries. A quadratic modeling and turning point approach. *American Journal of Environmental Economics*, 2(1), 9-18, <https://doi.org/10.54536/ajee.v2i1.1414>
- Faccarello, G. (2015). *Comparative Advantage*. The Elgar Companion to David Ricardo, Heinz D. Kurz and Neri Salvadori(eds), Cheltenham: Edward Elgar, 69–77. <http://dx.doi.org/10.4337/9781784715489.0011>
- Farooq, S., Ozturk, I., Majeed, M. T., & Akram, R. (2022). Globalization and CO2 emissions in the presence of EKC: a global panel data analysis. *Gondwana Research*, 106, 367-378. <https://doi.org/10.1016/j.gr.2022.02.002>
- Farooq, U. (2022). Foreign direct investment, foreign aid, and CO2 emissions in Asian economies: does governance matter?. *Environmental Science and Pollution Research*, 29(5), 7532-7547, <https://doi.org/10.1007/s11356-021-16115-3>
- Fatima, T., Saeed Meo, M., Bekun, F. V., & Ibrahim, T. O. (2021). The impact of energy consumption to environmental sustainability: an extension of foreign direct investment-induced pollution in Vietnam. *International Journal of Energy Sector Management*, 15(6), 1144-1162 <https://doi.org/10.1108/IJESM-01-2021-0001>
- Filonchik, M., Peterson, M. P., Zhang, L., Hurynovich, V., & He, Y. (2024). Greenhouse gases emissions and global climate change: Examining the influence of CO2, CH4, and N2O. *The Science of the Total Environment*, 935, 173359. <https://doi.org/10.1016/j.scitotenv.2024.173359>
- Fletcher, I. (2011). Why the theory of comparative advantage is wrong. *International Journal of Pluralism and Economics Education*, 2(4), 421-429, <http://dx.doi.org/10.1504/IJPEE.2011.046029>
- Fouquin, M. & Hugot, J. (2016). Back to the Future: International Trade Costs and the Two Globalizations. *CEPII Working Paper*, <https://econpapers.repec.org/RePEc:cii:cepidd:2016-13>
- Gaies, B., Nakhli, M. S., & Sahut, J. (2022). What are the effects of economic globalization on CO2 emissions in MENA countries? *Economic Modelling*, 116, 106022. <https://doi.org/10.1016/j.econmod.2022.106022>
- Ganda, F., & Panicker, M. (2025). Does access to energy matter? Understanding the complex nexus among energy consumption, ICT, foreign direct investment and economic growth on carbon emissions in Sub-Saharan Africa. *Energy Nexus*, 17, 100346. <https://doi.org/10.1016/j.nexus.2024.100346>
- Ge, M., Kannaiah, D., Li, J., Khan, N., Shabbir, M. S., Bilal, K., & Tabash, M. I. (2022). Does foreign private investment affect the clean industrial environment? Nexus among

- foreign private investment, CO2 emissions, energy consumption, trade openness, and sustainable economic growth. *Environmental Science and Pollution Research*, 29(18), 26182-26189, <https://doi.org/10.1007/s11356-022-18814-x>
- Ghazalian, P.L. (2025). Globalization and the Fallout of the COVID-19 Pandemic. *World, MDPI*, 6(1), 1-22, <https://doi.org/10.3390/world6010004>
- Ghazouani, T. (2024). Investigating the Dynamic Link between Globalization and Carbon Emissions in BRICS Nations: Insights from a Non-Parametric Perspective. *International Economics*, 100553. <https://doi.org/10.1016/j.inteco.2024.100553>
- Giovanni, F., Junguito, T. A. (2018). Federico-Tena World Trade Historical Database: Openness. <https://doi.org/10.21950/BBZVBN>, e-cienciaDatos, V1
- Gyamfi, B. A., Bein, M. A., Udemba, E. N., & Bekun, F. V. (2021). Investigating the pollution haven hypothesis in oil and non-oil sub-Saharan Africa countries: Evidence from quantile regression technique. *Resources Policy*, 73, 102119. <https://doi.org/10.1016/j.resourpol.2021.102119>
