Financial Development and FDI Effects on Environmental Quality through Capital Adequacy

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Dear Sir,

I am delighted to submit my research thesis, "Financial Development and FDI Effects on Environmental Quality through Capital Adequacy," as a requirement for graduation from United International University. This thesis represents the culmination of extensive research and analysis conducted throughout the four months from June 1, 2023 to September 29, 2023. It addresses critical issues related to financial development, foreign direct investment (FDI), capital adequacy, and environmental quality.

Professor Dr. Md Qamruzzaman has provided me with invaluable guidance, assistance, and mentorship throughout the research process. Their knowledge and insights were crucial in defining the research methodology and assuring the accuracy of the analysis.

The study investigates the intricate connections between financial development, foreign direct investment, adequate capital, and environmental quality, emphasizing carbon dioxide (CO2) emissions. Advanced econometric techniques, such as panel data analysis, spatial econometrics, cointegration analysis, and causality tests, provide a comprehensive understanding of these relationships. This research contributes to the existing corpus of knowledge by addressing issues of cross-sectional dependence, spatial interactions, and causal links.

The findings of this thesis highlight the importance of proactive policy measures in fostering sustainable economic growth while protecting the environment. The policy recommendations detailed in Chapter Five provide governments and institutions with actionable advice for balancing economic development and environmental conservation.

I thank United International University for facilitating access to the resources and data required to complete this research. I would also like to thank the international organizations and databases that provided the secondary data used in this study.

I thank my family and friends for their unwavering support and patience throughout the research. Their encouragement has been an ongoing source of inspiration.

In closing, the research presented in this thesis provides valuable insights into the complex relationships between financial development, FDI, adequate capital, and environmental quality. The proposed findings and policy recommendations will contribute to informed decision-making in economics, finance, and environmental policy.

Thank you for contemplating the evaluation of my thesis. I eagerly anticipate discussing the research findings and insights in greater depth.

Sincerest regards

Sylvia Kor

Certification of similarity index

Declaration of the student

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Acknowledgement

I want to express my profound gratitude to God for giving me the grit, sagacity, and tenacity to complete this research. Your direction and blessings have been a constant source of motivation for me.

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I would also like to thank United International University for providing access to extensive resources, such as libraries, databases, and research materials, which were essential to the success of this study.

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Throughout this research voyage, my family and friends' unwavering support, forbearance, and understanding have been my pillars of fortitude. Your confidence in me inspired me to pursue this thesis assiduously.

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This thesis is a testament to the collaboration and support of numerous individuals and organizations. I am grateful for the opportunity to conduct this research and for the guidance, encouragement, and favors that have accompanied me on this journey.

Sincerely

Sylvia Kor

Abstract

This study examines the intricate connections between financial development, carbon dioxide (CO_2) emissions, foreign direct investment (FDI), international trade, household consumption, and capital formation, focusing on their implications for environmental sustainability and economic growth. Using a robust econometric methodology, such as panel cointegration tests, the Fully Modified OLS (FMOLS) technique, and Panel Vector Error Correction Models (VECM), this study reveals important insights. The findings demonstrate that financial development can facilitate the transition to a low-carbon economy and stimulate economic growth. Foreign direct investment can promote the adoption of healthier technologies, but regulatory hazards may arise, whereas international trade can stimulate economic growth but increase emissions. Capital formation is essential to reducing CO_2 emissions, and household consumption patterns significantly impact emissions. The study provides policy recommendations emphasizing green investments, emission regulations, technology transfer, consumer education, and innovation to foster sustainable economic development while mitigating environmental impact.

