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Effects of Globalization and Trade on the environment: an Environmental Kuznets Curve Hypothesis

Subtitle: Should Globalization and Trade be at the expense of the Environment?

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“Success is not final; Failure is not Fatal: it is the courage to continue that counts”

Winston S. Churchill

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Abstract

This thesis examines the impact of globalization and trade on the environment, focusing on carbon dioxide emissions. Specifically, it tests the Environmental Kuznets Curve (EKC) hypothesis, which suggests that environmental degradation initially worsens with economic growth but eventually improves once a certain level of development is reached. Two dependent variables are used namely: production-based carbon emissions and consumption-based carbon emissions. The thesis employs an econometric model called Autoregressive Distributed Lag (ARDL) model to analyse panel data from 56 countries over the period of 1990-2021 and for economic sectors, including agriculture, Forestry and Fishing, Fossil fuel and Energy consumption, Alternative and Nuclear Energy, and renewable energy consumption.

The results indicate that an EKC relationship exists for production-based carbon emissions, but not for consumption-based carbon emissions. This suggests that policies targeting production-based emissions may be more effective in mitigating the environmental impact of globalization and trade. In addition, the role of globalization and trade in shaping carbon emissions is considered by the thesis. The results suggest that trade openness has a positive effect on both production-based and consumption-based emissions, while economic growth has a positive effect on production-based emissions but not on consumption-based emissions.

These findings highlight the importance of considering both production-based and consumption-based emissions when examining the environmental impact of globalization and trade. However, the thesis also highlights the complexity of the relationship between globalization, trade and the environment, and the importance of considering multiple factors and perspectives when examining this relationship.

Keywords: EKC, Trade, ARDL Model, CO_2 emissions, Globalization

Executive summary

GDP per capita may have two effects on pollution. On the one hand, the rise in GDP necessitates increased resource use, production, consumption, and therefore, pollution. On the other hand, economies transition to service-intensive structures and could increase investments in technical advancement, which reduces material consumption and pollution as a result of rising income levels. Similar to this, globalization may also result in such dual effects by triggering economic activities that increase pollution and by quickening the pace of technological advancement and environmental consciousness.

The focus of this thesis is to analyze the trade-environment relationship and what role globalization plays in it. Economic theory suggests that trade can have both positive and negative effects on the environment, depending on the circumstances. On the one hand, trade can lead to improvements in the environmental quality through the transfer of technology, knowledge and resources. On the other hand, trade can also lead to environmental degradation through increased production and consumption of goods and services, which can lead to higher levels of pollution, deforestation and other forms of environmental damage. In particular, the theory suggests that countries with weaker environmental standards may engage in "pollution havens", attracting industries with low environmental standards and regulations.

One important theoretical framework for understanding the relationship between economic growth and environmental quality is called the Environmental Kuznets Curve Hypothesis (EKC). This theory proposes that as countries develop, their demand for goods and services increases, leading to higher levels of production, consumption and pollution. However, as the countries reach a certain level of income, they begin to prioritize environmental quality and invest in cleaner technologies and policies, leading to a decline in pollution and environmental degradation.

Therefore, an analysis is carried out for fifty-six developing and developed countries, ranging from Europe, Asia, the pacific, Africa, Latin America, over the period 1990-2021 and for economic sectors, including agriculture, Forestry and Fishing, Fossil Fuel and Energy consumption, Alternative and Nuclear Energy, and renewable energy consumption.

This is done to check the relationship between the per capita output level and carbon dioxide emissions for the chosen sectors. Secondly, an econometric model called autoregressive distributed lag (ARDL) model is used which allows us to evaluate the casual relationship between X variables (GDP, agriculture, Forestry and Fishing, Fossil Fuel and Energy consumption, Alternative and Nuclear Energy, and renewable energy consumption) and our outcome variable which is also known as the Y variable or dependent variable. In this case, it will be carbon dioxide emissions. However, instead of using the total carbon dioxide emissions as the dependent variable, I am going to separate the production-based carbon emissions from the consumption-based carbon emissions. So that I can explore how they are separately affected by the X variables.

The autoregressive distributed lag (ARDL) model is incorporated in this thesis because it is a statistical model that is used to analyze the long-term relationship between two or more variables. In simple terms, it helps us to understand how changes in one variable affect the other over time. The study adds to the existing literature as it recommends a sustainable solution that can be applied to countries for carbon emissions reduction and challenges of globalization in the presence of trade.

The results showed that an EKC exists in production-based emissions but not in consumption-based emissions. The presence of the EKC in production-based emissions shows that as countries develop and become wealthier, they may be able to implement cleaner and more efficient technologies to reduce emissions from their own production activities.

However, the absence of an EKC in consumption-based emissions indicates that as countries become wealthier, they may also increase their consumption of goods and services, many of which may be produced in countries with less stringent environmental regulations. This could lead to an increase in emissions embodied in these imported goods and services, offsetting any reductions in production-based emissions.

Overall, the policy implications of this research highlights the need for international cooperation and coordination in addressing climate change, as well as the importance of considering issues of trade, investment, and climate justice.

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List of abbreviations

ARDL- Autoregressive distributed lag

CO_2 - Carbon Dioxide

CD- Cross-Sectional dependence

CBA- Consumption-based accounting systems

DFE- Dynamic Fixed effects

ECM- Error Correction Model

EKC- Environmental Kuznets Curve

GHG- Greenhouse Gas

GDP – Gross Domestic Product

IEA- International Energy Agency

IPCC- Intergovernmental Panel on Climate Change

MG- Mean group

NGO- Non-governmental organization

PBA- Production-based accounting systems

PMG- Pooled mean group

UNCED- Un conference on environment and development

WSSD- World summit on sustainable development

Introduction

The world is dealing with a number of environmental issues, such as pollution, deforestation, biodiversity loss, and climate change. These issues have serious social and economic repercussions and will probably have a severe effect on vulnerable communities especially in developing countries (IPCC,2018). Trade and globalization are strong proponents of economic growth and have contributed to significant improvements in living standards and reductions in poverty around the world. However, they have also been linked to greater environmental pressure, especially in poorer nations (Dasgupta, 2007).

Therefore, it is crucial for policymakers to understand how globalization, trade, and the environment are related as they attempt to strike a balance between the economic benefits of globalization and the need to assure sustainable development. Understanding the various elements that affect environmental quality and how globalization and trade interact with these aspects is crucial in order to establish effective policies to solve the environmental challenges confronting the world today.

Furthermore, globalization, trade and the environment are interconnected issues that have been the subject of intense debate and discussion in recent years. Many benefits have been brought to the world because of globalization and trade. But they also had negative impacts on the environment. As economic activities have become more globalized, the environmental impacts of trade have become more complex and difficult to manage (UN, 2019).

The transportation of goods across long distances is one of the primary ways that trade has an impact on the environment. This may result in higher greenhouse gas emissions, which fuel climate change. Deforestation, water pollution, and soil deterioration are just a few of the negative environmental effects that can result from the extraction and processing of raw materials for trade. There are also concerns about social and economic impacts of globalization. Some critics argue that globalization has led to increased inequality, as the benefits of economic growth have been unevenly distributed. This has led to calls for more equitable trade policies, and for greater support for workers and communities that have been negatively affected by globalization (Stiglitz, 2002).

Additionally, there is evidence that trade and globalization may have a big influence on people's health. For instance, the spread of illnesses like the avian flu and mad cow disease has been related to the international trade in food and agricultural goods (WHO, 2015). Secondly, the production of goods for export can have negative health impacts on the workers, particularly in developing countries where labour standards may be weak (ILO, 2019).

Despite these challenges, there are also opportunities for globalization and trade to contribute to sustainable development and environmental protection. For example, the United Nations Sustainable Development Goals (SDGs) recognize the important role of trade in promoting economic growth, reducing poverty, and achieving environmental sustainability (UN,2015).

However, in order to accomplish these objectives, it will be required to deal with the complex and interconnected issues of globalization, trade, and the environment. This will necessitate a number of policy changes, such as stricter environmental laws, more equal trade laws, and increased investment in environmentally friendly activities and technology. Additionally, it will call for increased cooperation and collaboration between governments, corporations, and civil society, as well as an understanding of the many views and requirements of various stakeholders.

Sustainability in globalization and Trade

Sustainability is defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987). This requires a holistic approach to economic development that considers the social, economic, and environmental dimensions of sustainability. In the context of globalization and trade, this means promoting sustainable economic growth that is environmentally responsible, socially inclusive, and economically viable.

One key challenge in achieving sustainable globalization and trade is the need to balance economic growth with environmental protection. This requires the development of policies and practices that minimize the environmental impacts of economic activity, while also promoting economic growth and development. For example, the use of renewable energy sources, such as wind and solar power, can help to reduce greenhouse gas emissions and mitigate the impacts of climate change (IPCC, 2018). Similarly, sustainable agriculture practices, such as agroforestry and organic farming, can help to reduce the environmental impacts of food production (FAO, 2018).

Another key challenge is the need to ensure that economic growth and trade benefit all members of society, particularly the poor and marginalized. This requires the development of social safety nets and support systems that help those who are negatively impacted by economic globalization and trade. To achieve sustainable globalization and trade, it is also necessary to promote international cooperation and collaboration. This can involve the development of international agreements and frameworks that promote environmental and social sustainability, as well as the promotion of international trade that is fair and equitable. Examples of such agreements include the Paris Agreement on climate change and the Sustainable Development Goals (SDGs) adopted by the United Nations in 2015 (UN, 2015).

Environmental regulations and standards

Environmental regulations and standards have a significant impact on the environment as they are designed to reduce the negative impacts of human activities on the natural world. The implementation of these regulations can vary widely between countries, depending on factors such as political will, economic resources, and cultural attitudes towards the environment. One example of the impact of environmental regulations can be seen in the case of air pollution in the United States. The Clean Air Act, which was first passed in 1963 and has been amended several times since, has been successful in reducing air pollution levels in the country (EPA,2021). However, the implementation of the Clean Air Act has faced challenges, particularly in terms of enforcement and compliance by industries (Pope,2017).

In contrast, other countries may have weaker environmental regulations, which can lead to more negative impacts on the environment. For example, in China, air pollution has become a major problem in recent years, due in part to the rapid pace of industrialization and weak environmental regulations (Bai et al.,2019).

The implementation of environmental regulations can also be influenced by political and economic factors. For example, developing countries may face challenges in implementing environmental regulations due to limited economic resources and competing priorities for development (Lele & Kurian,2018). In addition, countries with strong extractive industries, such as oil and gas, may face resistance to environmental regulations from industry groups and political leaders (Bast & Fisher, 2013).

The implementation of environmental regulations and standards can have a significant impact on globalization and trade, as they can create barriers to international trade and investment. For example, countries with strong environmental regulations may require foreign companies to comply with these regulations in order to do business in their country, which can increase the cost of doing business and reduce the competitiveness of foreign firms (Bast & Fisher, 2013).

Environmental regulations can also impact the types of goods that are traded internationally. For example, countries may impose restrictions on the import or export of goods that are deemed to be environmentally harmful, such as products made from endangered species or chemicals that are known to be toxic (WTO, 2021).

However, environmental regulations can also have positive effects on globalization and trade. An example is by reducing negative environmental impacts, regulations can create a more sustainable and stable global economy, which can benefit all countries (Lele & Kurian, 2018). Regulations that promote environmentally sustainable practices can create opportunities for innovation and new business models, which can drive economic growth competitiveness (Porter & Van de Linde, 1995).

Environmental Justice

The effects of trade policies on the environment and environmental justice are multifaceted and can be both positive and negative depending on the specific policies and their implementations. One way in which trade policies can impact the environmental justice is through their effects on the distribution of environmental risks and benefits. An example is, trade policies that promote the expansion of extractive industries in developing countries may lead to increased environmental degradation and pollution, which can disproportionately affect marginalized communities that are often located near such industries (Bryner, 2016). Similarly, trade policies that promote the export of agricultural products may incentivize the use of environmentally damaging production methods, such as the overuse of pesticides and fertilizers, which can harm the health and livelihoods of local communities (Friedman, 2017).

On the other hand, trade policies that promote sustainable development and the use of environmentally friendly technologies can have positive impacts on environmental justice. An example is the inclusion of environmental provisions in trade agreements can help to promote sustainable development and reduce the negative impacts of trade (Bryner, 2016).

Carbon emissions and climate change

The relationship between trade and carbon emissions depends on a range of factors, including the nature of the traded goods, the production processes involved, and the policies that govern trade and environmental protection. A way in which trade can have an effect on carbon emissions is through the carbon embodied in traded goods. Trade can lead to the displacement of carbon emissions from one country to another, as countries may import goods that are produced in countries with lower environmental standards or more carbon-intensive production processes (Chen & Zhang, 2019). For example, a country that imports steel from a country with less stringent environmental regulations may be indirectly responsible for the carbon emissions associated with the production of that steel. This is known as embodied carbon or carbon leakage.

Trade can also lead to the diffusion of low-carbon technologies and practices, which can help to reduce carbon emissions. Additionally, trade can facilitate the transfer of technology and knowledge between countries, which can help to promote the adoption of cleaner and more efficient production processes (Chen & Zhang, 2019). For example, the import of renewable energy technologies or energy-efficient appliances can help to reduce carbon emissions and promote sustainable development.

In terms of globalization, the expansion of global trade and investment has led to increased production and transportation of goods, which can lead to increased carbon emissions (Chen & Zhang, 2019). Globalization can also lead to increased industrialization and urbanization, which can further contribute to carbon emissions and climate change (Ghosh &Roy, 2020).

Furthermore, globalization can impact the ability of countries to implement effective climate policies. Trade liberalization and investment agreements can limit the ability of governments to regulate trade and investment in ways that promote environmental protection and reduce carbon emissions (Ghosh & Roy, 2019). In a nutshell, trade can have significant impacts on carbon emissions, and these impacts are closely linked to globalization. The specific impacts will depend on the nature of the traded goods, the production processes involved, and the policies that govern trade and environmental protection. By promoting sustainable production and consumption, and by supporting the diffusion of low-carbon technologies and practices, trade can help to mitigate carbon emissions and contribute to global efforts to address climate change.

Technology transfer and innovation

Technology transfer and innovation affects the environment in various ways. On the one hand, new technologies and innovations can lead to more efficient and sustainable use of resources, reduce pollution and mitigate climate change. On the other hand, they can also lead to increased resource consumption, waste generation, and environmental degradation, particularly if they are not designed with environmental considerations in mind.

One example of the positive effect of technology transfer and innovation on the environment is the use of precision agriculture technologies, which can help farmers optimize fertilizer and pesticide use, reduce soil erosion, and increase crop yields, while also improving soil health and reducing water pollution (Wang et al., 2020).

If technology transfer and innovation lead to increased resource consumption and waste generation, then they can cause a negative effect. For example, the widespread use of electronic devices such as smartphones and laptops has resulted in a significant increase in e-waste, which can contribute to environmental pollution and health risks (Baldé et al., 2017).

The production of many high-tech products requires the extraction of rare and valuable metals, which can have negative environmental and social impacts, particularly in developing countries where mining regulations may be weak and non-existent (Ali et al., 2017).

Climate change

According to (IPCC, 2014), climate change refers to a long-term shift in global weather patterns, including rising temperatures, changing precipitation patterns, and more frequent and severe weather events such as hurricanes, droughts, and floods. The primary cause of climate change is the release of greenhouse gases, such as carbon dioxide, into the atmosphere as a result of human activities such as burning fossil fuels and deforestation.

Some potential benefits of climate change could include increased agricultural productivity in some regions due to longer growing seasons, decreased heating costs in colder regions, and increased shipping opportunities due to melting Arctic Sea ice (WTO, 2018). However, these potential benefits are far outweighed by the many disadvantages, which include accelerated sea-level rise, more frequent and severe natural disasters, mass extinction of plant and animal species, and negative impacts on human health, among others (IPCC,2014).

Climate change can have significant effects on trade and globalization such as disrupting shipping lanes and port operations, damaging infrastructure and disrupting supply chains, and potentially leading to trade disputes between nations (WTO, 2018). One example of the impact of climate change on trade is the case of the Arctic region, which is experiencing rapid melting of sea ice due to rising temperatures. This has opened up new shipping routes and increased the potential for resource extraction in the region. However, it has also raised concerns about the potential environmental impacts of increased activity in the Arctic, as well as the potential for conflict over resource rights between nations (WTO, 2018).

Climate change affects all nations to some extent, but some regions of the world are more vulnerable than others due to factors such as geography, economic development, and infrastructure. Developing countries, particularly those in Africa and Asia, are generally considered to be more vulnerable to the impacts of climate change due to their dependence on agriculture, limited access to resources and technology, and exposure to extreme weather events (IPCC, 2014).

In contrast, developed countries such as the United States and Canada are generally considered to be less vulnerable to the direct impacts of climate change due to their greater economic resources and more advanced infrastructure. However, they are still vulnerable to the indirect impacts of climate change, such as disruptions to supply chains and increased costs for firms (WTO, 2018).

It is also important to note that some countries, particularly those in the Global South, contribute relatively little to greenhouse gas emissions but are disproportionately affected by climate change (WRI, 2021). This is known as the "climate injustice" or "climate equity" issue, as these countries often lack the resources and capacity to adapt to the impacts of climate change and are therefore more vulnerable to its negative effects. It is important to recognize that the impacts of climate change are not distributed evenly, and some countries contribute relatively little to greenhouse gas emissions but are disproportionately affected by its negative effects.