- Halliru, A. M., Loganathan, N., & Hassan, A. a. G. (2021). Does FDI and economic growth harm the environment? Evidence from selected West African countries. *Transnational Corporation Review*, 13(2), 237–251. <https://doi.org/10.1080/19186444.2020.1854005>
- Han, H., Ye, X., Bian, Y., Lin, S., Shen, Y., Huang, Z., & Lin, J. (2024). Decomposing high uncertainty in greenhouse gas mitigation pathways in emerging regions: An approach to evaluate risks toward carbon neutrality. *Science of The Total Environment*, 953, 176152. <https://doi.org/10.1016/j.scitotenv.2024.176152>
- Hanvoravongchai, P., & Paweenawat, J. (2025). Economic and Environmental Dynamics in Southeast Asia: The Impact of Tourism, Gross Domestic Product, Foreign Direct Investment, and Trade Openness on Carbon Dioxide Emissions. *Journal of Energy and Environmental Policy Options*, 8(1), 51-65. <http://resdojournals.com/index.php/JEEPO/article/view/406>
- He, K., Ramzan, M., Awosusi, A., Ahmed, Z., Ahmad M., Altuntas, M. (2021). Does Globalization Moderate the Effect of Economic Complexity on CO2 Emissions? Evidence From the Top 10 Energy Transition Economies. *Frontiers in Environmental Science*, 9, 778088. <https://doi.org/10.3389/fenvs.2021.778088>
- Hossain, R., Kumar Roy, C., & Akter, R. (2023). Dynamic effects of economic growth, foreign direct investment, and trade openness on environmental quality: Evidence from Asian economies. *Croatian Economic Survey*, 25(1), 79-114, <https://hrcak.srce.hr/304660>
- Huo, W., Ullah, M. R., Zulfiqar, M., Parveen, S., & Kibria, U. (2022). Financial development, trade openness, and foreign direct investment: a battle between the measures of environmental sustainability. *Frontiers in Environmental Science*, 10, 851290 <https://doi.org/10.3389/fenvs.2022.851290>
- Hussain, J., & Zhou, K. (2022). Globalization, industrialization, and urbanization in Belt and Road Initiative countries: implications for environmental sustainability and energy

- demand. *Environmental Science and Pollution Research*, 29(53), 80549-80567 <https://doi.org/10.1007/s11356-022-21520-3>
- Huwart, J.Y. and L. Verdier (2013), *Economic Globalisation: Origins and Consequences*, OECD Insights, OECD Publishing. <http://dx.doi.org/10.1787/9789264111899-en>
- Ideba, E. T., Orji, A., Anthony-Orji, O. I., Nevoh, C. H., Okoro, O. (2025). Trade Openness, Foreign Direct Investment and Environmental Sustainability Nexus In Nigeria. *Economic and Regional Studies*, 18(2), 164-176. <https://doi.org/10.2478/ers-2025-0014>
- IMF. (2024). *Gross domestic product: An economy's all*. Retrieved December 2, 2025, from <https://www.imf.org/-/media/files/publications/fandd/back-to-basics/callen-gdp.pdf>
- International Chamber of Commerce (ICC). (2024). New report: extreme weather events cost economy \$2 trillion over the last decade. Sustainability Report, <https://iccwbo.org/news-publications/policies-reports/new-report-extreme-weather-events-cost-economy-2-trillion-over-the-last-decade/>
- IPCC. (2013): *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.
- IPCC. (2021). *Greenhouse Gases. Annex VII: Glossary* [Matthews, J.B.R., V. Möller, R. van Diemen, J.S. Fuglestedt, V. Masson-Delmotte, C. Méndez, S. Semenov, A. Reisinger (eds.)]. In *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 2215–2256, doi:10.1017/9781009157896.022.