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List of Abbreviation

CO_2: Carbon Dioxide

FDI: Foreign Direct Investment

GDP: Gross Domestic Product

GWR: Geographically Weighted Regression

HHC: Household Consumption

SEM: Spatial Error Model

SLM: Spatial Lag Model

SDM: Spatial Durbin Model

TR: International Trade

VECM: Vector Error Correction Model

CHAPTER I: INTRODUCTION

I.1 Background of the study

Environmental quality is a global concern of the utmost importance, as it directly affects the well-being of both present and future generations. The degradation of the environment has far-reaching effects, such as climate change, biodiversity loss, and adverse health effects. Therefore, understanding the factors that affect environmental quality is of the utmost importance Ahmad et al. (2022). The relationship between financial development, foreign direct investment (FDI), and environmental quality is an area of research that has received much attention. Financial development refers to the expansion and sophistication of an economy's financial institutions and markets. It is essential to economic growth and development Saud et al. (2019). Conversely, FDI refers to the capital investment by foreign entities in domestic businesses or initiatives. Financial development and FDI can potentially affect environmental integrity Abdouli and Hammami (2017a) , although the nature of these effects is still debatable. Multiple studies have investigated the relationship between financial development, foreign direct investment (FDI), and environmental quality in various contexts. In China, for instance, researchers have examined the effect of two-way FDI on the country's environmental quality M. Li et al. (2023). It was discovered that the influx of foreign capital had contradictory effects, with some studies indicating a detrimental influence on local environmental quality quality M. Li et al. (2023). Similarly, research conducted in Arab countries has examined the effects of financial development, FDI, and effective governance on environmental degradation Ju et al. (2023). The results indicated that FDI hurt establishing environmental quality Ju et al. (2023). Additionally, research has examined the effect of economic growth on environmental quality. A study in Chinese urban areas discovered a correlation between enhanced water quality and decreased Sulphur dioxide (SO2) emissions and developed finance N. Wang et al. (2023). This suggests that financial growth can positively affect environmental quality in specific contexts N. Wang et al. (2023). The relationship between financial development, FDI, and environmental quality is intricate and multifaceted. Various variables, including technological innovation, governance, and GDP per capita, can also impact this relationship Ju et al. (2023) and Q. Wang et al. (2023). Additional research is required to obtain a comprehensive understanding of the mechanisms by which financial development and FDI affect environmental quality. This study aims to contribute to the existing literature by investigating the impact of financial development and FDI on environmental quality through the lens of capital sufficiency. The relationship between these variables will be examined in the context of **MY COUNTRY SAMPLE**. Thus, we expect to show how financial development and FDI can positively or negatively impact environmental quality. This research is essential for policymakers and other stakeholders to make informed decisions and devise strategies that promote sustainable development and environmental protection.

Diverse factors have both positive and negative impacts on environmental quality. These factors include governance, financial development, social capital, income inequality, pollution control, and the utilization of renewable energy. Good governance plays a crucial role in protecting the environment. Effective environmental policies, regulations, and enforcement mechanisms are essential for protecting the environment. The effectiveness of government and deregulation of environmental policies have been found to affect environmental quality positively Naoaj (2023). Financial development may have both positive and negative influences on environmental quality. Access to financial services and benefits can contribute to ecological preservation and sustainable development. Environmental degradation can result from financial activities prioritizing short-term profits over long-term sustainability. Accessibility to financial services has been identified as influencing the sustainability of foreign direct investment (FDI) in Belt and Road nations JinRu et al. (2022). Social capital is the networks, relationships, and entrust within a community. Collective action and cooperation can affect environmental quality. Socially capital-rich communities are more likely to engage in environmental conservation efforts and sustainable practices. Social capital has been shown to influence health outcomes and environmental quality in US counties Gharaibeh (2023). Income inequality can have significant effects on the condition of the environment. Studies have revealed that low-income neighborhoods tend to have higher environmental hazards and pollution levels. Environmental inequality, in which marginalized communities endure a disproportionate burden of environmental degradation, is a crucial issue that must be addressed if environmental justice is to be achieved JinRu et al. (2022). Pollution control measures are essential for preserving environmental quality. Regulations and technologies that reduce emissions from industries, power plants, and vehicles can substantially improve air and water quality. For instance, the Clean Air Act in the United States has led to reductions in conventional air pollution and greenhouse gas emissions, thereby protecting the environment and enhancing people's health Goldemberg et al. (2018). Transitioning to renewable energy sources has the potential to have positive effects on environmental quality. Wind, solar, geothermal, hydroelectric, and biomass energy technologies produce pure energy and reduce emissions of greenhouse gases. Renewable energy can aid in mitigating climate change, enhancing air quality, and decreasing reliance on fossil fuels Shoeib et al. (2022). These factors provide a comprehensive overview of the variables that can impact environmental quality. These factors provide a comprehensive overview of the variables that can impact environmental quality. To develop effective strategies for environmental conservation and sustainable development, it is essential to consider the interactions and interdependencies among these determinants.

Financial development, FDI, and adequate capital are significant determinants of environmental quality. These variables can have both positive and negative environmental effects. Financial development can support sustainable development and environmental conservation by providing access to financial services and benefits. However, financial activities prioritizing short-term profits over long-term sustainability can contribute to environmental devastation Ahmad et al. (2020). Additionally, FDI can have a substantial effect on environmental quality. While FDI can stimulate economic growth and development, improper management can contribute to environmental degradation Yiadom et al. (2022). Capital adequacy is also crucial for environmental quality. Finance ecological conservation efforts and support sustainable development with adequate capital Ruza and Caro-Carretero (2022).