Figure 1: list of events in International Environmental Involvement, referenced from (Baylis, J. et al., 2020).

1946	International Convention for the Regulation of Whaling
1956	UK Clean Air Act to combat 'smog' in British cities
1958	International Convention for the Prevention of Pollution of the Sea by Oil
1959	Antarctic Treaty
1962	Rachel Carson publishes *Silent Spring*
1967	Torrey Canyon oil tanker disaster
1969	Greenpeace founded
1971	At the Founex Meeting in Switzerland, Southern experts formulate a link between environment and development
1972	United Nations Conference on the Human Environment (UNCHE) in Stockholm
	Establishment of the United Nations Environment Programme (UNEP)
1973	MARPOL Convention on oil pollution from ships
	Convention on International Trade in Endangered Species (CITES)
1979	Long-Range Transboundary Air Pollution Convention (LRTAP)
1980	Convention on the Conservation of Antarctic Marine Living Resources
1982	UN Law of the Sea Convention (enters into force in 1994)
1984	Bhopal chemical plant disaster
1985	Vienna Convention for the Protection of the Ozone Layer
	Antarctic 'ozone hole' confirmed
1986	Chernobyl nuclear disaster
1987	Brundtland Commission Report
	Montreal Protocol on Substances that Deplete the Ozone Layer
1988	Establishment of the Intergovernmental Panel on Climate Change (IPCC)
1989	Basel Convention on the Transboundary Movement of Hazardous Wastes
1991	Madrid Protocol (to the Antarctic Treaty) on Environmental Protection
1992	United Nations Conference on Environment and Development (UNCED) held at Rio de Janeiro; publication of the Rio Declaration and *Agenda 21*; United Nations Conventions on Climate Change (UNFCCC) and Biological Diversity (CBD) both signed
1995	World Trade Organization (WTO) founded
1997	Kyoto Protocol to the UNFCCC
1998	Rotterdam Convention on Hazardous Chemicals and Pesticides (PIC, prior informed consent)
	Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters
2000	Cartagena Protocol to the CBD on Biosafety
	Millennium Development Goals set out
2001	US President George W. Bush revokes signature of the Kyoto Protocol
	Stockholm Convention on Persistent Organic Pollutants (POPs)
2002	World Summit on Sustainable Development (WSSD), Johannesburg
2005	Entry into force of the Kyoto Protocol and introduction of the first international emissions trading system by the European Union
2009	Copenhagen climate Conference of the Parties (COP) fails to provide a new international agreement
2010	Nagoya Protocol to the CBD on access and benefit sharing
2011	Durban climate COP aims to produce a new agreement by 2015
2012	Rio + 20 Conference
2013	Minimata Convention on mercury
2014	IPCC Fifth Assessment Report
2015	Paris Agreement at UNFCCC COP21
	UNGA adopts Sustainable Development Goals
2018	IPCC 1.5°C Report
	UNFCCC COP24 agrees 'rulebook' to implement the Paris Agreement

International organizations play a significant role in regulating globalization by providing a framework for global cooperation, establishing policies, and promoting sustainable development. The World Trade Organization (WTO), for instance, was established to govern international trade and ensure that trade policies are fair and non-discriminatory (WTO, 2021). The International Monetary Fund (IMF) provides financial assistance to countries facing economic challenges and promotes international monetary cooperation, (IMF, 2021). The United Nations Environment Programme (UNEP) promotes environmental sustainability by providing guidance and support to countries and organizations (UNEP, 2021).

These international organizations work together to address global challenges such as climate change, poverty, and inequality. For example, the United Nations Sustainable Development Goals (SDGs) provide a framework for global cooperation to promote sustainable development and address social, economic, and environmental challenges (United Nations, 2021).

International organizations also play a role in regulating transnational cooperations (TNCs) and promoting corporate social responsibility. The Organisation for Economic Co-operation and Development (OECD) provides guidelines for responsible business conduct and encourages TNCs to respect human rights and the environment (OECD, 2021). Therefore, these organizations play a crucial role in regulating globalization by promoting cooperation, establishing policies, and addressing global challenges. They provide a framework for global governance and help to ensure that globalization is sustainable, equitable, and beneficial for all.

Role of International organizations in promoting environmental sustainability

International organizations promote environmental sustainability through various initiatives and programs. These organizations work towards setting global standards, policies, and regulations to protect the environment and ensure sustainable development. One of the most prominent international organizations working towards environmental sustainability is the United Nations (UN). The UN has established several programs and initiatives to address environmental issues such as climate change, deforestation, and pollution. The UN Framework Convention on climate Change (UNFCCC) is one such initiative that aims to reduce greenhouse gas emissions and mitigate the effects of climate change. The UN also established the intergovernmental Panel on Climate Change (IPCC), which provides scientific advice and guidance to policymakers on climate change (IPCC, N.D).

Another international organization that plays a significant role in promoting environmental sustainability is the World Wildlife Fund (WWF). The WWF works towards the protection of endangered species and their habitats, as well as promoting sustainable development practices (WWF, n.d). the organization also engages with governments, businesses, and communities to develop sustainable environmental policies and practices. In addition to these organizations, there are many other international organizations that work towards promoting environmental sustainability, such as Greenpeace, the International Union for conservation of Nature (IUCN), and the World Resources Institute (WRI).

Developing countries and their economies

Globalization has had both positive and negative impacts on developing countries and their economies. While it has opened up new opportunities for trade, investment, and economic growth, it has also exposed these countries to new challenges and risks such as increased competition, economic volatility, and inequality. One of the positive impacts of globalization on developing countries is increased access to global markets. This has enabled developing countries to export their goods and services to a wide range of customers, leading to increased employment and economic growth. For example, in the 1990s, Vietnam opened up its economy to foreign investment and trade, which led to a significant increase in exports and foreign investment, resulting in sustained economic growth (World Bank, 2021).

However, globalization has also exposed developing countries to increased competition from larger and more developed economies. This has made it difficult for some developing countries to maintain their competitiveness in global markets. For example, the textile industry in Bangladesh, which is a major source of employment and exports, has faced increased competition from other low-wage countries such as Vietnam and Cambodia (The Economist, 2019). Moreover, globalization has also exposed developing countries to economic volatility and financial risks. Fluctuations in global commodity prices, currency exchange rates, and capital flows have had a significant impact on the economic stability of many developing countries. For example, the 1997 Asian financial crisis had a devastating impact on many developing countries in the region, leading to economic recession and social unrest (World Bank, 2021).

Globalization contributed to rising income inequality within developing countries too. While it has led to increased economic growth and employment, it has also led to a concentration of wealth and power in the hands of a few individuals and corporations.

Corporate Social responsibility

Corporate social responsibility (CSR) is the concept of businesses voluntarily taking responsibility for the social and environmental impacts of their activities. The effectiveness of CSR in promoting sustainable development and responsible business practices has been debated, with some arguing that it is an important tool for promoting social and environmental sustainability, while others argue that it is merely a form of “greenwashing” or a way for businesses to improve their image without making meaningful changes.

Several studies have found that CSR can have a positive impact on a company’s financial performance and reputation, as well as on the social and environmental outcomes of their activities (Dahlsrud, 2008). For example, a study by KPMG found that companies that prioritizes CSR are more likely to attract and retain customers, employees, and investors, which lead to improved financial performance (KPMG, 2017).

However, the impact of CSR on global trade is more complex and depends on various factors, including the size and type of business, the industry in which it operates, and the specific CSR initiatives it undertakes. Some argue that CSR can promote responsible business practices and help to prevent human rights abuses, environmental degradation, and other negative impacts of global trade (UNCTAD, 2018). Initiatives such as United Nations Global Compact, which encourages businesses to adopt sustainable and socially responsible policies and practices, have been credited with promoting responsible business conduct in global supply chains.

On the other hand, critics argue that CSR can be used to justify or even conceal unethical or exploitative business practices, and that it may not be sufficient to address the systemic issues that contribute to social and environmental problems in global trade (Matten and Moon, 2008). For example, some companies have been accused of using CSR initiatives such as fair trade or organic certification to create the appearance of ethical supply chains, while continuing to engage in exploitative labour practices or environmental degradation. All in all, developing and implementing CSR initiatives requires ongoing monitoring, evaluation, and improvement, as well as collaboration with stakeholders across the global supply chain.

Technology transfer and innovation

Technology transfer and innovation affect the environment too. On the positive side, technology can help reduce environmental degradation by improving resource efficiency and reducing the release of harmful pollutants into the environment. On the negative side, it can contribute to environmental problems. For example, the production and disposal of electronic devices can lead to the release of hazardous materials and contribute to electronic waste (Baldé et al., 2020). Additionally, the use of new technologies can lead to increased resource consumption and environmental impacts, such as the increased use of water and energy for data centres and other digital infrastructure (Mills, 2018).

One way to mitigate the negative impacts of technology and transfer innovation on the environment is through the development of sustainable technology. Sustainable technology refers to technologies that meet the needs of the present without compromising the ability of future generations to meet their own needs (United Nations, 1987). By incorporating environmental considerations into the design and development of new technologies, it is possible to reduce their environmental impact and promote sustainability (Schmidt et al., 2017).

Inconclusion, technology transfer and innovation have both positive and negative impacts on the environment. To mitigate the negative impacts and promote sustainability, it is important to develop and promote sustainable technology.

Structure of the thesis

This thesis will examine the impact of globalization and trade on the environment, with a particular focus on the Environmental Kuznets Curve (EKC) hypothesis. Chapter 1 will provide an analysis of the relationship between economic growth, trade and the environment. Also, between trade and globalization. Chapter 2 will provide a review of the literature between trade and the environment. Chapter 3 will discuss about the methodology. It will explain the econometric model that will be used and the variables. Chapter 4 will discuss the results obtained from the analysis. Chapter 5 will be the concluding chapter where recommendations will be made.

Chapter 1: Trade and Globalization

1.1. Economic growth, trade and the environment

Trade and globalization are closely connected concepts that have become increasingly important in the global economy. One of the important drivers of globalization has been the growth of international trade. As countries have become more connected, they have increasingly relied on each other for goods and services, leading to a rise in cross-border trade. This has been facilitated by advances in technology, transportation, and communication, which have made it easier and cheaper to trade across borders.

Moreover, trade has also been a major driver of economic growth, particularly in developing countries. By exporting goods and services, countries can earn foreign exchange and access new markets, which help to stimulate economic growth and create jobs. In addition, trade can lead to greater competition and efficiency, as firms are forced to improve their products and processes in order to remain competitive in the global marketplace.

One of the main ways in which trade and globalization are connected is through the growth of multinational corporations (MNCs). MNCs are companies that operate in multiple countries, often taking advantage of lower costs or new markets. As these companies have grown in size and influence, they have played a major role in driving global trade and investment flows. MNCs account for more than half of all global trade in goods and services (UNCTAD, 2019)

According to Stiglitz, (2002) the growth of trade and globalization has also led to concerns about inequality and environmental sustainability. Critics argue that globalization has exacerbated income inequality, both within and between countries, by favouring those with skills and capital over those without. In addition, increased trade can lead to environmental degradation, as countries race to extract resources and produce goods as cheaply as possible.

To address these challenges, policymakers and businesses have focused on promoting more inclusive and sustainable forms of trade and globalization. This includes efforts to promote labour and environmental standards, as well as initiatives to promote greater participation by small and medium-sized enterprises (SMEs) in global trade (UNCTAD, 2021).

1.2. The role of trade and globalization

Trade plays an important role in maintaining food supplies and food prices because sufficient food stocks in some countries exist side-by-side with shortages in other countries in a globalized market. The relationship between environmental degradation and the overuse of resources is complicated and sometimes, paradoxical. Globalization triggered changes in the industry, the movement of the population away from the land, and increased consumption among the population, which correlates with emissions of effluents and waste gases (Baylis, J et al. 2020).

According to Baylis et al. (2020), there is limited evidence that globalization has prompted a “race to the bottom” in the standards of the environment. Moreover, there have been arguments that increasing levels of affluence have brought local environmental improvements, like the way birth rates tend to fall as populations become wealthier. Economists stated that the opening of markets by globalization can increase efficiency and reduce pollution, given that things associated with the production of a good such as environmental and social damage are factored into its market price.

Globalization promotes the contribution of knowledge and the strong presence of non-governmental organizations (NGOs) in environmental politics. However, things human beings depend on for survival which are non-tradable (such as clean drinkable water, and a stable climate) remain threatened. They are public goods and do not have a market and as a result they are being depleted. Globally, we have dimensions of environmental change, but a successful reaction still depends on a disintegrated international political system of more than one hundred and ninety sovereign states.

In the history of environmental issues on the international agenda, there were two common environmental concerns before the era of globalization. First, was the conservation of natural resources and the second was the harm caused by pollution. There was no respect for pollution or wildlife within international boundaries.

The action of mitigation or conservation sometimes had to involve more than one state and Baylis J et al. (2020) stated that there were mostly unsuccessful efforts to control the exploitation of maritime resources which lay beyond national jurisdiction. This included the 1946 International Convention for the regulation of whaling and several multilateral fisheries commissions.

After the Second World War, global economic recovery came along with signs of new pollution, and ultimately the international agreements in the 1950s and 1960s. In the 1970s, new types of transnational pollution like acid rain coupled with the realization that environmental problems such as Ozone layer depletion and climate change is a concern on a global scale. The UN conference on environment and development (UNCED) held in Rio de Janeiro, Brazil in 1992 indicated the plan of sustainable development and an arrangement between the environmental concerns of developed states and the economic demands of the global south. The profile of the environment as an international issue was raised here.

On the tenth anniversary of the UNCED in 2002, the World Summit on Sustainable Development (WSSD) assembled at Johannesburg. The discussions were on the importance of globalization and the terrible state of the African continent. The issues in discourse were the eradication of poverty, provision of clean water, sanitation and agricultural improvements. The phases in which the environment entered the international political mainstream were marked by the UN conferences.

Moreover, according to Runge (1998) there have been apparent issues in Agricultural trade and the environment. Looking at Agriculture, there are some impacts of trade on the physical environment. One of the impacts of agricultural trade has to do with the extent of economic activity. literature in agriculture state that excessive scale partially brought in by trade may lead to substantial environmental stresses, especially in the sector of livestock. The second impact of agricultural trade on the environment is allocative efficiency. This argument states that specialization and comparative advantage utilize natural resources more efficiently than policies of national or local self- sufficiency. This view is contrary to extreme advocates of local self-reliance or food security. Natural resources in agriculture are more likely to be efficiently utilized if the countries with comparative advantages produce the resources and trade for others. Producing and consuming everything locally is unconvincing to be an efficient use of natural capital (Runge, 1998).

The third impact of agricultural trade on the environment talks about the composition of output by category and in the case of a sector like agriculture it leads to questions that are related to intrasectoral composition such as does trade favour sectors that are ecologically threatened? Taking the case of a specific sector like agriculture, for example, does trade influence extreme production of more highly polluting crops such as cotton at the expense of small grains? (Runge, 1998).

Trade may also affect the environment by bringing technological innovation and the transfer of both goods and bads. International diffusion of agricultural technology was blamed for the use of extreme inputs like fertilizers and agrichemicals.

Finally, a more serious effect of agricultural trade on the environment is on policy and politics. Rising incomes may make environmental protection more affordable. However, we are left with the question of whether nations are willing to pay for such protection and can disclose this choice through the political process. Consequently, market failure is linked to the possibility of government failure in causing negative environmental impacts to which societies didn't respond (Runge, 1998). Although there is increasing evidence showing the immense environmental impacts of agriculture, some of which are related to trade, the agricultural sector has continued to evade the level of environmental regulatory oversight which is common in many other sectors. This clearly implies that income growth is a necessary but not a sufficient condition for environmental improvements in agriculture.

1.3 Definition of Globalization

According to Kolb (2018) the term "globalization" refers to the increasing interconnectedness of the economies, cultures, and populations throughout the world as a result of technology, cross-border trade in products and services, and movements of capital, labour, and information. For many years, nations have developed economic alliances to support these movements. Nonetheless, the phrase became more common after the Cold War in the early 1990s because of how these cooperative agreements influenced contemporary daily life.

Globalization has wide-ranging, intricate, and politically fraught repercussions. Similar to significant technical advancements, globalization helps society as a whole while hurting some groups. Recognizing the relative costs and benefits can help solve issues while maintaining larger benefits.

Held et al. (2000) argue that globalization is a historical technique that changes spatial organization of social links and interactions by making global interaction to exercise power. According to Deardorff and Stern (2002) globalization entails that international markets are becoming more integrated. For two centuries such integration has been the topic of International Trade theory and economists have a good comprehension of its effects.

Albrow (1996) explains a comprehensive perspective of globalization in the form of spill overs in activities such as norms, skills and products that suggest that globalization exceeds the concept of economic globalization. At some point, environment has been transformed through political and social globalization. This is as a result of the international, political and organizational struggle and cross-cultural broadcasting.

Most studies suggest that globalization has a non-significant impact on changes in the environment. Akadiri et al. (2019) researched the impact of globalization, income, and tourism on CO_2 emissions for Turkey from 1970 to 2014 using the ARDL approach. Their results showed a non-significant negative effect of globalization on emissions although income and tourism both harm the environment by increasing CO_2 emissions. Similarly, Haseeb et al. (2018) looked at the effects of globalization on CO_2emissions in the presence of EKC for the BRICS economies over the period 1995-2014. They suggested that globalization has a negative but significant effect on carbon emissions.