- Jahanger, A. (2021). Impact of Globalization on CO<sub>2</sub> emissions based on EKC hypothesis in developing world: the moderating role of human capital. *Environmental Science and Pollution Research*, 29(16), 20731-20751. <https://doi.org/10.1007/s11356-021-17062-9>
- Jianguo, D., Ali, K., Alnori, F., & Ullah, S. (2022). The nexus of financial development, technological innovation, institutional quality, and environmental quality: evidence from OECD economies. *Environmental Science and Pollution Research*, 29(38), 58179–58200. <https://doi.org/10.1007/s11356-022-19763-1>
- Kalayci, C., & Hayaloglu, P. (2024). The Impact of Economic Globalization on CO<sub>2</sub> Emissions: The Case of NAFTA Countries. *Internal Journal of Energy Economics and Policy*, 9(1), 356-360. <http://dx.doi.org/10.32479/ijeep.7233>

- Kastratovic, R. (2019). Impact of Foreign Direct Investment on Greenhouse Gas Emissions in Agriculture of Developing Countries. *Australian Journal of Agriculture and Resource Economics*, 63(3), 620-642. <https://doi.org/10.1111/1467-8489.12309>
- Kim, S. (2020). The Effects of Foreign Direct Investment, Economic Growth, Industrial Sector, Renewable and Nuclear Energy, and Urbanization on Korean Greenhouse Gas Emissions. *Sustainability*, 12(4), 1-14.
- Kiviyiro, P., & Arminen, H. (2014). Carbon dioxide emissions, energy consumption, economic growth, and foreign direct investment: Causality analysis for Sub-Saharan Africa. *Energy*, 74, 595–606. <https://doi.org/10.1016/j.energy.2014.07.025>
- Kiviyiro, P., & Arminen, H. (2014). Carbon dioxide emissions, energy consumption, economic growth, and foreign direct investment: Causality analysis for Sub-Saharan Africa. *Energy*, 74, 595–606. <https://doi.org/10.1016/j.energy.2014.07.025>
- Kounis, N., Burgering, C., & Renout, S. (2023). The decoupling of emissions and economic growth. *SustainaWeekly*.
- Laufer, W.S. (2003). Social Accountability and Corporate Greenwashing. *Journal of Business Ethics* 43, 253–261. <https://doi.org/10.1023/A:1022962719299>
- Lee C.C., Yuan Z., Wang Q. (2022). How does information and communication technology affect energy security? International evidence. *Energy Econ.* 109:105969. <https://doi.org/10.1016/j.eneco.2022.105969>
- Lee, S.K., Choi, G., Lee, E. & Jin, T. (2020). The impact of official development assistance on the economic growth and carbon dioxide mitigation for the recipient countries. *Environmental Science and Pollution Research* 27(33), 41776-41786, <https://doi.org/10.1007/s11356-020-10138-y>
- Lu, R. (2024). The Heckscher-Ohlin Model in Modern International Trade. *Advances in Economics Management and Political Sciences*, 67(1), 26-31, <http://dx.doi.org/10.54254/2754-1169/67/20241255>
- McLaughlin, E. (2021). How have economists thought about climate change? Retrieved 20 June 2025, from <https://economicsobservatory.com/how-have-economists-thought-about-climate-change>
- Morrissey, K. (2020). Resource and Environmental Economics. International Encyclopedia of Human Geography (Second Edition), 463-466 <https://doi.org/10.1016/B978-0-08-102295-5.10755-3>
- Movius, L. (2010). Cultural Globalization and Challenges to Traditional Communication Theories. *Platform Journal of Media and Communication*, 2(1), 6-18.