The relationship between financial development and environmental quality can be substantial. Access to financial services and benefits can contribute to environmental preservation and sustainable development. Financial institutions can fund environmental protection initiatives like renewable energy and pollution management. Nevertheless, financial activities that prioritize short-term profits over long-term sustainability can result in environmental degradation. Therefore, it is crucial to align financial development with sustainable development objectives Ahmad et al. (2020).

Foreign direct investment can have both positive and negative environmental effects. FDI can stimulate economic growth and development, but improper management can lead to environmental degradation. Foreign direct investment can introduce new technologies and practices that enhance environmental quality. FDI can also cause environmental degradation if it is not correctly regulated. Therefore, it is essential to align FDI with environmental conservation objectives Yiadom et al. (2022).

A sufficient amount of capital is essential for environmental quality. Sufficient capital can assist in financing environmental conservation efforts and bolster sustainable development. Financial institutions can fund environmental protection initiatives like renewable energy and pollution management. Consequently, it is crucial to guarantee that sufficient funds are available for environmental conservation efforts Ruza and Caro-Carretero (2022).

I.2 Statement of the Problem

This study aims to comprehensively analyze the complex connections between financial development (FD), foreign direct investment (FDI), international trade, household consumption, capital formation, and carbon dioxide (CO_2) emissions in addressing global climate change challenges. The researchers recognize the importance of understanding these relationships to inform policy formulation, investment decisions, and individual behavior in achieving sustainable development goals and mitigating the adverse effects of climate change.

FD, characterized by efficient financial markets and institutions, can significantly impact the causes and consequences of CO_2 emissions. It can allocate resources to green technologies, promoting economic growth that reduces emissions. However, financial institutions also face risks associated with CO_2 emissions, necessitating a comprehensive exploration to guide policymakers and financial stakeholders in managing these risks effectively.

The relationship between FDI and CO_2 emissions is complex, as FDI can facilitate the transfer of environmentally friendly technologies and influence host countries' environmental standards.

However, foreign investors may encounter regulatory risks, requiring a nuanced examination of the potential trade-offs and opportunities associated with FDI.

International trade plays a dual role in stimulating economic growth while potentially increasing emissions due to higher industrial activity and emissions embodied in traded goods. It is crucial to analyze these dynamics, considering efficiency gains from trade and the potential for technology transfer.

Household consumption patterns directly impact carbon footprints, making it essential to investigate how consumer preferences and external factors influence consumption. Understanding these factors is pivotal for designing effective strategies to reduce emissions at the grassroots level.

Capital formation is critical to directing investments towards sustainable technologies and infrastructure. The study acknowledges the potential of capital formation in driving emissions reductions while recognizing the influence of climate policies on investment decisions.

By systematically examining these relationships, the research aims to provide evidence-based insights for policymakers, businesses, and individuals on leveraging financial systems, investments, trade, consumption, and capital formation to accelerate the transition to a low-carbon economy. Ultimately, the study aims to contribute to the broader discourse on climate change mitigation and sustainable development, guiding actions that align economic growth with environmental stewardship.

I.3 Objectives of the Study

This research study investigates the complex relationship between financial development, foreign direct investment (FDI), international trade, household consumption, capital formation, and carbon dioxide (CO2) emissions. The specific objectives of the study are as follows:

1. Understand the Impact of Financial Development: The study assesses how financial development, characterized by efficient financial markets and institutions, influences CO2 emissions. It seeks to explore how financial systems allocate resources to green and sustainable technologies, potentially reducing emissions while recognizing the risks financial institutions pose due to CO2 emissions.

2. Examine the Relationship Between FDI and CO2 Emissions: The study aims to investigate the multifaceted relationship between FDI and CO2 emissions. This includes analyzing how FDI can facilitate technology transfer, influence host countries' environmental standards, and impact emissions. It aims to identify opportunities and challenges associated with FDI in the context of emissions reduction.

3. Analyze the Role of International Trade: The study aims to dissect the impact of international trade on CO2 emissions. It involves examining how trade stimulates economic growth, potentially leading to higher emissions and the phenomenon of emissions embodied in traded goods. The study seeks to understand how trade can be harnessed to promote cleaner technologies and sustainable practices.

4. Investigate Household Consumption Patterns: The study explores the influence of household consumption choices on CO_2 emissions. It seeks to understand how individual decisions regarding energy use, transportation, and product consumption impact emissions. Additionally, the study will assess how external factors such as energy costs and climate impacts affect household consumption behavior.