Majeed and Mazhar (2020) made research on the impact of globalization (trade) on carbon dioxide emissions for heterogeneous income groups for the period 1961 to 2018. They followed the EKC approach together with energy consumption, human capital and bio capacity. Their findings indicate mixed impacts of trade openness on environmental degradation depending on the level of income and existing level of environmental degradation.

Due to the fact that globalization has been connected to several issues in the political, economic, social, cultural, and environmental fields all over the world, viewing the problem of pollution just from one perspective might be deceptive. Investigating the varied effects of globalization and its implications for environmental sustainability is crucial (Farooq et al. 2002).

Greenhouse gases surround the surface of the whole earth harming both developed and developing countries, thereby making environmental degradation a worldwide problem. Most of the consequences of environmental degradation are floods and earthquakes and they destroy natural resources like forests, agricultural land, wildlife as well as human life. Another cause of environmental degradation is rapid economic growth. This is why environmentalists and economists are more concerned about these issues.

Globalization can be divided in to three types namely, social, political and economic globalization. These three types influence one another. For example, economic globalization is fuelled by liberalized national trade policy. Political policies have an impact on social globalization as well, making it easier for individuals to interact and travel freely throughout the world. With the importation of products and services that expose individuals to foreign cultures, economic globalization has an impact on social globalization too. These different types are further explained below for a better understanding.

1.4. Social Globalization

Farooq et al. (2022) mentioned that social globalization affects environmental quality through three mechanisms. They include transportation, lifestyle changes and technology spill overs. Transportation is the predominant driver of globalization and represents an important component of social globalization. It has significantly contributed to global carbon emissions. Global flights brought about 915 million tonnes of carbon dioxide in 2019. Environmentalists draw attention to the exploitation of natural resources in developing and transitioning economies that are trying to follow western lifestyles. In terms of lifestyle, increased social globalization is leading to a catch- up between developing and developed countries. This copying of lifestyle is generally associated with deforestation which makes the environment more vulnerable. When compared to discussed mechanisms, social globalization can lower carbon emissions through technology spill overs. (Farooq et al. 2022)

1.5. Political Globalization

According to Bernauer (2013), the relationship of the environment with political globalization is also worth investigating as political scientists gradually include environmental policies in mainstream political sciences. Spilker (2012a, 2012b) stated three mechanisms through which political globalization can affect environmental quality. He argued that membership in intergovernmental organizations (IGOs) has an impact on the ecological quality of the developing world in the following three ways. First, intergovernmental organizations can compel member nations to follow their rules. This includes environmentally friendly ones.

Secondly, intergovernmental organizations can promote norms of good behaviour and discourage bad behaviour. Thirdly, even though economies join intergovernmental organizations for specific purposes like economic assistance, they can be obligated to follow environmentally friendly practices. For example, Laos joined the Association of Southeast Asian Nations (ASEAN) in 1997 and was required to implement several reforms related to sustainable agricultural development, thereby indirectly improving environmental quality.

These discussed mechanisms and their implications are not the same across developed and developing economies. An example is the Kyoto Protocol has set carbon reduction targets for developed countries, while developing countries are generally excluded from carbon reduction targets. This can easily be seen as why the International Energy Agency (IEA) concluded that carbon dioxide emissions of developing countries increased at a much faster rate. In a nutshell, the role of political and social globalization in ecological quality cannot be disregarded.

1.6. Economic Globalization

Economic globalization refers to the increasing interdependence and integration of the global economy, particularly through the free movement of goods, services, capital, and people across national borders. It is characterized by the expansion of international trade and investment, the growth of multinational corporations, and the development of global financial markets.

According to OECD (2010), one way to measure economic globalization is through trade indicators such as the value of international trade and the share of exports and imports in a country's gross domestic product (GDP). Other indicators include foreign direct investment (FDI) flows, the number of multinational corporations, and the degree of economic openness, as measured by the World Bank's "trade and openness index."

Economic globalization is closely linked to other dimensions of globalization, such as political and social globalization. For example, the expansion of international trade and investment can lead to increased economic growth and job creation, but it can also lead to income inequality and environmental degradation. The growth of multinational corporations can create new opportunities for innovation and technology transfers, but it can also limit the ability of governments to regulate economic activity and protect workers' rights. The development of global financial markets can provide access to capital and risk management tools, bit it can also create financial instability and worsen economic crises.

Generally, the relationship between economic globalization and other dimensions of globalization is complex and multifaceted and can have both positive and negative effects on political and social outcomes. The direction and magnitude of these effects depend on a range of factors, including the specific policies and institutions in place, the distribution of economic benefits and costs and the degree of international cooperation and coordination.

According to Gao Shangquan (2000), economic globalization includes increasing interdependence of world economies due to the growing scale of cross-border trade of commodities and services, the flow of international capital, and the wide and fast spread of technologies. This reflects the continuous expansion and mutual integration of market frontiers and is a trend that cannot be reversed for the economic development of the whole world at the turn of the millennium. The two main forces of economic globalization are marketization and the rapidly growing significance of information in all types of productive activities. The process of economic globalization is the process of global industrial restructuring and readjustment as well.

Industrial structures of all countries have been upgraded and readjusted. Economic globalization has intensified the competition in the international market among enterprises from different countries. Both domestic and international enterprises have been resorting to mergers and acquisitions for the purpose of raising their positions and improving their competitiveness in the international market. Developed countries, however, have been playing a dominant role in the process of economic globalization.

Moreover, the dominant role of developed countries in the process of economic globalization is also shown in the fact that it is the developed countries that determine the rules for international economic exchanges. The involvement of developing countries in the globalization process can make them to better utilize their comparative advantages, and introduce advanced technologies, foreign capital and management experience. It is also advantageous for getting rid of monopolistic behaviours and strengthening market competition.

Nonetheless, although economic globalization provides more development opportunities for developing countries, it is also posing huge risks. First, economic globalization increased the gap between the North and the South rather than reducing it (Gao Shagquan, 2000). Secondly, developing countries are at risk of being hit by unfavourable external factors. Therefore, to prevent and get rid of the risks brought by economic globalization to developing countries, international economic organizations should play a bigger role in the process of economic globalization.

Generally, globalization is one of the possible drivers of environmental pollution this is because it stimulates production and consumption levels. It also helps to spread environmental technologies. Carbon dioxide emissions can directly be increased by more production and consumption activities. If the techniques of production do not change during the process of globalization, environmental conditions will worsen. On the contrary, if globalization creates the deployment of eco-friendly technologies, standards of the environment will improve with increasing trade volume and foreign direct investment. All in all, anti-globalists argue that globalization has a negative effect on environmental standards. While pro-globalists suggest the opposite (Danish et al. 2022).

1.7. Economic growth and the environment

The relationship between economic growth and the environment has been a topic of intense debate among economists, policymakers and environmentalists. While economic growth can bring many benefits, including higher standards of living and improved access to goods and services, it can also lead to environmental degradation and resource depletion. One of the main challenges related to economic growth is its impact on greenhouse gas emissions and climate change. As economies grow, they typically consume more energy, which can lead to higher levels of greenhouse gas emissions. This can contribute to climate change, which has the potential to cause significant environmental and economic damage (IPCC, 2018).

The depletion of natural resources is another challenge related to economic growth. As economies grow, they typically consume more resources, including minerals, timber, and water. This can lead to resource depletion and environmental degradation, particularly in developing countries where the regulations of the environment may be weaker (UNEP,2019).

Despite all these challenges, there are ways in which economic growth can contribute to environmental sustainability. For example, technological innovation and improvements in resource efficiency can help to reduce the environmental impact of economic activity. In addition, policies that promote sustainable development, such as investments in renewable energy and green infrastructure, can help to mitigate the negative environmental impacts of economic growth (OECD,2021).

To address these challenges, policymakers and businesses have increasingly focused on promoting sustainable forms of economic growth. This includes initiatives to promote renewable energy, improve resource efficiency, and reduce greenhouse gas emissions. In addition, there has been growing recognition of the need to integrate environmental considerations into economic decision-making, this includes the use of environmental pricing mechanisms like carbon taxes (IMF,2019).

CHAPTER 2: Trade and the environment

2.1. Conceptual framework of the Environmental Kuznets Curve Hypothesis (EKC)

The environmental Kuznets curve which is named after Kuznets (1955) is a hypothesis that comes from the first work of Kuznets. He showed an inverted-U shaped relationship between income per capita and income inequality. In the initial stages, as income per capita rises, income inequality follows the same path but begins to fall after reaching a turning point. With respect to this, the first stage of income growth is distinguished by an unequal income distribution. Nonetheless, as economic productivity rises, income distribution moves towards equality. (Kuznets, 1955)

Thus, it is stated by Kuznets that the transition from a pre-industrial to an industrial development initially led to income inequality. The EKC brought a lot of attention from theorists, policy makers and empirical researchers. It started to be widely applied in environmental studies through the research of Grossman and Krueger which was carried out in 1991. They showed that the relationship between income per capita and environmental degradation follows an inverted U-shaped curve just like the income per capita and income inequality of Kuznets (Leal and Marques 2022)

According to Leal and Marques (2022), the EKC is often interpreted in two ways. One of them is categorized into two stages, namely the early and later stages of economic development. The early stages on one hand are described by a decreasing capacity of ecosystem regeneration as a result of the intensive use of resources that leads to an increasing ecological footprint and pollution. On the other hand, the early stages are associated with lenient environmental regulations related to a low capacity to pay for environmental conservation.

The latter stages are distinguished by mitigation of environmental degradation arising from the dissemination of clean technology and innovation, effectiveness and environmental awareness of the society and institutional quality related to a rise in the level of income. In addition to this, the early and later stages are also characterized by two effects namely the policy and income effect. The policy effect comprises of greater public concern about the environment, which causes rigorous regulatory requirements. The income effect comprises of the increase in income that causes an increase in the willingness to pay for environmentally friendly features.

The second way in which the EKC is often interpreted as described by Leal and Marques (2022) is when economic development is categorized into three stages namely, (1) the pre-industrial economy. This is mainly distinguished by the primary sector and low levels of income. (2) The second stage is the industrial economy. It is distinguished by the secondary sector and associated with middle-income levels. (3) The third stage is the post-industrial economy. This is formed by the tertiary sector and services, and it has to do with higher levels of income. Economic activity is limited in the pre-industrial economy. This causes a natural resource abundance and reduced formation of waste. In this stage environmental degradation rises because of the lack of environmental awareness, the use of pollutant technology and the prioritisation of economic growth.

The industrial economy consists of natural resources that are starting to run out and growing waste accumulation as a result of industrialization. A positive relationship between economic growth and environmental deterioration is verified in the industrial economy. This occurs before the turning point is achieved. Moreover, the post-industrial economy is characterised by a structural change in the economy, a services-directed economy and changing to information- and technology-intensive industries. This change is related to the reinforcement of environmental regulations, the use of cleaner and more efficient technology, and a strengthening of environmental awareness, causing mitigation of environmental degradation. A negative relationship between economic growth and environmental deterioration is confirmed in this stage and it happens after the turning point has been reached.

Moreover, there are features that affect the inverse-U shaped relationship between environmental deterioration and income levels. They include scale, composition and technique effects, income elasticity and international trade (this includes the pollution haven hypothesis, diffusion of modern technologies, foreign direct investments, etc.).

2.2. Scale effect

Copeland and Taylor (2003) stated that the scale effect measures the rise in pollution that would be generated if the economy were simply scaled up, holding the mix of goods produced and production techniques constant. For example, if there were constant returns to scale and all the endowments of the economy increased by ten percent and there were no changes in emissions intensities and relative prices, then we should expect to see a ten percent increase in pollution.

The scale effect indicates that economic development has a negative consequence on the environment. Bigger production output requires more exploited natural resource base to meet the demand. As a result, it increases environmental degradation. Economic development is also classified by high energy consumption from fossil-fuel energy sources which stay cheaper, and the evident choice compared to renewable energy. Depending on fossil-fuel energy consumption for industrial processes may lower production costs and help in the expansion of goods and services to meet the growing demand. Thus, induces industry- related emissions (Sarkodie and Strezov, 2018)

2.3. Composition effect

The composition effect states that economic development has a negative and /or positive influence on the environment. It depends on the structural change in the economy. As agrarian economy moves to energy-intensive and carbon- intensive industries, environmental degradation tends to rise with increasing economic growth. The environmental degradation, however, begins to fall as pollution-intensive industries contract and move to service-oriented industries. In a nutshell, the composition effect simply involves the shifting of resources from the industrial sectors that are polluting to the cleaner service sector and establishing cleaner industries (Sarkodie and Strezov, 2018a)

2.4. Technique effect

According to Dinda (2004) and Sarkodie and Strezov (2018b), the technique effect indicates that economic development has a positive influence on the environment. Environmental quality will improve as higher-income countries tend to spend more on research and development, the replacement of polluting and vintage technologies with cleaner and more sophisticated technologies. Coupled with stringent environmental regulations and industry standards.

Therefore, the EKC hypothesis suggests that the negative influence of income levels on the environment as a result of scale effect only happens at the initial stages of economic development. However, the positive influence of a joint composition and technique effects will recompense the previous environmental damage and therefore decline emission levels.

2.5. International trade

One of the crucial factors that explain the EKC hypothesis is trade policy. Environmental policies also play a role. Trade liberalization causes countries to specialize in sectors where they have a comparative advantage. The impact of trade liberalization will damage the environment if the sector with a comparative advantage comes from soft environmental regulations because each country will specialize in sectors with weak environmental regulations and move from industrial production with high pollution abatement costs (Grossman and Krueger, 1991).

The state of pollution-intensive industries and the environmental regulations in place will determine the net effect of pollution levels. Trade liberalization can be associated with the pollution haven hypothesis through the composition effect. Even though free trade is useful by creating jobs, improving skills and raising income levels. This in turn will contribute to a cleaner environment.

Furthermore, emissions embedded in trade refer to the greenhouse gas emissions that are indirectly generated through the production of goods and services in one country but are ultimately consumed in another country. These emissions can be significant and have important implications for efforts to mitigate climate change, as they can distort the picture of emissions responsibility and complicate international climate policies.

To account for these emissions, scholars and policymakers often distinguish between production-based and consumption-based emissions. Production-based emissions refer to the emissions that are generated within a country's borders as a result of its production activities, while consumption-based emissions refer to the emissions that are embodied in the goods and services that are consumed within a country, regardless of where they were produced.

Several studies have highlighted the importance of considering consumption-based emissions in addition to production-based emissions. For example, Peters et al. (2011) found that when the emissions embodied in traded goods were considered, the emissions of developed countries were significantly higher than previously estimated based on production-based emissions alone. Similarly, Davis and Caldeira (2010) found that the United States' consumption-based emissions were substantially higher than its production-based emissions.

Consumption-based emissions are important to consider since they can give a more realistic picture of a country's emissions responsibilities, especially for industrialized nations that consume a lot of products and services made in other countries. It can also show the degree to which emissions are transferred to other nations, which may have an impact on attempts to combat climate change on a global scale.

The requirement for detailed information on the emissions intensity of various goods and services, as well as information on trade flows between countries, makes accounting for consumption-based emissions challenging, especially for developing countries that may have less detailed data on their production and trade activities.

Despite these obstacles, there is a growing understanding of the significance of taking both production-based and consumption-based emissions into account. For instance, the IPCC has advised that both forms of emissions be considered in national greenhouse inventories, and a number of nations have started to include consumption-based emissions in their climate policy and reporting (IPCC, 2014).

If developing countries have weak environmental regulations, they attract a shift of pollution-intensive and energy-intensive industries from developed countries. So, the pollution haven hypothesis hypothesizes that high-income countries with strict environmental standards will move their pollution-intensive industries to poor countries with lenient environmental pollution policies.

Therefore, weak environmental policies and regulations in poor countries become a source of comparative advantage and consequently a shift in the pattern of trade. Hence, promote environmental degradation in poor countries (sun et al., 2017; Sarkodie and Strezov, 2019). Vintage technologies too can be replaced to lower the level of pollution if innovation, research and development, clean and modern technologies are transferred through foreign direct investment from developed to developing countries.

2.6. Trade as a channel to foster technological diffusion

Trade can be an effective channel for fostering technological diffusion between countries. The term "technological diffusion" describes how new technology move from one nation or region to another. Trade can facilitate this diffusion by enabling the transfer of knowledge and technology between partners.

One way in which trade facilitates technological diffusion is through foreign direct investment (FDI). When a business establishes a subsidiary or buys an existing business in another nation, it engages in foreign direct investment (FDI). Therefore, FDI can bring new technologies and knowledge to the host country, which can help improve its productivity and competitiveness. For example, multinational corporations such as Toyota and Samsung have invested heavily in research and development in their home countries and have subsequently transferred their technology and knowledge to their subsidiaries in other countries through foreign direct investment (UNCTAD, 2020).

Another way in which trade facilitates technological diffusion is through international technology licensing. This occurs when a company in one country licenses its technology to a company in another country. The licensing company receives royalties in return for allowing the licensee to use its technology. This can be an effective way for companies in developing countries to gain access to new technologies that they would not otherwise be able to afford. For example, in the pharmaceutical industry, international technology licensing has enabled developing countries to gain access to new medicines and treatments (UNCTAD, 2020)

Trade can also facilitate technological diffusion through the creation of global value chains (GVCs). GVCs refer to the process by which different stages of production are spread across different countries. This enables countries to specialize in certain stages of the production process, and to gain access to new technologies and knowledge from other countries. For example, in the electronics industry, some countries specialize in the production of components such as microchips, while others specialize in the assembly of finished products such as computers (Gereffi, 2018).