- Mpure, D. M. N., Duodu, E., Abille, A. B., & Ayamga, E. A. (2024). The environmental impact of international trade in Sub-Saharan Africa: exploring the role of policy and institutions for environmental sustainability. *Research in Globalization*, 9, 100240, <https://doi.org/10.1016/j.resglo.2024.100240>

- Muhammad, B., & Khan, S. (2021, May). Understanding the relationship between natural resources, renewable energy consumption, economic factors, globalization and CO2 emissions in developed and developing countries. In *Natural resources forum* (Vol. 45, No. 2, pp. 138-156). Oxford, UK: Blackwell Publishing Ltd. <https://doi.org/10.1111/1477-8947.12220>
- Murshed, M. (2023). An empirical re-investigation for verifying the pollution haven hypothesis concerning the foreign direct investment-carbon intensity nexus: Contextual evidence from BRICS. *Environmental Challenges*, 13, 100793. <https://doi.org/10.1016/j.envc.2023.100793>
- Namahoro J.P., Wu Q., Xiao H., Zhou N. (2021). The impact of renewable energy, economic and population growth on CO2 emissions in the East African region: evidence from common correlated effect means group and asymmetric analysis. *Energies*, 14 (2), 312. [10.3390/en14020312](https://doi.org/10.3390/en14020312)
- NASA. (2024). Solar System Temperatures, [https://science.nasa.gov/resource/solar-system-temperatures/#:~:text=Mean%20Temperatures%20on%20Each%20Planet&text=The%20mean%20temperatures%20of%20planets,%20\(15%C2%B0C\)](https://science.nasa.gov/resource/solar-system-temperatures/#:~:text=Mean%20Temperatures%20on%20Each%20Planet&text=The%20mean%20temperatures%20of%20planets,%20(15%C2%B0C))
- Nasim, I., Bashir, F., Munir, F., & Kiran, I. (2023). Foreign direct investment, industrial value added, trade liberalization and environmental degradation in South Asian countries. *Pakistan Journal of Humanities and Social Sciences*, 11(1), 646-654, <https://doi.org/10.52131/pjhss.2023.1101.0381>
- Nguyễn, H. V., & Phan, T. T. (2025). Impact of economic growth, international trade, and FDI on sustainable development in developing countries. *Environment, Development and Sustainability*, 27(2), 4017-4043, <https://doi.org/10.1007/s10668-023-04060-9>
- Nick, H., Shogren, J.F., & White, B. (2001). *Introduction to Environmental Economics*. Oxford University Press, New York, United States.
- Nwabueze, E.E. Abner, I.P., Nwude, C.E., Samuel, O.J. & Udo, S.E. (2023). Financial development, foreign direct investment, and CO2 emissions nexus: evidence from Sub-Saharan Africa. *Journal of Hunan University Natural Sciences*, 50(6). <https://doi.org/10.55463/issn.1674-2974.50.6.12>
- Nyang, S. (1998). Conceptualizing globalization. *American Journal of Islamic Social Sciences*, 15, 129-132
- OECD (2011), *Globalisation, Comparative Advantage and the Changing Dynamics of Trade*, OECD Publishing, Paris, <https://doi.org/10.1787/9789264113084-en>.
- Osibanjo, A. O., Oyewunmi, A. E., & Salau, O. P. (2014). Globalization and Multinational Corporations: The Nigerian Business Environment in Perspective. *IOSR Journal of Business and Management (IOSR-JBM)*, 16(11), 1-7.
- Ostrom, E. (1990). *Governing the Commons: The evolution of institutions for collective action*. Cambridge University Press, United Kingdom. ISBN 0 521405998

- Papadas, D. (2024). Exploring the nexus of economic growth, energy mix, services, trade openness, and environmental quality: Evidence from N11 countries. *Development and Sustainability in Economics and Finance*, 2, 100028, <https://doi.org/10.1016/j.dsef.2024.100028>
- Perveen, F., & Khan, A. A. (2021). Impact of official development assistance on sustainable development of Pakistan. *American Economic & Social Review*, 8(1), 11-21, <https://doi.org/10.46281/aesr.v8i1.1454>
- Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, 22(2), 265–312. <https://doi.org/10.1002/jae.951>
- Pesaran, M. H. (2020). General diagnostic tests for cross-sectional dependence in panels. *Empirical Economics*, 60(1), 13–50. <https://doi.org/10.1007/s00181-020-01875-7>
- Pitelis, C., & Sugden, R. (2000). The nature of the transnational firm. *Routledge*. p. H72. ISBN 0-415-16787-6.