5. Assess the Role of Capital Formation: The study aims to evaluate the significance of capital formation in directing investments towards low-carbon technologies and infrastructure. It includes analyzing how capital formation can contribute to emissions reduction and sustainable development. Furthermore, the study will examine how climate policies, such as carbon pricing mechanisms, affect investment decisions and capital allocation.

6. Provide Evidence-Based Insights: The study aims to generate evidence-based insights to inform policymakers, businesses, and individuals on strategies and policies to accelerate the transition to a low-carbon economy. By understanding the complex relationships between these factors, the study aims to contribute to developing effective mitigation strategies and sustainable development pathways.

7. Contribute to Climate Change Mitigation: The ultimate goal is to contribute to global efforts to mitigate climate change by analyzing how financial systems, investments, trade, consumption, and capital formation can be leveraged to reduce CO_2 emissions and promote sustainable practices.

By accomplishing these aims, our study aims to provide valuable insights into the nexus of finance, investments, trade, consumption, and emissions, thereby guiding actions and policies that facilitate economic growth while addressing the pressing need to combat climate change.

I.4 Summary of the Study

This comprehensive research paper explores the intricate relationships between financial development, Foreign Direct Investment (FDI), international trade, household consumption, capital formation, and carbon dioxide (CO_2) emissions. The study aims to provide a holistic understanding of how these factors intersect and impact global efforts to mitigate climate change.

The research reveals that financial development, characterized by efficient markets and institutions, plays a dual role in influencing CO_2 emissions. On the one hand, it can allocate resources to green technologies, aiding emissions reduction. On the other hand, it faces risks due to environmental concerns.

Foreign Direct Investment emerges as a powerful tool for emissions reduction through technology transfer and sustainable projects. It also highlights how host countries' environmental standards can attract foreign investors, thus advancing sustainable practices.

International trade fosters economic growth but can also escalate emissions. The concept of emissions embodied in trade is uncovered, emphasizing the need for sustainable trade practices to mitigate this effect.

Individual consumption choices have a significant impact on emissions reduction. Energy-efficient practices, eco-friendly transportation, and waste management can lead to substantial carbon footprint reductions. Rising energy costs and climate impacts shape consumption patterns.

Capital formation is crucial in the transition to a low-carbon economy. Investments in green technologies and infrastructure play a pivotal role in curbing emissions. However, regulatory changes, including carbon pricing mechanisms, impact investment decisions.

The study provides implications for policymakers, businesses, and individuals. It emphasizes the importance of aligning financial systems with sustainability goals, leveraging FDI for emission reduction, promoting sustainable trade practices, and fostering energy-efficient consumption. Additionally, it highlights the critical role of capital formation in driving the low-carbon transition.

A Call for Action: To conclude, the research calls for decisive action. Stakeholders can chart a sustainable course forward by understanding the complex relationships between finance, investments, trade, consumption, and capital formation. The study equips them with evidence-based insights to navigate the intersection of economics.

I.6 Limitation of the existing study

The existing literature on the relationship between financial development, Foreign Direct Investment (FDI), international trade, household consumption, capital formation, and carbon dioxide (CO_2) emissions provides valuable insights but also exhibits certain limitations. These limitations include:

1. Data Availability and Quality: Many studies rely on data from various sources, which may only sometimes be consistent or accurate. Data gaps, especially in developing countries, can hinder the robustness of empirical analyses.

2. Causality vs. Correlation: Some literature emphasizes correlations between financial development, FDI, trade, consumption, capital formation, and CO_2 emissions, but establishing causality remains a challenge. Causation is often inferred rather than definitively proven.

3. Heterogeneity Across Regions: The studies often aggregate findings, overlooking regional variations. Due to differing economic structures, policies, and environmental challenges, what works in one region may only apply to some.

4. Time Lags and Dynamics: The temporal aspects of the relationships are complex. Financial development, FDI, trade, consumption, and capital formation changes may take years to impact emissions. Short-term analyses may overlook long-term dynamics.

5. Policy Endogeneity: Many studies need to sufficiently address the endogeneity of environmental policies, which can influence emissions and economic factors like financial development and FDI. Ignoring this endogeneity can lead to biased results.

6. Neglecting Non-CO2 Greenhouse Gases: Some literature primarily focuses on CO2 emissions, neglecting other greenhouse gases like methane and nitrous oxide. A comprehensive analysis should consider the broader spectrum of emissions contributing to climate change.

7. Limited Behavioral Insights: While studies often quantify the impacts of various factors, they may need more insight into the underlying behavioral aspects, such as consumer preferences, corporate strategies, or investor decision-making processes.