2.7. Environmental policies

We can see that countries vary in the global environmental damage they inflict and in their success at managing environmental quality in their country. Per capita, richer nations generate more carbon emissions than poorer ones. According to Bowles et al. (2017), this is predicted given that increasing wealth per capita results from increased production of products and services per individual, which has an influence on the biosphere. Richer nations produce more CO_2 per person, but they also have better laws in place to manage their own natural resources, such as forests, soil, biodiversity, and water.

Consider the "polluter pays" theory. This notion might be regarded as an application of the basic economics of environmental initiatives. Making the polluter responsible for the costs of environmental external effects is a technique to internalize (and subsequently eradicate) them. Environmental external effects frequently impose costs on others. To achieve this, the polluting activity might be taxed in a way that equalizes the marginal private and marginal societal costs. This may be a successful strategy to reduce pollution. Yet, the same reduction might be achieved by giving the company a subsidy for using an alternative technology that produced less pollution. Changes to environmental systems can trigger self-reinforcing feedback mechanisms, which can cause tiny initial changes to have much bigger impacts and cause faster and more severe degradation than expected. This presents a dilemma for environmental policymakers (Bowles et al. 2017)

2.8. Income Elasticity of the environmental quality

Baldwin (1995) mentioned that the income elasticity of environmental quality demand is the proportional change in the environmental quality demand per the proportional change in income level. When income levels rise, people tend to choose a higher standard of life and are more ready to pay for a cleaner environment. In essence, they choose quality over quantity and are more concerned about the environment. They thus demand improved environmental services, which brings about an economic structural shift. decreasing the rate of environmental degradation as a result.

When we look at the relationship between income level and the EKC, a higher income level slowly tends to change the behavioural patterns and lifestyles towards energy-intensive and carbon- intensive products. Rich people's consumer behaviour leans towards energy- efficient products and services. More actions like donations to environmentally friendly organizations and defensive spending become a characteristic of the rich. Studies on the EKC hypothesis (Dinda, 2004; Sarkodie and Strezov, 2018a; Baldwin, 1995) highlighted the role of income elasticity in the fall of environmental degradation.

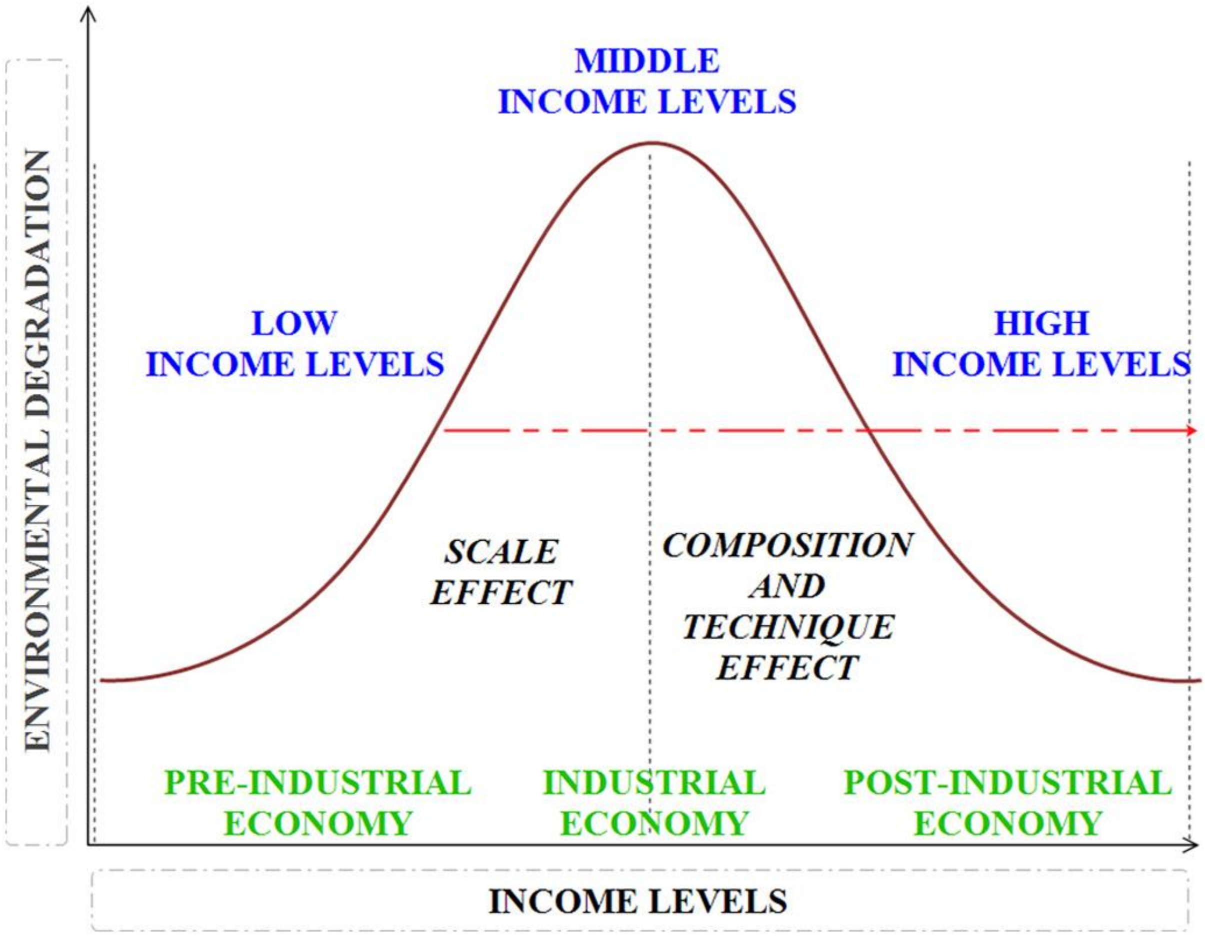

Figure 2. The relationship between environmental degradation and income levels. referenced from (Sarkodie and Strezov, 2018)

The concept of the EKC appeared following Grossman and Krueger's (1991) study which showed that the relationship between economic growth and pollution looks like an inverted U-shaped curve. From figure 2 above we can see how income levels affect the environment. In the primary stages of economic development environmental degradation and pollution increases. But they diminish with further economic growth after getting to a certain income level.

A bell-shaped EKC pattern as described by Grossman (1995) can be influenced by three different factors including scale, composition and technique effect. As a nation is developing, there is a scale effect that causes pollution to increase along with its level of economic activity. Here, environmental problems are ignored by policymakers, the condition of the environment continues to deteriorate, and people are more tolerant of pollution. Also, the economy undergoes a structural change from dirtier to cleaner economic activity when the nation enters a more advanced stage of development.

This entails creating cleaner industries and moving resources away from the polluting industrial sectors and into the more environmentally friendly service sector. The composition effect is what is known as this. At the final stage of economic development, technological progress speeds up as government enforce environment-saving policies and citizens request for a healthier and cleaner environment. This results in a lower level of environmental degradation under the technique effect.

Erdogan (2014) presented an overview of the empirical investigations. He concluded that most of the empirical research did not discover evidence to substantiate the effects of pollution havens brought about by the transfer of foreign direct investment from industrialized to poor nations. Empirical research does support the notion that trade integration and economic expansion lead to environmental disruption of some environmental standards. An exception, though, is, CO_2 emissions.

The influence of trade on pollution was not only addressed by Grossman and Krueger. Many other studies also wrote about it with respect to the EKC hypothesis. The table 1 below shows a collection of studies on the EKC hypothesis, the environmental indicator used and their results. It also highlights the names of the authors, the year of publication of the article and the econometric method employed for analysis. The relationship between carbon emissions, econometric growth and other explanatory variables included in the study or descriptions added, explained the observed relationship between carbon emissions and economic growth. A comprehensive review of each separate study cannot be done here but some general observations will be taken into consideration.

First, most of the studies use panel data analysis simply because of a lack of time-series data for enough period for individual countries. Secondly, it is reasonable to conclude that there is no unambiguous and robust evidence in support of the EKC. Even though six out of the seventeen studies in table 1 below report findings in support of the EKC.

One thing that the studies in table 1 share is that they rely on domestic production-based emissions data to evaluate the EKC. This has two setbacks. The first setback of using production-based emission data is that it disregards non-trivial emissions related to international transportation and international trade. International trade cannot be ignored while determining the fundamental driving forces behind global, regional, and national emissions. Peters et al. (2011) mentioned that attributing emissions from international transportation to countries is debatable and there is no transparent and agreed-upon method to allocate all these emissions to trading countries.

The second setback of using production-based carbon emissions is that it disregards the fact that the reductions in per capita carbon emissions especially in rich countries committed to the Kyoto protocol (also called Annex I parties) have been at least partly offset by a rise in emissions in developing countries who are industrializing and exporting. Who are not committed to any binding emissions targets (the non-Annex I parties). This was shown by Blanco et al. (2014) and Aichele and Felbermayr (2012). Furthermore, the Annex I countries have been able to lower their national production-based carbon emissions by importing carbon-intensive industrial products from abroad. This is because of the dramatic internationalization of trade in global production chains. Thus, for some countries production-based and consumption-based emissions are identified to differ considerably. (Mir and Storm, 2016).

The main cause of global warming is mostly the carbon emissions emitted from fossil fuel consumption. A notable increase in energy demand leads to CO_2 emissions. However, less effort has been made on the consideration of consumption-based carbon emissions associated with the consumption of goods and services in each country. This is a crucial point because consumption-based carbon emissions are calculated by tracking different paths through traded goods and services and directly or indirectly capturing emitted ones. Consequently, accounts for carbon leakages which are one of the important problems for national emission inventories (Danish et al.,2022).

	Author	Place	Time	Indicator and Method	Outcome and Explanation
1	Ahmad et al. (2016)	India	1971 to 2014	Economic growth, energy consumption, and CO_2 emissions. Autoregressive distributed lag and Granger Causality test was used.	The EKC hypothesis was invalid in India. The growth rate of CO_2 emissions depends on energy consumption. On a disaggregated level, coal energy source contributes more to pollution than a natural gas energy source.
2	Alam et al. (2011)	India	1971 to 2006	Economic growth, CO_2 emissions, and energy consumption. Multivariate Toda and Yamamoto model, Impulse- response and Granger Causality test was used.	There was no EKC hypothesis. The study discovered a feedback hypothesis between CO_2 emissions and energy consumption but no Causal relationship between energy consumption and economic growth.
3	Antonakakis et al. (2017)	106 Countries	1971 to 2011	Economic growth, CO_2 emissions, and energy consumption. Panel vector auto regression and Impulse-Response method was used.	The EKC hypothesis is invalid. A feedback hypothesis between energy consumption and economic growth was discovered by the study.
4	Apergis and Payne (2009)	6 Central American Countries	1971 to 2004	Economic growth, energy consumption and CO_2 emissions. A panel vector error correction model was used.	Valid EKC hypothesis. There is a long-run relationship between energy consumption and CO_2 emissions. A unidirectional causality running from energy consumption to output and a bidirectional causality between CO_2 emissions and energy consumption was revealed by the Granger causality test.

5	Cole (2004)	OECD countries	1980 to 1997	Water pollutants, air pollutants, the share of manufacturing, exports and trade openness. Fixed and random effects model	There was EKC hypothesis in higher-income countries. The inversed-U shaped relationship is somehow associated with the demand for environmental regulation and increased investment in pollution abatement technologies.
6	Heidari et al. (2015)	5 ASEAN Countries	1980 to 2008	Economic growth, energy consumption and CO_2 emissions. Panel smooth transition regression was used.	The EKC hypothesis in ASEAN countries was invalid. Energy consumption increases CO_2 emissions even in regime changes in contrast to economic growth that increases CO_2 emissions in the first regime.
7	Hu et al. (2018)	25 Developing countries	1996 to 2012	GDP per capita, CO_2 emissions, commercial services per capita, the share of renewable energy, size of renewable consumption per capita. Fully- modified ordinary least squares and dynamic ordinary least squares regression was used.	There was no EKC hypothesis found. The study discovered a positive effect of economic growth on renewable energy and vice versa. The negative role of renewable energy on CO_2 emissions was confirmed.
8	Jalil and Mahmud (2009)	China	1975 to 2005	Economic growth, energy consumption, trade and CO_2 emissions. An autoregressive distributed lag bounds test was used.	Valid EKC hypothesis. The Granger causality shows a unidirectional causality running from economic growth to CO_2 emissions. The main determinants of CO_2 emissions are economic growth and energy consumption.

9	Jaunky (2011)	36 High-income countries	1980 to 2005	Economic Growth and CO_2 emissions. Generalized method of moments and vector error correction model was used.	Valid EKC hypothesis. There is a unidirectional causality running from economic growth to CO_2 emissions.
10	Kais and Sami (2016)	58 countries	1990 to 2012	Economic growth, energy consumption and CO_2 emissions. Generalized method of moments was used.	The existence of EKC hypothesis in 58 countries was found in the study. A positive long-run relationship between economic growth and CO_2 emissions was confirmed.
11	Narayan & Narayan (2010)	43 Developing countries	1980 to 2004	CO_2 emissions and economic growth. Panel cointegration was used.	There was no EKC hypothesis. The study showed that 15 of 43 countries decline pollution at long-run income levels.
12	Saboori et al. (2016)	Malaysia	1980 to 2009	CO_2 emissions and economic growth. Autoregressive distributed lag was used.	Invalid EKC hypothesis. No inverted U- shape between CO_2 emissions and economic growth. The study discovered a long-run equilibrium relationship between economic growth and CO_2 emissions.
13	Sarkodie (2018)	17 African Countries	1971 to 2013	Per capita GDP, CO_2 emissions, birth rate, energy consumption, fertility rate, agriculture and ecological footprint. Fixed and random effects, Utest and Westerlund error- correction model was used.	The validity of EKC hypothesis was confirmed at a turning point of US $5702. A unidirectional causality running from economic development to environmental degradation was established.

14	Wang et al. (2016)	China	1990 to 2012	Economic growth, CO_2 emissions and energy consumption. Vector error-correction, impulse- response and Granger Causality test was used.	There was no EKC hypothesis. The study discovered a unidirectional causality running from energy consumption to CO_2 emissions and a feedback hypothesis between economic growth and energy consumption.
15	Yang and Zhao (2014)	China	1970 to 2008	CO_2 emissions, economic growth and energy consumption. Granger causality test and directed acyclic graphs was used.	There was no EKC hypothesis. The study discovered a unidirectional causality running from energy consumption to CO_2 emissions and a feedback hypothesis between CO_2 emissions and economic growth.
16	York et al. (2003)	142 Countries	1996	Modernization, human ecology and political economy variables. The Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) model was used.	Valid EKC hypothesis. Institutional change enhances ecological sustainability. Age-structure of the population has environmental effects.
17	Zaman and Moemen (2017)	90 countries from low, middle- income, and high-income countries.	1975 to 2015	Economic growth, energy consumption, service value added and CO_2 emissions. The generalized method of moments was used.	EKC hypothesis confirmed in low and middle- income countries. Service value added increases CO_2 emissions in the long term. Increasing levels of energy consumption seem to facilitate the growth of environmental pollution.

Table 1: A summary of various empirical literatures on the EKC hypothesis

2.9. Gaps in the assessment of the EKC

The EKC is a widely used method to analyse the environmental performance of economies. However, it has been noted that crucial components for environmental degradation such as consumption instead of production and technological progress may not have been taken into consideration. This leads to a criticism of the EKC since it does not consider the evolution of consumption corresponding with economic growth. This simply means that the EKC only describes how the process of production is changed into something environmentally friendly as an effect of economic growth (Leal and Marques, 2022)

Kaika and Zervas (2013) stated that the EKC focuses only on domestic production and pays no attention to the effect of the consumption of imported goods on the environment. So, the EKC disregarded the income elasticity of demand for dirty goods. If the demand for dirty goods persists with high- income levels, then it will lead to their importation by developed countries from the developing economies to satisfy demand. Thus, economic growth will cause more environmental degradation and any environmental improvement caused by the technological process will be offset.

Technological progress is an important tool to aid with the mitigation of climate change and global warming. Those in support of the EKC presume that environmental mitigation depends on technological progress and improvement. In order to accomplish the Sustainable Development Goals, also known as the agenda 2030, it is crucial to produce more economic growth with less environmental damage. The issue of rising climate disasters across the globe is a result of global economic growth patterns. Therefore, reducing global emissions and moving toward decarbonisation is a priority. But the accomplishment of sustainable development goals needs large investment (Leal and Marques, 2022)

In addition, Leal and Marques (2022) mentioned that in the later stages of economic growth, the EKC hypothesis assumes that the environmental damage as a result of economic growth can be reversed. But this assumption is an object of criticism by various researchers. Being able to reverse environmental damage might be effective for specific air and water pollutants. However, it might not work with things like carcinogenic chemicals because they are considered irreparable. Environmental damage due to industrialization is also complicated to reverse.

The most critical environmental problem humanity has ever faced is global warming. For now, it is not sufficient to only analyse if a country or group of countries perform the EKC trajectory. It is essential to start exploring how the environmental damage that is provoked in the first stage of the EKC can be repaired.

A doubt about if the growth path discovered by the inverted U-shaped is a Pareto efficient is also raised here. Pareto efficient or optimal describes the optimum resource allocation at which it is impossible to reallocate for the benefit or improvement of a specific resource allocation without harming the allocation of others. According to Leal and Marques (2022), the message that the EKC hypothesis passes is to “grow now and clean later”. So, this makes it incompatible with being Pareto efficient because this growth strategy is highly intensive in resources.