- Polloni-Silva, E., Ferraz, D., De Castro Camioto, F., Rebelatto, D. a. D. N., & Moralles, H. F. (2021). Environmental Kuznets Curve and the Pollution-Halo/Haven Hypotheses: An investigation in Brazilian municipalities. *Sustainability*, 13(8), 4114. <https://doi.org/10.3390/su13084114>
- Porter, M. E., & Van Der Linde, C. (1995). Toward a new conception of the Environment-Competitiveness relationship. *The Journal of Economic Perspectives*, 9(4), 97–118. <https://doi.org/10.1257/jep.9.4.97>
- Rauf, A., Ali, N., Sadiq, M. N., Abid, S., Kayani, S. A., & Hussain, A. (2023). Foreign Direct Investment, Technological Innovations, Energy Use, Economic Growth, and Environmental Sustainability Nexus: New Perspectives in BRICS Economies. *Sustainability*, 15(18), 14013. <https://doi.org/10.3390/su151814013>
- Sahar, A., Odugbesan, J. A., & Saei, A. (2023). To what Extent Does Globalization Influence Climate Change Sensitivity in Sub-Saharan Africa Countries: Evidence from DCCE-MG Approach, 13(2), 112. <https://doi.org/10.5296/ber.v13i2.21017>
- Samargandi, N. (2017). Sector value addition, technology and CO2 emissions in Saudi Arabia. *Renewable and Sustainable Energy Reviews*, 78, 868-877
- Sarkodie, S. A., & Strezov, V. (2019). Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. *Science of the Total Environment*, 646, 862-871. <https://doi.org/10.1016/j.scitotenv.2018.07.365>
- Sarkodie, S. A., & Strezov, V. (2019). Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. *Science of the Total Environment*, 646, 862-871. <https://doi.org/10.1016/j.scitotenv.2018.07.365>

- Shangquan, G. (2000). Economic Globalization: Trends, Risks and Risk Prevention. United Nations Development Policy and Analysis Division, Department of Economic and Social Affairs, USA. <http://www.un.org/esa/policy/devplan/index.html>
- Shao X., Zhong Y., Liu W., Li R.Y.M. (2021). Modeling the effect of green technology innovation and renewable energy on carbon neutrality in N-11 countries? Evidence from advanced panel estimations. *J. Environ. Manag.*, 296, 113189. [10.1016/j.jenvman.2021.113189](https://doi.org/10.1016/j.jenvman.2021.113189)
- Sharmiladevi, J. C. (2017). Understanding Dunning's OLI Paradigm. *Indian Journal of Commerce and Management Studies*, Educational Research Multimedia & Publications, India, 8(3), 47-52.
- Siddiqui, F., Yusheng, K., & Kumari, S. (2024). Unveiling the dynamics: how foreign aid shapes renewable energy, technology, globalization, and sustainable environments in BRICS nations. *Discover Sustainability*, 5(1), 96, <https://doi.org/10.1007/s43621-024-00210-9>
- Singh, A. K., Kumar, S., & Gupta, M. (2024). Relationship between digitalization and environmental sustainability in selected countries. In *Green transition impacts on the economy, society, and environment* (pp. 83-107). IGI Global <https://10.4018/979-8-3693-3985-5.ch006>
- Sparrow, P., Brewster, C., & Harris, H. (2004). *Globalizing Human Resource Management*, London: Routledge, 15-38.
- Spiliakos, A. (2024). Tragedy of the Commons: What it is and 5 examples. *Business Insights*, Harvard Business School Online, <https://online.hbs.edu/blog/post/tragedy-of-the-commons-impact-on-sustainability-issues>
- Stauder, M. Do Overseas Development Assistance and Foreign Direct Investment Impact The Carbon Dioxide Emissions Of Developing Countries?.
- Stern, D. I. (2004). The rise and fall of the environmental Kuznets curve. *World Development*, 32(8), 1419–1439. <https://doi.org/10.1016/j.worlddev.2004.03.004>
- Stern, N. (2006). *The Economics of Climate Change: The Stern Review*. Cambridge University Press, United Kingdom. [https://webarchive.nationalarchives.gov.uk/ukgwa/20100407172811mp\\_/http://www.cambridge.org/9780521700801](https://webarchive.nationalarchives.gov.uk/ukgwa/20100407172811mp_/http://www.cambridge.org/9780521700801)
- Sultana, T., Hossain, S., Voumik, L. C., Raihan, A. Does globalization escalate carbon emissions? Empirical evidence from selected Next-11 countries. *Energy Reports*, 10, 86-98. <https://doi.org/10.1016/j.egy.2023.06.020>
- Thompson, W. R. (2007). Measuring Long-term Processes of Political Globalization, in *Routledge: "Globalization as Evolutionary Process: Modeling Global Change."* p. 59. [ISBN 978-1-135-97764-](https://doi.org/10.1016/j.egy.2023.06.020)
- Ullah, A., Raza, K., Nadeem, M., Mehmood, U., Agyekum, E. B., Elnaggar, M. F., ... & Kamel, S. (2022). Does globalization cause greenhouse gas emissions in Pakistan? A promise

to enlighten the value of environmental quality. *International Journal of Environmental Research and Public Health*, 19(14), 8678, <https://doi.org/10.3390/ijerph19148678>

- United Nations (1987). Our Common Future. Retrieved 18 June 2025, from <https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf>
- United Nations Conference on Trade and Development (UNCTAD) (2023). TRADE AND DEVELOPMENT REPORT 2023. <https://unctad.org/publication/trade-and-development-report-2023>
- United Nations Educational, Scientific and Cultural Organization (UNESCO) (2024). “Imminent risk of a global water crisis, warns the UN World Water Development Report 2023.” Retrieved 18 June 2025, from <https://www.unesco.org/en/articles/imminent-risk-global-water-crisis-warns-un-world-water-development-report-2023>
- United Nations. (2015). The Sustainable Development Agenda. Retrieved 18 June 2025, from <https://www.un.org/sustainabledevelopment/development-agenda/>
- United States Environmental Protection Agency. (2025). “What are the trends in greenhouse gas emissions and concentrations and their impacts on human health and the environment?” *Report on the Environment*, <https://www.epa.gov/report-environment/greenhouse-gases>
- Vanham, P. (2019). A Brief History of Globalization. Cologny World Economic Forum, 17 June 2019. <https://www.weforum.org/agenda/2019/01/how-globalization-4-0-fits-into-the-history-of-globalization>
- Vlahinić Lenz, N., & Fajdetić, B. (2021). Globalization and GHG Emissions in the EU: Do We Need a New Development Paradigm? *Sustainability*, 13(17), 9936. <https://doi.org/10.3390/su13179936>
- Voumik, L. C., Rahman, M. H., Rahman, M. M., Ridwan, M., Akter, S., & Raihan, A. (2023). Toward a sustainable future: Examining the interconnectedness among Foreign Direct Investment (FDI), urbanization, trade openness, economic growth, and energy usage in Australia. *Regional sustainability*, 4(4), 405-415 <https://doi.org/10.1016/j.regsus.2023.11.003>
- Vural, G. (2020). How do output, trade, renewable energy and non-renewable energy impact carbon emissions in selected Sub-Saharan African Countries? *Resources Policy*, 69(0301-4207), 101840. <https://doi.org/10.1016/j.resourpol.2020.101840>
- Wang, Q., Wang, X., & Li, R. (2022). Does official development assistance alleviate the environmental pressures during the urbanization of recipient countries? Evidence from the sub-Saharan Africa countries. *Environmental Impact Assessment Review*, 95, 106787, <https://doi.org/10.1016/j.eiar.2022.106787>
- Wolfe, B. (2020). The Age of Exploration. *Encyclopedia Virginia*. <https://encyclopediavirginia.org/entries/exploration-the-age-of>.

- World Bank Group. (2020). Climate Action Drives Development Results – Lessons from The World Bank Group’s First Climate Change Action Plan.