Taking these factors into consideration it is probable that the environmental damage provoked in the first stages of the EKC might not be repairable. When a growth path simultaneously takes charge of both economic development and the environment, it could avoid substantial losses and avoid the big environmental impact of economic development. Finally, in order to achieve decarbonisation, it is important and urgent for all countries all over the world to collaborate.

2.10. Potential contribution of this study

Based on the existing studies of the EKC hypothesis, which is illustrated in table 1 above, the potential contribution of this study is as follows: previous studies related to the environment mostly focused on variables like Economic growth, carbon emissions and energy consumption. However, when it comes to using CO_2 emissions as an environmental indicator, most studies do not specify whether they are using production-based or consumption-based CO_2 emissions. According to Karakaya et al. (2019), there are two methods when measuring the emissions of greenhouse gases caused by humans namely, production-based and consumption based-emissions.

The former estimates emissions from domestic production of goods and services regardless of whether they are exported or consumed domestically. Countries are obligated to create their national GHG emission inventories using production-based accounting as a result of the Kyoto Protocol and its follow-up agreements. Nevertheless, this method has drawn criticism since it ignores international emission flows in the form of products and services that are produced in one nation and used in another.

In order to address this problem, some studies recommend considering national emissions determined by consumption-based accounting systems (CBA) in GHG assessments for development and international comparisons. These studies recommend using the CBA technique in emission estimates in order to better understand environmental footprints since it links all emissions, direct and indirect occurring along the manufacturing chain to the final user of the products (Peters and Hertwich 2008; Tukker and Dietzenbacher 2013; Steininger et al. 2014; Afionis et al. 2017; Grasso 2017; Peters et al. 2016)

The allocation of the CO_2 trade balance between the two trading partners is the primary distinction between the production-based accounting (PBA) and the consumption-based accounting (CBA). The PBA often offers large benefits to the nations who have delegated some of their emissions to developing nations. This result notably sparks some criticism from nations hosting emission-intensive exporting businesses, who believe that the obligation should fall on the importers of emission-intensive goods.

For instance, it is more likely that a nation would have more consumption-based emissions than production-based emissions if it has a significant trade imbalance, where imports outpace exports. On the other side, it is feasible to find that a country's consumption-based emissions are lower than the production-based emissions if it primarily exports energy-intensive items and imports less energy-intensive products in its commerce. As a result, although some nations profit from this outcome, it may be detrimental to others (Karakaya et al.2019)

Moreover, a significant number of empirical EKC studies use domestic production-based carbon emissions data to test the Kuznets hypothesis and consequently overlooking the emissions included in international trade and in global commodity chains.

According to the IPCC (2007) guidelines, greenhouse gas emissions are counted as the national emissions coming from domestic production. This geographical definition conceals the greenhouse gas emissions contained in international trade and covers the empirical fact that domestic production based GHG emissions in the EU for example have declined. However, consumption-based emissions related to the EU standards of living have gone up.

This study will estimate the impact of trade on the environment by incorporating both production and consumption-based carbon emissions in the methodology. This will be done in order to be able to analyse the different effects they will have on the environment. Rather than focusing on only one. Secondly, the role of globalization will be considered on the environmental impact of trade for both selected developing and developed nations.

The study will add to the literature as it will recommend a sustainable solution that can be applied to developing and developed countries for carbon emission reduction and challenges of globalization in the presence of trade. Finally, the autoregressive distributed lag (ARDL) model will be incorporated into this study which will allow us to evaluate valid and consistent results

Chapter 3: A new empirical investigation of the EKC

3.1. Data

The study will use panel data spanning 1990-2021 from a global standpoint by taking data from 56 developing and developed countries ranging from Europe, Asia, the pacific, Africa, Latin America, etc. Variables will be taken from World Development Indicators of the World Bank. Both production-based and consumption-based carbon dioxide emissions will be analysed along with other sectors. The sectors that will be looked at are Agriculture, Forestry and Fishing, Fossil Fuel Energy consumption, Alternative and Nuclear Energy, and renewable energy consumption. This will be done to check the relationship between the per capita output level and carbon dioxide emissions for the different sectors. Other variables that will be added are GDP per capita, open trade and foreign direct investments.

3.2. Specification of the model

To find out about the relationship between carbon dioxide emissions of the selected sectors and income level, we will examine the following model specification for the chosen sectors:

$$PCO_{2ct} = \beta_0 + \beta_1 Y_{ct} + \beta_2 (Y_{ct})^2 + \sum_y \beta_y X_{y,ct} + \mu_{ct} \qquad (1)$$

$$CCO_{2ct} = \beta_0 + \beta_1 Y_{ct} + \beta_2 (Y_{ct})^2 + \sum_y \beta_y X_{y,ct} + \mu_{ct} \qquad (2)$$

Where PCO_{2ct} and CCO_{2ct} stands for production-based and consumption-based Carbon dioxide emissions in country c and year t.

Y_{ct} Stands for the Sectoral Output

$X_{y,ct}$'s Represents the independent variables related with the emissions of Co_2.

μ_{ct} Represents the error term.

The model and explanatory variables were formed on the existing literature of (Zoundi, 2017; Ganda, 2019; Sugiawan & Managi, 2016; Udeagha & Ngepah, 2019; Danish et al.2022).

The environmental Kuznets curve hypothesis is the theoretical hypothesis guiding this research. Research related to the environmental Kuznets curve hypothesis of the relationship between output and emissions use extensive quadratic specification of output level. This specification takes into consideration the non-linear link between per capita level of output and sectoral Co_2 emissions. In order to measure a country's output level, this research will use real GDP per capita. Moreover, things such as the total final energy consumption and share of renewable energy in the total final energy consumption will be incorporated for other variables.

In order to consider the long and short run of the relationship between the level of output and carbon dioxide emissions, Panel autoregressive distributed lag (ARDL) model will be used. It is a statistical model used to analyse the long-term relationship between two or more variables. The model works by estimating the short-term and long-term effects of changes in one variable on another variable. It does this by adding lagged values of both variables in the model. This model has more advantages than other panel models like the fixed effects and others. Irrespective of whether the variables are stationary at the level, first difference or at an integration, the long-run relationship can be searched with this model. Moreover, the estimates of the ARDL are unbiased even though some regressors are endogenous (Harris and Solis, 2003). The ARDL model for equation (1) and (2) will take the following error correction form:

$$\Delta PCO_{2ct} = \varphi_c ECT_{ct} + \sum_{j=1}^{p-1} \alpha_{cj}^{*} \Delta PCO_{2ct-j} + \sum_{j=0}^{q-1} \Delta X_{ct-j} \beta_{cj}^{*} + \mu_{ct} \quad (3)$$

$$\Delta CCO_{2ct} = \varphi_c ECT_{ct} + \sum_{j=1}^{p-1} \alpha_{cj}^{*} \Delta CCO_{2ct-j} + \sum_{j=0}^{q-1} \Delta X_{ct-j} \beta_{cj}^{*} + \mu_{ct} \quad (4)$$

$$ECT_{ct} = PCO_{2ct-1} + X_{ct}\theta_c \quad (5)$$

$$\mathrm{ECT}_{\mathrm{ct}} = \mathrm{CCO}_{\mathrm{2ct-1}} + \mathrm{X}_{\mathrm{ct}}\theta_{\mathrm{c}} \quad (6)$$

Δ Is the difference.

PCO_{2ct} and CCO_{2ct} is the production-based and consumption-based Carbon dioxide emissions in country c and year t.

The difference between the production-based and consumption-based carbon emissions is that Consumption-based accounting counts the carbon emissions imported through international trade, whereas production-based accounting only counts the generation of carbon emissions in a specific geographic region (single country).

X_{ct} Is the vector of the explanatory variables, including Y and Y^2

ECT_{ct} Is the error correction term and μ_{ct} is the error term.

The error correction model (ECM) is a group of multiple time series models that explicitly estimate how quickly a dependent variable (Y) returns to equilibrium following a change in an independent variable (X). The ECM is useful for estimating both short term and long-term effects of one time series data on a another. Therefore, they often work well with theories of political and social approaches. It is useful when dealing with integrated data but can also be used with stationary data.

Moreover, the ECM is versatile and as a result it has a number of desirable properties such as: (1.) it helps with the easy interpretation of short-term and long-term effects. (2.) it models theoretical relationships. (3) it is applicable to both integrated and stationary time series data. (4) it can be estimated with ordinary least squares (OLS).

φ_c = (1-$\sum_{j=1}^{p} \alpha_{cj}$) is the coefficient on the error correction term and it keeps the speed of convergence to the long-run equilibrium. The coefficients of the error correction term must be significantly negative, that is (φ_c< 0) so that the system meets the long run equilibrium.

$$\theta_c = -\frac{\sum_{j=0}^{q} \beta_{cj}}{\varphi_c}$$ is the long-run coefficient.

Whereas the short-run coefficient is given by $\alpha^*_{cj} = -\sum_{d=j+1}^{p} \alpha_{c,d}$ and $\beta^*{}_{cj} - \sum_{d=j+1}^{p} \beta_{cd}$

A mean group (MG) or Pooled mean group (PMG) can be used to estimate a Panel ARDL model (Pesaran et. al 1999; Hitke et. al 2021). The difference between the mean group and the pooled mean group is that the pooled mean group imposes a homogeneity restriction on the long-run coefficients, but it allows short-run coefficient and error variances to be different across countries. While the mean group allows parameters to be different across countries. The Hausman test will be performed to know whether the mean group or pooled mean group estimator is appropriate for the panel ARDL model in this research.

3.3: Results

The results were analysed using a statistical software called Stata and the version that was used is 17. Table 2 contains the results of the descriptive statistics. Descriptive statistics in a regression analysis refer to the summary statistics that are used to describe key features of the variables being studied. In particular, these statistics are used to describe the distribution of the data, to identify any outliers or influential observations, and to assess the relationship between variables.

They are important in a regression analysis because they provide a basis for understanding and interpreting the results of the regression model. They help to identify potential issues with the data and to determine whether the assumptions of the model have been met. They also provide insights into the nature of the relationship between the variables and can help to guide further analysis.

Table 2: The descriptive statistics of the analysis.

Variable (Short name)	Variable (Long name)	Obs	Mean	Max	Min	Std.dev
PCO	Production-based carbon emissions	1,792	52.074	126.673	-35.193	22.533
CCO	Consumption-based carbon emissions	1, 792	95.300	331.251	-21.602	37.517
FDI	Foreign Direct Investment, net flows (% of GDP)	1, 792	3.714	138.215	-57.532	9.191
AFF	Agriculture, Forestry and Fishing, value added (% of GDP)	1, 792	8.404	56.544	0.1950	10.261
REC	Renewable energy consumption (% of total final energy consumption)	1, 792	30.370	98.34	0	27.704
FFEC	Fossil Fuel and Energy Consumption (% of total)	1,728	63.172	131.177	-2.829	27.858

Alternative and nuclear energy	Alternative and nuclear energy (% of total energy use)	1,664	11.063	50.593	-7.912	12.225
Trade	Trade openness (% of GDP)	1, 792	75.872	388.120	-5.992	47.223
TNRR	Total natural resources rents	1, 792	3.517	55.875	-0.048	6.827
GDP	GDP per capita (annual %)	1, 792	1.527	23.201	-41.099	4.603

Table 3 below shows the correlation matrix.

	PCO	CCO	FDI	AFF	REC	FFEC	ANE	TRADE	TNRR	GDP
PCO	1.00									
CCO	-0.79	1.00								
FDI	-0.08	0.01	1.00							
AFF	-0.28	0.43	-0.14	1.00						
REC	-0.37	0.52	-0.14	0.73	1.00					
FFEC	0.42	-0.52	0.08	-0.60	-0.86	1.00				
ANE	-0.13	0.13	-0.03	-0.32	-0.12	-0.15	1.00			
TRADE	-0.15	0.02	0.40	-0.32	-0.20	0.05	0.07	1.00		
TNRR	-0.25	0.25	-0.04	0.40	0.56	-0.45	-0.24	-0.05	1.00	
GDP	0.01	-0.07	0.08	-0.06	-0.06	0.07	0.02	0.08	-0.06	1.00

The strength of the linear link between variables in a dataset is displayed using a correlation matrix. It indicates the correlation using the correlation coefficient. A degree of link between variables is referred to as correlation. We can say there is a positive correlation when an increase in variable X causes an increase in variable Y. while a negative correlation occurs when an increase in variable X causes a decrease in variable Y. -1 indicates a perfectly negative linear correlation between two variables. 0 indicates no linear correlation between two variables and 1 indicates a perfectly positive linear correlation between two variables. From the table above, there is a weak positive correlation between GDP and production-based emissions. While there is a weak negative correlation between GDP and consumption-based emissions.

Alternative and nuclear energy have a weak positive correlation with consumption-based emissions and a weak negative correlation with production-based emissions. In addition to this, trade have a weak negative correlation with production-based and a weak positive correlation with consumption-based carbon emissions. However, there is a strong negative correlation between production and consumption-based emissions.

3.3.1. Testing for cross-section dependence

The Pesaran's (2004) cross- section dependence test, also known as the Pesaran CD test will be carried out to detect cross-sectional dependence in the panel data. Panel data refers to a dataset that includes observations on multiple individuals or entities overtime. Cross-sectional dependence occurs when the observations on one entity are influenced by the observations on another entity in the same period. The Pesaran's CD test was developed by Mohammad Hashem Pesaran in 2004 and it assumes that if there is no cross-sectional dependence in the panel data, then the residual errors from a regression model should be uncorrelated across individuals. The null hypothesis of the test is that there is no cross-sectional dependence in the panel data, while the alternative hypothesis is that there is cross-sectional dependence.

This test is a useful tool for researchers working with panel data, as it allows them to test for cross-sectional dependence and adjust their analysis accordingly. However, before doing the CD test, I will first of all do a panel data analysis. It has different approaches, but the fixed effects model will be used here. Below is the results of the fixed-effects regression for the dependent variable (production- based carbon emissions) and the independent variables.

Table 4: results of the fixed effects regression for the dependent variable (Production-based emissions)

Production-based carbon emissions	**Coefficient**	**t**	**P > | t |**
Foreign direct investment	0.023	0.90	0.367
Agriculture, forestry and fishing	0.740	10.00	0.000
Renewable energy consumption	0.149	2.71	0.007
Fossil fuel energy consumption	0.548	11.40	0.000
Alternative and nuclear energy	0.408	6.70	0.000
Trade Openness	-0.037	-2.94	0.003

Total natural resources rents	0.299	3.34	0.001
GDP per capita	-0.009	-0.17	0.866
GDP^2	0.007	2.30	0.021

From the results above there is a negative relationship between trade openness and production-based carbon emissions. The p-value of 0.003 shows that they are statistically significant because it is less than the 0.05 significance level.

There is also a negative relationship between per capita GDP and production-based carbon emissions. On the other hand, foreign direct investment and GDP per capita are not significant because their p-values are high (greater than 0.05). The rest of the variables are all statistically significant. It is important to note that the lack of statistical significance does not necessarily mean that a variable is not important or relevant in explaining the outcome variable. Other factors such as measurement error, omitted variable bias or other limitations of the data or model could also affect the results. The prob > F which is the probability of obtaining the estimated F-statistics or greater (the p-value) is 0.0000. it is less than the 0.05 significance level. This means that there is evidence to reject the null hypothesis. Since the statistical analysis shows that the significance level is below the cut-off value that was set (0.05). I reject the null hypothesis. The null hypothesis in a fixed effect regression typically states that there is no significant difference between the groups being compared. From the results above there is proof of statistical significance between the variables.

Table 5: fixed-effects regression for the dependent variable (consumption-based carbon emissions)

Consumption-based emissions	**Coefficient**	**t**	**P > | t |**
Foreign direct investment	-0.047	-0.91	0.361
Agriculture, forestry and fishing	0.400	2.69	0.007
Renewable energy consumption	0.638	5.81	0.000
Fossil fuel energy consumption	-0.416	-4.31	0.000
Alternative and nuclear energy	-0.352	-2.88	0.004
Trade Openness	-0.001	-0.03	0.976

Total natural resources rents	-0.386	-2.15	0.032
GDP per capita	0.032	-0.30	0.768
GDP^2	-0.002	-0.37	0.714

From the results above, there is a positive relationship between output (GDP per capita) and consumption-based carbon emissions. However, they are not statistically significant because the p-value is greater than the 0.05 significance level. There is a negative relationship between trade openness and consumption-based carbon emissions. They are also not statistically significant given that the p-value is above the 5% level. Agriculture forestry and fishing, which has a positive relationship with the consumption-based carbon emissions is significant. All the remaining variables are statistically significant. The null hypothesis is also rejected here. The prob > F is 0.0000. It means that the likelihood of observing the relationship between the dependent variable and the independent variable by chance is extremely low. Therefore, I can conclude with a high degree of confidence that the relationship between the variables is meaningful and not likely to be due to random chance.

Furthermore, after conducting Pesaran's test of cross-sectional dependence, the following results were obtained for the first dependent variable which is production-based emissions and the independent variables.

Pesaran's test of cross-sectional dependence = 0.747, Pr = 0.4553

Average absolute value of the off-diagonal elements = 0.497

The results indicate that the CD statistic is not significant. This is due to the fact that the Pr= 0.4553 is greater than the 0.05 significance level. Therefore, the null hypothesis of no cross-section dependence is accepted. The average absolute value of the off-diagonal elements is 0.497, which is low. Off-diagonal elements refer to the correlations between the individual observations in the panel data set. The closer the average absolute value of the off-diagonal elements is to one, the stronger the cross-sectional dependence. Hence, there is enough evidence suggesting that there is no presence of cross-sectional dependence between the variables.

Moreover, the results of the cross-sectional dependence test between the second dependent variable (consumption-based emissions) and the independent variables is as follows.

Pesaran's test of cross-sectional dependence = 0.427, Pr = 0.6692

Average absolute value of the off-diagonal elements = 0.415

In this case too, the null hypothesis is accepted just like the results above. Hence there is no presence of cross-sectional dependence.

3.3.2. Panel unit root tests

According to (Pesaran et al., 1999, 2001), all variables must be stationary at the level or the first difference for the panel ARDL model. Traditional unit root tests were used in earlier research to investigate the stationarity of variables, including those by Levin et al. (2002), Breitung (2000), Im et al. (2003), and Hadri (2000). However, these conventional unit root tests are susceptible to bias and inconsistent results since they require cross-sectional error independence in the panel data.

In order to test for stationarity, I must discover if the variables are cross-sectionally independent or dependent. From the results above, the cross-section dependency (CD) test developed by Pesaran (2004) to confirm the existence of cross-section dependence was used and the results confirmed that there is no cross-section dependence. The CD test may be used with many different panel data models, such as stationarity and unit root dynamic heterogeneous panels with brief periods and huge cross-section units. Additionally, it is robust to the presence of unit roots. Table 6 below shows the CIPS test statistics, which confirm that all the variables are stationary at the level or the first difference at the 5% significance level. This result allows me to proceed with the analysis of panel cointegration and ARDL estimation. The test is based on an expanded version of the common augmented Dickey-Fuller (ADF) regressions, which include the cross-sectional averages of lagged levels and first differences of the individual time series.

Table 6: results of the panel unit root test

Variables	CIPS t-stat (level)	p-value	CIPS t-stat (difference)	p-value
Production-based emissions	**7.88**	**1.0000**	**-17.96**	**0.0000**
Consumption-based emissions	**5.06**	**1.0000**	**-20.22**	**0.0000**
Foreign direct investment	**-9.12**	**0.0000**	**-26.43**	**0.0000**
Agriculture, forestry and fishing	**-9.53**	**0.0000**	**-22.80**	**0.0000**
Renewable energy consumption	**5.87**	**1.0000**	**-17.61**	**0.0000**
Fossil fuel energy consumption	**6.32**	**1.0000**	**-14.38**	**0.0000**
Alternative nuclear energy	**5.48**	**1.0000**	**-17.10**	**0.0000**
Trade	**-0.95**	**0.1702**	**-23.21**	**0.0000**
Total natural resources rent	**-5.64**	**0.0000**	**-25.30**	**0.0000**
GDP per capita	**-18.06**	**0.0000**	**-30.65**	**0.0000**

3.3.3. Panel cointegration test

The majority of studies consider residual-based cointegration tests, which call for the long-run cointegrating vector to be at levels equal to the short-run adjustment process in their differences, as described by Engle & Granger (1987), Kao (1999), and Pedroni (2004). This limitation is regarded as a common-factor limitation. For residual-based cointegration tests, failure to adhere to such a constraint reduces their power (Banerjee et al., 1998; Kremers et al., 1992). Even when cointegration is strongly predicted by theory, the loss of power may prevent the null hypothesis of no-cointegration from being rejected (Westerlund, 2007).

Rather than depending on common-factor limitations, Westerlund (2007) created panel cointegration tests based on structural dynamics. Compared to previous residual-based cointegration tests, this one has a greater power and a better size accuracy. Group mean statistics (G_τ and G_α) and panel statistics (P_τ and P_α) are the four test statistics that were suggested by Westerlund (2007).

To determine if at least one cross section is cointegrated, the group mean statistics are used. On the other hand, panel statistics are intended to determine if the entire panel is cointegrated. The panel statistics will be employed in this study. Westerlund (2005) cointegration test will be used. It is a panel data test that determines whether a long-run relationship exists between two or more non-stationary variables. One of the advantages it has is that it can be applied to a panel of data with both cross-sectional and time series dimensions, which makes it a useful tool for analysing data that has both spatial and temporal dimensions.

Secondly, it is easy to implement and can be used with a variety of statistical software packages. This makes it a popular choice for researchers and practitioners who need a simple yet powerful tool for analysing panel data.

After conducting a cointegration test between the dependent variable (production-based emissions) and the independent variables, the statistics obtained was 14.66. while the p-value is 0.0000. so, the null hypothesis of no cointegration is rejected.

The statistics of the second cointegration test between the dependent variable (consumption-based emissions) and the independent variables is as follows; statistics = 1.92 p-value = 0.0276. The null hypothesis of no cointegration is rejected too. Thus, there is evidence showing that the variables are cointegrated. So, this means that there exist a long run equilibrium relationship. In other words, cointegration implies that the variables move together in the long run, despite the fact that they may be unrelated or even negatively correlated in the short run.

3.3.4. ARDL estimation

Following the conclusion of the stationarity and cointegration tests, I estimate the ARDL model. The Hausman test is used to determine whether the mean group (MG) or pooled mean group (PMG) estimator will be incorporated, as recommended by Pesaran & Smith (1995) and Pesaran et al. (1999). The numbers from the Hausman test are insignificant for all sectors.

Suggesting that the PMG estimator is preferable to the mean group estimator. Therefore, the PMG-ARDL model to estimate the income- emissions relationship is adopted.

Table 7 below shows the long-run and short-run coefficients of the PMG-ARDL model with quadratic specifications for the dependent variable, production-based carbon emissions and the independent variables. While table 8 shows the linear estimates.

Table 7: PMG-ARDL estimates for the production-based emissions and the independent variables. Quadratic specification

Short run estimates				**Long run estimates**		
variables	**coefficients**	**t-statistic**	**p-value**	**coefficients**	**t-statistic**	**p-value**
GDP	**0.025**	**0.80**	**4.25**	**0.347**	**4.53**	**0.000**
GDP^2	**-0.002**	**-0.41**	**0.683**	**-0.036**	**-3.39**	**0.001**
Foreign direct investment	**0.012**	**0.32**	**0.750**	**0.035**	**0.85**	**0.396**
Agriculture Forestry and fishing	**0.426**	**1.62**	**0.105**	**0.291**	**2.35**	**0.019**
Renewable energy consumption	**0.025**	**0.31**	**0.759**	**-0.142**	**-2.78**	**0.005**
Fossil fuel and energy consumption	**0.162**	**1.59**	**0.112**	**0.340**	**7.90**	**0.000**
Alternative and nuclear energy	**3.014**	**1.10**	**0.270**	**-0.065**	**-1.40**	**0.161**
Trade openness	**0.045**	**2.95**	**0.003**	**-0.009**	**-0.54**	**0.590**
Error correction	**0.130**	**6.11**	**0.000**			

The long-run coefficients of GDP per capita and its square term is significantly positive and negative respectively, confirming the validity of an inverted U-shaped environmental Kuznets curve for the income-emissions relationship. In other words, this means that this result supports the EKC hypothesis. Therefore, this is consistent with Apergis and Payne (2009), Hu et al. (2018), Jalil and Mahmud (2009), Jaunky (2011) and Sarkodie (2018) whose results confirmed that there is the presence of the EKC for the output-emissions relationship.

Secondly, considering production-based carbon emissions as the dependent variable of the ARDL model, heterogeneity of the income-emissions relationship across all sectors was observed. Based on the estimated long-run coefficients of the GDP per capita and its square term, all the sectors can be divided into two groups, and they are sectors with a negative-income emissions relationship and sectors with a positive income-emissions relationship. None of these sectors supported the EKC hypothesis. The first group supporting a negative income-emissions relationship comprises alternative and nuclear energy and renewable energy consumption. I observe in these sectors that with rising income levels, carbon emissions monotonically decline. Generally, the negative relationship implies that the composition and technique effects offset the scale effect in these sectors.

Therefore, the results imply that the EKC hypothesis does not apply to the renewable energy sector and that greater income levels may potentially result in reduced emissions in this sector. The EKC does not also apply to the alternative and nuclear energy sector too.

The second group supports a positive income-emissions relationship, and it comprises agriculture, forestry and fishing and fossil fuel and energy consumption. In these sectors I observe that with rising income levels, carbon emissions increase. This suggests that the scale effect outweighs the composition and technique effect in these sectors.

Table 8: results of the multiple linear regression for the production-based emissions and our independent variables. Linear specification

variables	coefficients	t-statistic	p-value
GDP	**0.248**	**2.71**	**0.007**
GDP^2	**0.030**	**5.95**	**0.000**
Foreign direct investment	**-0.106**	**-2.41**	**0.016**
Agriculture Forestry and fishing	**-0.459**	**-6.54**	**0.000**
Renewable energy consumption	**-0.113**	**-3.06**	**0.002**
Fossil fuel and energy consumption	**0.091**	**2.53**	**0.011**
Alternative and nuclear energy	**-0.270**	**-6.84**	**0.000**
Trade openness	**-0.091**	**-9.66**	**0.000**

In the context of a multiple regression, the null hypothesis is that the independent variables do not have a significant effect on the dependent variable. However, from the results on table 8, I reject the null hypothesis of the linear regression. This is because the p-value is significant (less than 0.05 significance level). This means that there is strong evidence to suggest that the independent variables are associated with the dependent variable, in this case production-based emissions.

Table 9 below shows the results of the PMG-ARDL estimation for the dependent variable consumption-based emissions with quadratic specifications. While table 10 shows the linear specifications. From the results, we can see that the long run coefficients of GDP per capita and its square term is not significantly negative and significantly negative respectively. Confirming that there is no U-shaped environmental Kuznets curve for the income-emissions relationship. This is consistent with the findings of studies such as Yang and Zhao (2014), Wang et al. (2016), Saboori et al. 92016), Hu et al. (2015). Their findings showed that there was no EKC for the income-emissions relationship. In addition to this, heterogeneity of the income-emissions relationship across sectors was also observed. Agriculture, forestry and fishing have a positive income-emissions relationship. While renewable energy consumption, fossil fuel and energy consumption and alternative and nuclear energy have a negative income-emissions relationship.

Table 9: PMG-ARDL estimates for the dependent variable, consumption-based emissions and the independent variables. Quadratic specification

	Short-run estimates			**long-run estimates Quadratic**		
variables	**coefficients**	**t-statistic**	**p-value**	**coefficients**	**t-statistic**	**p-value**
GDP	**0.013**	**0.11**	**0.916**	**-0.145**	**-0.92**	**0.356**
GDP^2	**-0.010**	**-0.54**	**0.593**	**-0.083**	**-3.93**	**0.000**
Foreign direct investment	**0.004**	**0.03**	**0.974**	**0.171**	**3.56**	**0.000**
Agriculture Forestry and fishing	**-0.097**	**-0.26**	**0.792**	**1.100**	**6.72**	**0.000**
Renewable energy consumption	**0.586**	**2.14**	**0.033**	**-0.021**	**-0.12**	**0.906**
Fossil fuel and energy consumption	**0.175**	**0.74**	**0.461**	**-0.309**	**-1.74**	**0.082**
Alternative and nuclear energy	**-2.541**	**-0.60**	**0.552**	**-0.378**	**-1.58**	**0.114**
Trade openness	**-0.035**	**-0.74**	**0.457**	**-0.010**	**-2.37**	**0.018**

Error correction	**0.137**	**5.69**	**0.000**

In table 10 below, the result of the linear regression shows that the values are significant. Therefore, the null hypothesis is rejected too. Showing that the independent variables are associated with the dependent variable (consumption-based emissions)

Table 10: estimates of the multiple linear regression for the consumption-based emissions and the independent variables. Linear specification

variables	**coefficients**	**t-statistic**	**p-value**
GDP	**0.248**	**2.71**	**0.007**
GDP^2	**0.030**	**5.95**	**0.000**
Foreign direct investment	**-0.106**	**-2.41**	**0.016**
Agriculture Forestry and fishing	**-0.459**	**-6.54**	**0.000**
Renewable energy consumption	**-0.113**	**-3.06**	**0.002**
Fossil fuel and energy consumption	**0.091**	**2.53**	**0.011**
Alternative and nuclear energy	**-0.270**	**-6.84**	**0.000**
Trade openness	**-0.091**	**-9.66**	**0.000**

Chapter 4: Discussions and policy implications

4.1: discussions of the results of the analysis

GDP per capita may have two effects on pollution. On the one hand, the rise in GDP necessitates increased resource use, production, consumption, and therefore, pollution. On the other hand, economies transition to service-intensive structures and could increase investments in technical advancement, which reduces material consumption and pollution as a result of rising income levels. Similar to this, globalization may also result in such dual effects by triggering economic activities that increase pollution and by quickening the pace of technological advancement and environmental consciousness.

The link between pollution and per capita GDP in the context of the EKC predicts this outcome. The term "developing stage" refers to this stage of economies, and these economies' structures mainly rely on the industrial sector, which is less environmentally friendly than the service sector. Because economies at this stage are growing in size and producing more. The scale effect is thought to be responsible for the rise of pollution. The square of GDP per capita, however, demonstrates the greater per capita income levels that allow individuals to make investments in innovative production methods with resource and energy-efficient characteristics. Additionally, an economy's proportion of the service sector which generates less pollution than the industrial sector intensifies concurrently with rising income levels.

Furthermore, our results showed the existence of Environmental Kuznets Curve hypothesis in production-based emissions but not in consumption-based emissions. This could have important implications for the impact of globalization and trade on the environment. The EKC hypothesis suggests that there is an inverted-U-shaped relationship between income and environmental degradation, where environmental degradation initially increases with income, but then decreases after a certain level of income is reached. The fact that the EKC is present in production-based emissions but not in consumption-based emissions suggests that the relationship between income and environmental degradation may depend on the nature of the economic activity.

The presence of the EKC in production-based emissions shows that as countries develop and become wealthier, they may be able to implement cleaner and more efficient technologies to reduce emissions from their own production activities.

However, the absence of an EKC in consumption-based emissions indicates that as countries become wealthier, they may also increase their consumption of goods and services, many of which may be produced in countries with less stringent environmental regulations. This could lead to an increase in emissions embodied in these imported goods and services, offsetting any reductions in production-based emissions.

The role of globalization and trade in this context is complex, as increased trade can lead to both increases and decreases in emissions. On the one hand, increased trade can lead to the relocation of production activities to countries with more stringent environmental regulations, leading to a reduction in global emissions. On the other hand, increased trade can also lead to an increase in emissions embodied in traded goods, particularly for countries that rely heavily on imports.

Overall, these findings indicate that policies aimed at reducing emissions need to consider both production-based and consumption-based emissions, and that policies aimed at reducing emissions from production activities may need to be complemented by policies aimed at reducing emissions embodied in traded goods and services.

One example of a policy that aims to address the environmental impacts of trade is the European Union's Emissions Trading System (ETS), which puts a cap on greenhouse gas emissions from power plants, factories and airlines, and allows companies to trade emissions allowances. The ETS aims to incentivize companies to reduce emissions and invest in low-carbon technologies. This is a good policy which other countries should try and adopt so that carbon emissions will be reduced more.

Moreover, from my results in table 7, based on the estimated long-run coefficients of the GDP per capita and its square term and production-based emissions as our dependent variable, all the sectors were divided into two groups, and they are sectors with a negative income-emissions relationship and sectors with a positive income-emissions relationship. A negative-income emissions relationship was found in the renewable energy consumption sector. Therefore, the results imply that the EKC hypothesis does not apply to the renewable energy sector and that greater income levels may potentially result in reduced emissions in this sector. This may have significant policy implications for encouraging the development of renewable energy sources as a way to combat climate change and reduce greenhouse gas emissions. The policy repercussions may include prioritizing initiatives that support the growth of renewable energy sources. Examples of such policies are:

(1.) Subsidies and incentives: Governments may offer subsidies and incentives to promote the use of renewable energy sources like solar, wind, and hydropower. To make renewable energy more cost-competitive with fossil fuels, this might entail tax credits, feed-in tariffs, or other financial incentives.

(2.) renewable energy targets: targets could be set by the government for renewable energy use, instructing that a certain percentage of the energy mix must come from renewable sources. This could encourage investment in renewable energy infrastructure and drive innovation in the sector.

(3.) research and development: governments could invest in research and development to improve the efficiency and cost-effectiveness of renewable energy technologies. This could lead to breakthroughs in energy storage, grid integration and other areas that are critical to expanding the use of renewable energy.

(4.) carbon pricing: carbon pricing mechanism could be implemented by the government such as a carbon tax or cap-and-trade system, to put a price on carbon emissions and incentivize the use of renewable energy sources. All in all, the findings of the analysis suggest that policies to promote renewable energy development could have a significant impact on reducing greenhouse gas emissions and addressing climate change. This is in line with a study by Aklin and Urpelainen (2018). Who also found a negative income-emissions relationship in the renewable energy sector.

Furthermore, a negative income-emissions relationship was also found in the alternative and nuclear energy sector. One policy implication to promote the use of these forms of energy in a sustainable manner is that financial incentives or subsidies may be provided by governments to encourage the development of alternative and nuclear energy technologies, especially in the early stages of their adoption. For example, feed-in-tariffs have been used in many countries to support the deployment of renewable energy technologies. Additionally, policies that promote research and development of these technologies could help to further reduce emissions. For example, the U.S. department of energy's advanced research projects agency-energy (ARPA-E) funds high-risk, high-reward research projects aimed at developing new energy technologies.