- World Bank Group. (2025). What You Need to Know About the World Bank Group's 2nd Climate Change Action Plan. Retrieved 18 June 2025, from <https://www.worldbank.org/en/news/feature/2021/06/22/what-you-need-to-know-about-the-world-bank-group-2nd-climate-change-action-plan>
- World Bank. (2025). *GDP per capita (Constant LCU)*. Metadata Glossary. Retrieved February 23, 2025, from <https://databank.worldbank.org/metadataglossary/world-development-indicators/series/NY.GDP.PCAP.KN>
- World Economic Forum, EcoWatch (2023). *Climate change is costing the world \$16 million per hour: study*. Retrieved July 18, 2025, from <https://www.weforum.org/stories/2023/10/climate-loss-and-damage-cost-16-million-per-hour/>
- World Health Organization (WHO) (2024). Hunger numbers stubbornly high for three consecutive years as global crises deepen: UN report. Retrieved 18 June 2025, from <https://www.who.int/news/item/24-07-2024-hunger-numbers-stubbornly-high-for-three-consecutive-years-as-global-crises-deepen--un-report>
- World Health Organization. (2023). Climate Change. Retrieved July 18, 2025 from <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>
- World Meteorological Organization (WMO). (2024). *The state of greenhouse gases in the atmosphere based on global observations through 2023* (20th ed.). <https://library.wmo.int>
- World Trade Organization (WTO). (2024). *World Trade Report 2024: Trade and inclusiveness—How to make trade work for all*. Retrieved from <https://www.wto.org>
- Wu, C.F., Chang, T., Wu, T.P., Leng, K.J., Lin, M.C., Huang, S.C., (2022). Impact of globalization on the environment in major CO<sub>2</sub>-emitting countries: Evidence using bootstrap ARDL with a Fourier function. *Frontier Public Health*. 10:907403. <https://doi.org/10.3389/fpubh.2022.907403>
- 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. <https://doi.org/10.1016/j.renene.2021.10.084>
- Xuan, V. N. (2025). Nexus of FDI, GDP, renewable energy, trade openness, and environmental pollution in Japan: New evidence from ARDL method. *Environmental and Sustainability Indicators*, 26, 100677 <https://doi.org/10.1016/j.indic.2025.100677>
- Yanikkaya, H. (2003). Trade openness and economic growth: a cross-country empirical investigation. *Journal of Development Economics*, 72(1), 57-89.

- Yiadam, E. B., Mensah, L., & Bokpin, G. A. (2022). Environmental Risk and Foreign Direct Investment: The Role of Financial Sector Development. *Environmental Challenges*, 9, 100611. <https://doi.org/10.1016/j.envc.2022.100611>
- Yılmaz, A. (2023). Carbon emissions effect of trade openness and energy consumption in Sub-Saharan Africa. *SN Business & Economics*, 3(2). <https://doi.org/10.1007/s43546-022-00380-6>
- Yusuf, A. M., Abubakar, A. B., & Mamman, S. O. (2020). Relationship between greenhouse gas emission, energy consumption, and economic growth: evidence from some selected oil-producing African countries. *Environmental Science and Pollution Research*, 27(13), 15815–15823. <https://doi.org/10.1007/s11356-020-08065-z>
- Zaidi, S. A. H., Zafar, M. W., Shahbaz, M., & Hou, F. (2019). Dynamic linkages between globalization, financial development and carbon emissions: Evidence from Asia Pacific Economic Cooperation countries. *Journal of Cleaner Production*, 228, 533–543. <https://doi.org/10.1016/j.jclepro.2019.04.210>
- Zhoug, S., Su, B. (2023). Assessing factors driving international trade in natural resources 1995–2018. *Journal of Cleaner Production*, 389, 136110. <https://doi.org/10.1016/j.jclepro.2023.136110>
- Zhu, X., & Van Ierland, E. (2006). The enlargement of the European Union: Effects on trade and emissions of greenhouse gases. *Ecological Economics*, 57(1), 1-14. <https://doi.org/10.1016/j.ecolecon.2005.03.030>