The second group that supports a positive income-emissions relationship comprises agriculture forestry and fishing and fossil fuel energy consumption. Therefore, this implies that policies aimed at reducing emissions from these sectors may need to focus on reducing overall energy consumption, instead of just improving efficiency or promoting the use of alternative energy sources. Examples of policies that could help to reduce emissions from these sectors include carbon pricing mechanisms such as, carbon taxes or cap-and-trade systems, which create a financial incentive for companies to reduce their emissions. In addition, regulations that require companies to report their emissions or to meet emissions reduction targets could also be effective in reducing emissions from these sectors.

4.2. Policy Implications of this study in international relations

Based on the results of this study, there exists an environmental Kuznets Curve (EKC) in production-based emissions but not in consumption-based emissions. This has important implications for international relations. Specifically, this suggests that policies aimed at reducing emissions should focus on the production side of the economy rather than consumption. For example, policies that promote the use of renewable and alternative energy sources, reduce fossil fuel consumption, and encourage foreign direct investment in clean technologies could be effective in reducing production-based emissions. Policies that target consumption-based emissions, such as carbon taxes or emissions trading schemes, may not be as effective given the absence of an EKC relationship.

One potential concern with policies aimed at reducing production-based emissions is that they could lead to carbon leakage, where emissions simply shift to countries with weaker environmental regulations. To address this, policymakers could consider implementing border carbon adjustments or other measures to ensure that all countries are held to the same environmental standards.

The policy implications of finding that an environmental Kuznets Curve (EKC) exists in production-based emissions but not in consumption-based emissions is relevant to international relations because they have implications on how countries can work together to address climate change and reduce global emissions. First, the findings suggest that countries should focus on reducing production-based emissions rather than consumption-based emissions. This has effects on international trade and cooperation, as countries with high levels of production-based emissions may need to shift their economies towards cleaner production processes, which could involve changes in trade patterns and investment flows.

Secondly, the findings highlights the importance of international cooperation in addressing climate change. Given that emissions are a global issue, countries will need to work together to reduce emissions and mitigate the environmental impact of economic growth. This could involve sharing best practices, providing financial assistance to developing countries to support their transition to cleaner technologies, and implementing international agreements and regulations to reduce emissions.

Finally, the study also raises questions about climate justice and the distributional impacts of climate policies. Countries with high levels of consumption-based emissions may argue that they should not bear the full burden of reducing emissions, since much of the pollution is generated by goods and services that are consumed by other countries. This could create tensions and disagreements between countries, which could have implications for international relations.

Overall, the policy implications of this research highlights the need for international cooperation and coordination in addressing climate change, as well as the importance of considering issues of trade, investment, and climate justice.

Chapter 5

Conclusion

This paper investigates the impact of globalization and trade on the environment using the EKC hypothesis. The Panel-ARDL model was incorporated and two dependent variables, production-based and consumption-based emissions were employed in the model. Stata 17 software package was used to perform all the regressions and subsequent tests. 56 countries were taken for the observation. The research adapted econometric analysis of secondary data gathered from World Bank Data. The results showed the existence of EKC in production-based but not in consumption-based emissions. Secondly, the EKC analysis can be undertaken with various pollutant indicators such as Methane, Nitrous oxide, ecological footprint and greenhouse gas emissions. The pollutant that this study uses is Carbon dioxide emissions.

Overall, the impact of globalization and trade on the environment is complex and varies depending on the specific context. Policymakers may need to consider a range of policies to promote sustainable development and reduce emissions, such as carbon taxes, subsidies for clean technologies and regulations on multinational corporations. One example is the Paris Agreement, an international agreement under the United Nations Framework Convention on Climate Change, which aims to limit global warming to well below 2 degrees Celsius above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5 degrees Celsius. The Paris Agreement includes commitments from countries to reduce emissions, increase resilience to climate change, and provide financial support to developing countries.

One limitation of this study is that it did not incorporate other macroeconomic variables in the context of the EKC such as tourism revenue (Paramati et al., 2017; Zhang & Gao, 2016), urbanization (He et al., 2017; Pata, 2018; Wang et al., 2016) and financial development (Ozatac et al., 2017). Therefore, a more thorough knowledge of the sectoral EKC phenomenon's pattern may be achieved by doing the inquiry with the inclusion of other macroeconomic and pollution variables, which could be conducted in future research.

Finally, to answer the question of my sub-topic which states "should globalization and trade be at the expense of the environment"? The answer is a big no. In the case of globalization, it may have two effects on the environment. It can trigger economic activities that increase pollution, and it can also quicken the pace of technological advancement and environmental consciousness. However, it is a complex process that involves the integration of economies, societies, and cultures across national borders.

While globalization has brought many benefits such as increased economic growth, improved standards of living, and greater global cooperation, it also has negative environmental impacts. To address these challenges, it is important to ensure that globalization is pursued in a sustainable manner. This means integrating environmental considerations into trade and investment policies, promoting sustainable production and consumption patterns, investing in clean technologies and infrastructure. Governments, businesses, and civil society organizations all have a role to play in promoting sustainable globalization and protecting the environment for future generations.

In the case of trade, economic growth and development are important for raising living standards but they should not come at the expense of degrading the natural environment upon which we all depend. Instead, trade and economic development should be pursued in a sustainable manner just like globalization.

Appendices

The table below is the list of countries used for this observation.

countries	countries
Argentina	**Israel**
Armenia	**Italy**
Angola	**Japan**
Australia	**Korea, Rep**
Austria	**Latvia**
Bahamas	**Lithuania**
Bangladesh	**Luxembourg**
Belgium	**Mexico**
Benin	**Netherlands**
Botswana	**New Zealand**
Burkina Faso	**Nigeria**
Burundi	**Norway**
Canada	**Poland**
Cameroon	**Portugal**
Chile	**Slovakia**
Colombia	**Slovenia**
Cote d’ivoire	**Spain**
Czechia	**Sweden**
Denmark	**Switzerland**
Democratic republic of Congo	**Senegal**
Estonia	**The Gambia**
Finland	**Türkiye**
France **Ghana**	**United Kingdom** **United States**
Germany	**Kenya**
Greece	**South Africa**
Hungary	
Iceland	
India	
Ireland	

The tables below show the full results of the ARDL estimates, including the results of the Hausman test and Dynamic fixed effects regressions.

```
. regress pco GDP GDP2 FDI AFF REC FFEC ANE trade

      Source |       SS           df       MS      Number of obs   =     1,664
-------------+----------------------------------   F(8, 1655)      =     73.17
       Model |  139924.028         8  17490.5035   Prob > F        =    0.0000
    Residual |   395628.01     1,655  239.050157   R-squared       =    0.2613
-------------+----------------------------------   Adj R-squared   =    0.2577
       Total |  535552.038     1,663   322.03971   Root MSE        =    15.461

------------------------------------------------------------------------------
         pco | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
         GDP |   .2475021    .091241     2.71   0.007     .0685421    .4264621
        GDP2 |   .0304627   .0051189     5.95   0.000     .0204225    .0405029
         FDI |  -.1059847   .0439418    -2.41   0.016    -.1921721   -.0197974
         AFF |  -.4585414   .0700865    -6.54   0.000    -.5960088   -.3210739
         REC |  -.1129764   .0368949    -3.06   0.002    -.1853419   -.0406108
        FFEC |   .0912458   .0360287     2.53   0.011     .0205791    .1619124
         ANE |  -.2704577   .0395195    -6.84   0.000    -.3479712   -.1929442
       trade |  -.0914233   .0094624    -9.66   0.000    -.1099829   -.0728637
       _cons |   65.99434   3.882875    17.00   0.000     58.37847     73.6102
------------------------------------------------------------------------------
```

```
. regress cco GDP GDP2 FDI AFF REC FFEC ANE trade

      Source |       SS           df       MS      Number of obs   =     1,664
-------------+----------------------------------   F(8, 1655)      =    124.56
       Model |   939649.55         8  117456.194   Prob > F        =    0.0000
    Residual |  1560631.68     1,655  942.979866   R-squared       =    0.3758
-------------+----------------------------------   Adj R-squared   =    0.3728
       Total |  2500281.23     1,663  1503.47639   Root MSE        =    30.708

------------------------------------------------------------------------------
         cco | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
         GDP |  -.9416265   .1812162    -5.20   0.000    -1.297064   -.5861895
        GDP2 |  -.0699103   .0101668    -6.88   0.000    -.0898514   -.0499692
         FDI |   .2151313   .0872739     2.47   0.014     .0439524    .3863102
         AFF |   1.442771   .1392005    10.36   0.000     1.169744    1.715799
         REC |   .5059041   .0732778     6.90   0.000     .3621771    .6496311
        FFEC |   .0089937   .0715575     0.13   0.900    -.1313592    .1493465
         ANE |   .8198336   .0784907    10.44   0.000      .665882    .9737851
       trade |    .137577   .0187936     7.32   0.000     .1007153    .1744387
       _cons |   52.63739   7.711877     6.83   0.000     37.51132    67.76345
------------------------------------------------------------------------------
```

Pooled Mean Group Regression
(Estimate results saved as pmg)

Panel Variable (i): id

Time Variable (t): year

Number of obs = 1612

Number of groups = 52

Obs per group: min = 31

avg = 31.0

max = 31

Log Likelihood = -2492.129

D.pco	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
__ec						
GDP	.3474802	.0766999	4.53	0.000	.1971512	.4978092
GDP2	-.0359909	.0106232	-3.39	0.001	-.0568119	-.0151698
FDI	.0345048	.040639	0.85	0.396	-.0451461	.1141558
AFF	.2909487	.1240401	2.35	0.019	.0478346	.5340628
REC	-.142839	.0514174	-2.78	0.005	-.2436153	-.0420627
FFEC	.3403468	.0431089	7.90	0.000	.255855	.4248387
ANE	-.0653749	.0466782	-1.40	0.161	-.1568625	.0261126
trade	-.0093807	.0173993	-0.54	0.590	-.0434827	.0247212
SR						
__ec	.1297347	.021247	6.11	0.000	.0880913	.171378
GDP						
D1.	.0248503	.0311693	0.80	0.425	-.0362403	.085941
GDP2						
D1.	-.0020903	.0051153	-0.41	0.683	-.0121161	.0079355
FDI						
D1.	.0119898	.037567	0.32	0.750	-.0616402	.0856197
AFF						
D1.	.4256869	.2625463	1.62	0.105	-.0888944	.9402681
REC						
D1.	.024774	.0808541	0.31	0.759	-.1336972	.1832452
FFEC						
D1.	.1615895	.1016962	1.59	0.112	-.0377314	.3609105
ANE						
D1.	3.013988	2.73056	1.10	0.270	-2.33781	8.365787
trade						
D1.	.0450923	.0152985	2.95	0.003	.0151078	.0750768
_cons	-5.095734	.8903266	-5.72	0.000	-6.840742	-3.350726

Dynamic Fixed Effects Regression: Estimated Error Correction Form
(Estimate results saved as DFE)

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
__ec						
GDP	.2017264	.1904716	1.06	0.290	-.171591	.5750439
GDP2	.0113937	.0116234	0.98	0.327	-.0113877	.0341752
FDI	.2176801	.0907103	2.40	0.016	.0398913	.395469
AFF	.5581001	.2171326	2.57	0.010	.132528	.9836723
REC	.1873449	.1676356	1.12	0.264	-.1412149	.5159047
FFEC	.2372305	.1597605	1.48	0.138	-.0758943	.5503553
ANE	.2007261	.1893508	1.06	0.289	-.1703945	.5718468
trade	-.1244082	.0368889	-3.37	0.001	-.1967091	-.0521073
SR						
__ec	.1163083	.0080774	14.40	0.000	.1004768	.1321398
GDP						
D1.	-.01996	.0195889	-1.02	0.308	-.0583536	.0184336
GDP2						
D1.	.0015514	.0010758	1.44	0.149	-.0005571	.00366
FDI						
D1.	.0135953	.0084375	1.61	0.107	-.0029419	.0301326
AFF						
D1.	.3546503	.0529663	6.70	0.000	.2508382	.4584624
REC						
D1.	.0903895	.0562689	1.61	0.108	-.0198955	.2006745
FFEC						
D1.	.2587436	.0584966	4.42	0.000	.1440924	.3733948
ANE						
D1.	.1696151	.061052	2.78	0.005	.0499553	.2892749
trade						
D1.	.0245158	.0101111	2.42	0.015	.0046984	.0443333
_cons	-4.510655	1.82145	-2.48	0.013	-8.080631	-.9406783

```
. hausman DFE pmg,sigmamore

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |      DFE          pmg         Difference       Std. err.
-------------+----------------------------------------------------------------
         GDP |    .2017264     .3474802     -.1457538        .1452613
        GDP2 |    .0113937    -.0359909      .0473846               .
         FDI |    .2176801     .0345048      .1831753        .0668469
         AFF |    .5581001     .2909487      .2671515        .1402872
         REC |    .1873449     -.142839      .3301839        .1351206
        FFEC |    .2372305     .3403468     -.1031163        .1308636
         ANE |    .2007261    -.0653749      .2661011        .1564872
       trade |   -.1244082    -.0093807     -.1150275        .0266343
------------------------------------------------------------------------------
                          b = Consistent under H0 and Ha; obtained from xtpmg.
           B = Inconsistent under Ha, efficient under H0; obtained from xtpmg.

Test of H0: Difference in coefficients not systematic

    chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =  11.41
Prob > chi2 = 0.1796
(V_b-V_B is not positive definite)
```

Pooled Mean Group Regression
(Estimate results saved as pmg)

Panel Variable (i): id
Time Variable (t): year

Number of obs	=	1612
Number of groups	=	52
Obs per group: min	=	31
avg	=	31.0
max	=	31
Log Likelihood	=	-3985.482

D.cco	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
__ec						
GDP	-.145043	.1571885	-0.92	0.356	-.4531268	.1630409
GDP2	-.0832928	.0212107	-3.93	0.000	-.1248651	-.0417206
FDI	.1712801	.0480732	3.56	0.000	.0770584	.2655018
AFF	1.999963	.2976684	6.72	0.000	1.416543	2.583382
REC	-.0213517	.1807993	-0.12	0.906	-.3757118	.3330084
FFEC	-.3092544	.1777823	-1.74	0.082	-.6577013	.0391925
ANE	-.3775643	.239108	-1.58	0.114	-.8462073	.0910787
trade	-.099657	.0420614	-2.37	0.018	-.1820959	-.0172181
SR						
__ec	.1370892	.0240999	5.69	0.000	.0898541	.1843242
GDP						
D1.	.0129089	.1227204	0.11	0.916	-.2276186	.2534364
GDP2						
D1.	-.0100347	.0187519	-0.54	0.593	-.0467877	.0267183
FDI						
D1.	.0041904	.1302249	0.03	0.974	-.2510458	.2594266
AFF						
D1.	-.0973638	.3701046	-0.26	0.792	-.8227555	.6280278
REC						
D1.	.5857943	.2743233	2.14	0.033	.0481305	1.123458
FFEC						
D1.	.1751314	.2375764	0.74	0.461	-.2905098	.6407727
ANE						
D1.	-2.541059	4.270071	-0.60	0.552	-10.91024	5.828126
trade						
D1.	-.0353076	.0474998	-0.74	0.457	-.1284054	.0577903
_cons	-15.93178	2.753721	-5.79	0.000	-21.32897	-10.53458

Dynamic Fixed Effects Regression: Estimated Error Correction Form
(Estimate results saved as DFE)

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
__ec						
GDP	-.1809546	.3813374	-0.47	0.635	-.9283621	.5664529
GDP2	-.0193572	.0233302	-0.83	0.407	-.0650835	.0263691
FDI	-.1408387	.1801037	-0.78	0.434	-.4938355	.2121582
AFF	1.382469	.4395242	3.15	0.002	.5210176	2.243921
REC	.5436448	.3363571	1.62	0.106	-.115603	1.202893
FFEC	-.0758912	.3179168	-0.24	0.811	-.6989966	.5472143
ANE	-.0511752	.3790221	-0.14	0.893	-.7940448	.6916944
trade	.1341123	.0735228	1.82	0.068	-.0099898	.2782144
SR						
__ec	.1747562	.0123221	14.18	0.000	.1506053	.1989071
GDP						
D1.	.048795	.0590413	0.83	0.409	-.0669239	.1645138
GDP2						
D1.	.0010051	.0032413	0.31	0.756	-.0053476	.0073579
FDI						
D1.	-.0090584	.0254301	-0.36	0.722	-.0589005	.0407837
AFF						
D1.	-.5908688	.1602278	-3.69	0.000	-.9049094	-.2768281
REC						
D1.	.7611996	.1696897	4.49	0.000	.4286139	1.093785
FFEC						
D1.	-.4306426	.1762889	-2.44	0.015	-.7761626	-.0851227
ANE						
D1.	-.3394706	.1840549	-1.84	0.065	-.7002115	.0212702
trade						
D1.	.0291185	.0304743	0.96	0.339	-.0306101	.0888471
_cons	-11.7333	5.625135	-2.09	0.037	-22.75837	-.7082435

```
. hausman DFE pmg,sigmamore

                    ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |      DFE          pmg         Difference       Std. err.
-------------+----------------------------------------------------------------
         GDP |   -.1809546     -.145043       -.0359116        1.326928
        GDP2 |   -.0193572    -.0832928        .0639357        .0789492
         FDI |   -.1408387     .1712801       -.3121187        .6292495
         AFF |    1.382469     1.999963       -.6174936        1.511052
         REC |    .5436448    -.0213517        .5649965        1.164645
        FFEC |   -.0758912    -.3092544        .2333633        1.099702
         ANE |   -.0511752    -.3775643        .3263891        1.306391
       trade |    .1341123     -.099657        .2337693        .2541671
------------------------------------------------------------------------------
                          b = Consistent under H0 and Ha; obtained from xtpmg.
           B = Inconsistent under Ha, efficient under H0; obtained from xtpmg.

Test of H0: Difference in coefficients not systematic

    chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =   3.25
Prob > chi2 = 0.9176
```

References

Ali, M., Wang, W., Ghani, N., & Ali, M. (2017). Impacts of mining on water resources in South Africa: A review. Scientific Research and Essays, 12(31), 246-253.

Akadiri, S.S., Alola, A. A., Akadiri, A. C. (2019). The role of globalization, real income, tourism in environmental sustainability target. Evidence from Turkey. Science of The Total Environment. 687.10.1016/j.scitotenv.2019.06.139.

Aklin, M (2015). Re-exploring the trade and environment nexus through the diffusion of pollution. Environ Resource Econ (2016) 64:663-682. DOI 10.1007/s10640-015-9893-1

Aklin, M., & Urpelainen, J. (2018). Diffusion of renewable energy: A review. Annual review of resource economics, 10(1), 347-372.

Albrow, M., (1996). Global Age. Blackwell Publishing Ltd, Oxford.

Bai, Y., et al. (2019). China's war on air pollution and its impact on health. The Lancet, 394(10215), 1538-1540.

Balde, C. P., Forti, V., Gray, V., Kuehr, R., & Stegmann, P. (2017). The global e-waste monitor 2017: Quantities, flows, and resources. United Nations University, International Telecommunication Union, and International Solid Waste Association.

Balde, C.P., Wang, F., Kuehr, R., Huisman, J. (2020): Quantities, flows and the circular economy potential. United Nations University (UNU), International Telecommunications Union (TU), and International Solid Waste Association (ISWA).

Baldwin, R., 1995. Does Sustainability Require Growth. The Economics of Sustainable Development.pp. 51–78.

Bast, E., & Fisher, D.R. (2013). Environmental regulation and international trade: Empirical results for the United States and Canada. Canadian Journal of Economics, 46(4), 1312-1340.

Baylis, J et al. (2020). The Globalization of World Politics. An Introduction to International Relations. Eighth Edition: Oxford University Press.

Bernauer, T., 2013. Climate change politics. Annu. Rev. Polit. Sci. 16 (1), 421–448.

Bibi F, Jamil M. Testing environment Kuznets curve (EKC) hypothesis in different regions. Environ Sci Pollut Res Int.2021.Mar; 28(11): 13581-13594.doi: 10.1007/s11356-020-11516-2.Epub 2020 Nov 13. PMID:33185793.

Bowles, S., Carlin, W. and Stevens, M. (2017). 'Economics of the environment: Dynamic environmental policies: Policy choices matter'. Unit 20 in The CORE team, *The Economy*. Available at: https://www.core-econ.org. [Accessed on 6/04/2023]

Brock, W.A., Taylor, M.S., (2010). The green Solow model. J. Econ. Growth 15 (2), 127–153.

Brundtland, G.H. (1987). Our common future: The World Commission on Environment and Development. Oxford University Press.

Bryner, G. C. (2016). Environmental justice and trade policy. In the Oxford Handbook of International Environmental Law (pp. 391-401). Oxford University Press.

Chen, W., & Zhang, Z. (2019). The impact of international trade on carbon emissions: Empirical evidence from China. Journal of Cleaner Production, 220, 152-163.

Cole, M. A. (2004). Trade, the pollution haven hypothesis and the environmental Kuznets curve: Examining the linkages. Ecological Economics, *48*(1), 71–81. https:// doi. org/ 10. 1016/j. ecole con. 2003. 09. 007.

Congregado, E., Feria-Gallardo, J., Golpe, A. A., & Iglesias, J. (2016). The environmental Kuznets curve and CO2 emissions in the USA: Is the relationship between GDP and CO2 emissions time varying? Evidence across economic sectors. Environmental Science and Pollution Research, 23(18), 18407–18420. https:// doi. org/ 10. 1007/ s11356- 016- 6982-9.

Copeland, Brian R. and Taylor, M. Scott. Trade and the Environment: Theory and Evidence, Princeton: Princeton University Press, 2003. https://doi.org/10.1515/9781400850709.

Dahlsrud, A. (2008). How corporate social responsibility is defined: an analysis of 37 definitions. Corporate Social Responsibility and Environmental Management, 15(10, 1-13.

Dasgupta, S. (2007). Climate change, trade, and the environment: issues and options for developing countries. Strategies and Priorities for African Agriculture: Economywide Perspectives from Country Studies, 105-142.

Davis, S.J., & Caldeira, K. (2010). Consumption-based accounting of CO2 emissions. Proceedings of the National Academy of Sciences, 107(12), 5687-5692.

Deardorff, A.V, Stern, R.M (2002). What you should know about globalization and the World Trade Organization. Https://doi.org/10.1111/1467-9396.00340.

Dinda, S., 2004. Environmental Kuznets Curve hypothesis: a survey. Ecol. Econ. 49,431–455. https://doi.org/10.1016/j.ecolecon.2004.02.011.

Engle, R. F., & Granger, C. W. J. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica, 55*(2), 251. https:// doi. org/ 10. 2307/ 19132 36

Environmental Protection Agency. (2021). The Clean Air Act. Retrieved from https://www.epa.gov/laws-regulations/summary-clean-air-act.

Ervin, David E. "Agriculture, Trade and the Environment: Anticipating the Policy Challenges." Paris: Organization for Economic Cooperation and Development (OECD). OECD\GD (97)171. 1997a.

Erdogan, A.M., (2014). Foreign direct investment and environmental regulations: a survey. J. Econ. Surv. 28 (5), 943–955.

Erdogan, S., Yıldırım, S., Yıldırım, D. C., & Gedikli, A. (2020). The effects of innovation on sectoral carbon emissions: Evidence from G20 countries. Journal of Environmental Management, *267*, 110637. https:// doi. org/ 10. 1016/j. jenvm an. 2020. 110637.

Farooq, S., Ozturk, I., Majeed, M.A., Akram, R. (2022). Globalization and CO_2 emissions in the presence of EKC: A global Panel data analysis. Gondwana Research, Volume 106.

Ford Runge, C (1998). Emerging issues in agricultural trade and the environment. University of Minnesota, U.S.A: Centre for International food and Agricultural Policy. Working Paper WP98-3.

Friedman, G. (2017). Trade and environmental justice: Toward a global political ecology. MIT Press.

Ganda, F. (2019). Carbon emissions, diverse energy usage and economic growth in South Africa: Investigating existence of the environmental Kuznets curve (EKC). Environmental Progress & Sustainable Energy, 38(1), 30–46. https:// doi. Org/ 10. 1002/ ep. 13049.

Gereffi, G. (2018). Global value chains and development: Redefining the contours of 21st century capitalism. Cambridge University Press.

Ghosh, D., & Roy, J. (2020). Globalization, carbon emissions, and climate change: A study of panel data from selected emerging economies. Environmental Science and Pollution Research, 27 (34), 43126-43135.

Grossman, G.M., Krueger, A.B., (1991). Environmental impacts of a North American Free Trade Agreement. Working Paper No. 3914. National Bureau of Economic Research, Cambridge, MA.

Grossman, G. M. (1995). Pollution and growth: What do we know? In The economics of sustainable development (pp. 19–46). Cambridge University Press.

Harris, R. I. D., & Sollis, R. (2003). Applied time series modelling and forecasting. Wiley.

Haseeb, A., Xia, E., Danish, Baloch, M.A., Abbas, K., (2018). Financial development, globalization, and CO 2 emission in the presence of EKC: evidence from BRICS countries. Environ. Sci. Pollut. Res. 25 (31), 31283–31296.

Held, D., McGrew, A., Goldblatt, D., Perraton, J., (2000). Global transformations: Politics, economics and culture. In: Politics at the Edge, pp. 14–28.

Hitke, M.M., Shrestha, A., Kakinaka, M. (2021). Investigating whether the environmental Kuznets curve hypothesis holds for sectoral CO2 emissions: evidence from developed and developing countries. Environment, Development and Sustainability (2022) 24:12712–12739 https://doi.org/10.1007/s10668-021-01961-5.

Intergovernmental Panel on Climate Change (IPCC). (2014). Climate Change 2014.: Mitigation of climate change. Cambridge University Press.

International Labour Organization (ILO). (2019). World Employment and Social Outlook-Trends 2019. Retrieved from https://www.ilo.org/global/research/global-reports/weso/2019/lang--en/index.htm.

IMF. (2019). Fiscal Policies for Paris Climate Strategies. International Monetary Fund.

IPCC. (2018). Global Warming of 1.5 ºC. Intergovernmental Panel on Climate Change.

Journal of Cleaner Production, 271, 122642. https:// doi. org/ 10. 1016/j. jclep ro. 2020. 122642.

D. Kaika, E. Zervas, The Environmental Kuznets Curve (EKC) theory-Part A: concept, causes and the CO2 emissions case, Energy Pol. 62 (2013) 1392–1402.

Kalt, J. P. "The Impact of Domestic Environmental Regulatory Policies on U.S. International Competitiveness." Discussion Paper E-35-02, Harvard Energy and Environmental Policy Center, March 1985.

Kao, C. (1999). Spurious regression and residual-based tests for cointegration in panel data. Journal of Econometrics, 90(1), 1–44. https:// doi. org/ 10. 1016/ S0304- 4076(98) 00023-2

Karakaya, E., Yilmaz, B., & Alatas, S. (2019). How production-based and consumption-based emissions accounting systems change climate policy analysis: the case of CO_2 convergence. Environmental Science and Pollution Research (2019) 26:16682–16694 https://doi.org/10.1007/s11356-019-05007-2.

KPMG. (2017). The KPMG Survey of Corporate Responsibility Reporting 2017. https://assets.kpmg/content/dam/kpmg/xx/pdf/2017/10/kpmg-survey-of-corporate-responsibility-reporting-2017.pdf.

Lele, S., & Kurian, M. (2018). Environmental regulations and sustainable development in developing countries. World Development, 106, 116-126.

Lenzen, M., Kanemoto, K., Moran, D., & Geschke, A. (2012). Mapping the structure of the world economy. Environmental Science & Technology, 46(15), 8374-8381.

Majeed, M.T., Mazhar, M., (2020). Re-examination of environmental Kuznets curve for ecological footprint: The role of bio capacity, human capital, and trade. Pak. J. Commer. Soc. Sci. 14 (1), 202–254.

Mills, D. (2018). The environmental impact of the digital economy. Carbon Trust.

Moutinho, V., Madaleno, M., & Elheddad, M. (2020). Determinants of the Environmental Kuznets Curve considering economic activity sector diversification in the OPEC countries.

Ngepah, N., udeagha M.C. (2019). Revisiting trade and environment nexus in South Africa: fresh evidence from new measure. Environmental Science and Pollution Research (2019) 26:29283–29306. https://doi.org/10.1007/s11356-019-05944-y.

Leal, P.H and Marques, A.C. (2022). The evolution of the environmental Kuznets curve hypothesis assessment: A literature review under a critical analysis perspective. University of Beira interior, management and economics department, Portugal.

Matten, D., & Moon, J. (2008). “implicit” and “Explicit” CSR: A conceptual Framework for Understanding CSR in Europe. Academy of Management Review, 33(2), 404-424.

OECD. (2021). Green Growth and Sustainable Development. Organisation for Economic Co-operation and Development.

Pedroni, P. (2004). Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. Econometric Theory. https:// doi. org/ 10. 1017/ S0266 46660 42030 73

Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. Journal of the American Statistical Association, 94(446), 621–634. https:// doi. Org/ 10. 1080/01621 459. 1999. 10474 156.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16(3), 289–326. https:// doi. org/ 10. 1002/ Jae. 616.

Peters, G.P., Minx, J.C., Weber, C.L., & Edenhofer, O. (2011). Growth in emission transfers via international trade from 1990 to 2008. Proceedings of the National Academy of Sciences, 108 (21), 8903-8908.

Pope, C. (2017). The Clean Air Act: A proven tool for reducing air pollution. American Journal of Public Health, 107(S1), S57-S58.

Porter, M. E. & Van der Linde, C. (1995). Green and competitive: Ending the stalemate. Harvard Business Review, 73(5), 120-134.

Runge, C. Ford, François Ortalo-Magné and Philip Vande Kamp. Freer Trade, Protected Environment: Balancing Trade Liberalization and Environmental Interests. New York: Council on Foreign Relations Press, 1994.

Runge, C. Ford and Glenn Fox. "Feedlot Production of Cattle in North America: Environmental Implications of Expanded North American Trade under NAFTA." Montreal, Canada: Issue Study Prepared for the NAFTA Effects Advisory Group North American Commission for Environmental Cooperation (NACEC). 1998.

Sarkodie, S.A and Strezov, V. (2018). A review on environmental Kuznets Curve hypothesis using bibliometric and Meta-analysis. Department of environmental sciences, faculty of science and engineering: Macquarie University, NSW 2019, Australia.

Sarkodie, S.A., Strezov, V., 2018a. Assessment of contribution of Australia's energy production to CO2 emissions and environmental degradation using statistical dynamic approach. Sci. Total Environ. 639, 888–899. https://doi.org/10.1016/j.scitotenv.2018.05.204.

Sarkodie, S.A., Strezov, V., 2018b. Empirical study of the Environmental Kuznets curve and Environmental Sustainability curve hypothesis for Australia, China, Ghana and USA. J. Clean. Prod. 201, 98–110. https://doi.org/10.1016/j.jclepro.2018.08.039.

Schmidt, J. H., et al. (2017). Sustainability criteria for the process design of biorefineries from a techno-economic and environmental perspective. Biofuels, Bioproducts and Biorefining, 11(2), 218-238.

Stern, D. I., Common, M. S., & Barbier, E. B. (1996). Economic growth and environmental degradation: The environmental Kuznets curve and sustainable development. World Development, 24(7), 1151–1160. https:// doi. Org/ 10. 1016/ 0305- 750X (96) 00032-0.

Stern, D. I. (2004a). Economic Growth and Energy. In Encyclopaedia of Energy (pp. 35–51). Elsevier.https:// doi. org/ 10. 1016/ B0- 12- 176480- X/ 00147-9.

Stiglitz, J.E. (2002). Globalization and its Discontents. Norton.

Sugiawan, Y., & Managi, S. (2016). The environmental Kuznets curve in Indonesia: Exploring the potential of renewable energy. Energy Policy, 98, 187–198. https:// doi. Org/ 10. 1016/j. enpol. 2016. 08. 029.

Sun, C., Zhang, F., Xu, M., 2017. Investigation of pollution haven hypothesis for China: an ARDL approach with breakpoint unit root tests. J. Clean. Prod. 161, 153–164. https:// doi.org/10.1016/j.jclepro.2017.05.119.

Spilker, G., 2012a. Helpful organizations: membership in inter-governmental organizations and environmental quality in developing countries. Br. J. Polit.Sci. 42 (2), 345–370.

Spilker, G., 2012b. Globalization, Political Institutions and the Environment in Developing Countries. Routledge, New York and London.

The Economist. (2019). Bangladesh’s garment industry: A stitch in time. https://www.economist.com/asia/2019/04/27/bangladeshs-garment-industry-a-stitch-in-time.

UNCTAD. (2018). World Investment Report 2018: Investment and New Industrial Policies. https://unctad.org/system/files/official-document/wir2018_en.pdf.

UNCTAD. (2020). Technology and Innovation Report 2020: Breakthroughs in Frontier Technologies- Towards Sustainable Development. United Nations.

UNCTAD. (2021). Trade and Development Report 2021: From recovery to Transformation. United Nations Conference on Trade and Development.

UNEP. (2019). Global Resources Outlook 2019: Natural Resources for the Future We Want. United Nations Environment Programme.

United Nations. (1987). Report of the World commission on Environment and Development: Our Common Future. Oxford University Press.

United Nations (UN). (2015). Transforming our world: the 2030 Agenda for Sustainable Development. Retrieved from https:// sustainabledevelopment.un.org/post2015/transforming ourworld.

Westerlund, J. (2007). Testing for error correction in panel data. Oxford Bulletin of Economics and Statistics, 69(6), 709–748. https:// doi. org/ 10. 1111/j. 1468- 0084. 2007. 00477.x

World Bank. (2021). Globalization. https://www.worldbank.org/en/topic/globalization.

World Health Organization (WHO). (2015). Globalization, Food, and Health. Retrieved from https://www.who.int/trade/glossary/story076/en.

World Resources Institute. (2021). Climate Equity. Retrieved from https://www.wri.org/topics/climate-equity.

Yasmeen, R., Li, Y., Hafeez, M., Ahmad, H. (2018). The trade-environment nexus in the light of governance: a global potential. Environmental Science and Pollution research (2018) 25:34360-34379 https://doi.org/10.1007/s11356-018-3390-3.

Yuan, J., et al. (2021). Technological Innovation and environmental sustainability: A review based on bibliometric analysis. Renewable and Sustainable Energy Reviews, 139, 110695.