8. Assumption of Rationality: Many economic models underlying this literature assume rational behavior by individuals, firms, and governments. In reality, decision-makers may only sometimes act rationally, especially concerning long-term environmental concerns.

9. Limited Policy Prescriptions: The literature sometimes fails to offer practical policy recommendations that can guide governments, businesses, and individuals to address emissions while promoting economic growth.

10. The dynamic nature of climate policies, such as carbon pricing mechanisms, is an important aspect that needs to be considered in research. It is crucial to recognize that these policies are continuously evolving, and studies should consider the changing regulatory landscape and its impact on emissions and economic factors.

11. Sociocultural factors significantly influence consumption choices and investment decisions, but they are often overlooked in research. Understanding the role of these factors in shaping sustainability practices is essential for developing effective policies and strategies.

12. The data period used in studies is another limitation that needs to be addressed. As the global landscape rapidly changes, it is necessary to constantly update and reevaluate findings to ensure their relevance and accuracy

Addressing these issues could enhance the quality of this field's research and assist policymakers and stakeholders in navigating the difficult relationship between economic growth and environmental sustainability.

I.7 Definition of key terms

Financial development: FD refers to the advancement and effectiveness of a country's financial system, including its institutions, markets, and instruments. It plays a crucial role in facilitating the efficient allocation of financial resources within an economy Shahid, Saeed [1].

Carbon dioxide emissions: Often called CO2 emissions, are the release of carbon dioxide gas into the atmosphere, primarily caused by human activities such as burning fossil fuels Das and Sharma [2] deforestation, and industrial processes. CO2 is a significant greenhouse gas that contributes to climate change Yoro and Daramola [3] & Shakoor, Ashraf [4].

Foreign Direct Investment: FDI is the investment made by a company or individual in one country into business interests located in another country Zeng and Li [5]. FDI typically involves significant control and influence by the investing entity over the foreign business Hintošová [6].

International trade: It involves the exchange of goods and services between countries through importation and exportation Hulme [7]. It plays a crucial role in shaping a nation's economy Witt, Lewin [8].

Household consumption: It represents the total expenditure by households on goods and services for personal use, including items like food, housing, transportation, and entertainment Salo, Savolainen [9].

Capital formation: Also called investment in capital goods, refers to accumulating physical Le Clech, Guevara-Pérez [10], human Xia, Qamruzzaman [11], and natural capital Topcu, Altinoz [12]. It involves allocating resources toward investments in infrastructure, machinery, technology, education, and skills development to enhance economic productivity Rehman and Islam [13].

Green and sustainable technologies: It encompass innovations and practices that minimize adverse environmental impacts Huang, Chau [14]. They include renewable energy sources, energy-efficient manufacturing processes, eco-friendly transportation solutions, and sustainable agricultural practices Raihan [15].

Energy efficiency: It refers to achieving a specific level of output or service with less energy input. It involves using less energy to perform tasks or produce goods and services, reducing energy waste and associated emissions Santarius, Bieser [16].

Carbon pricing mechanisms: These are policies designed to internalize the external costs of carbon emissions. They can take the form of carbon taxes, cap-and-trade systems, or other market-based approaches that assign a price to carbon emissions, encouraging emissions reduction Addicott, Badahdah [17].

Stranded assets: These are investments that become financially or economically unviable due to changing regulations, market shifts, or technological advancements Caldecott, Clark [18]. In the context of this study, it refers to investments in carbon-intensive industries that lose value as emissions regulations become stricter Bos and Gupta [19].

CHAPTER II: REVIEW OF THE LITERATURE

2.1 Introduction

The second chapter of this research thesis provides a comprehensive review of the current literature on the main topics of interest in this study: financial development, foreign direct investment (FDI), capital adequacy, and their connection to environmental quality, specifically carbon dioxide (CO_2) emissions. The purpose of this literature review is to offer a thorough comprehension of the theoretical foundations, empirical discoveries, and significant insights within these areas. It prepares the groundwork for creating the conceptual framework and hypotheses that will be used to guide the empirical investigation in the following chapters.

Financial development, foreign direct investment (FDI), and capital adequacy are essential for economic growth and stability. These factors also impact environmental quality, although their effects are different. The review discusses financial development and how it is seen from different perspectives and measured differently in research. The following sections delve into the connection between financial development and environmental quality, focusing on how financial systems impact emissions.

The environmental implications of foreign direct investment, which plays a crucial role in driving globalization, are being analyzed. The literature discusses the various impacts of foreign direct investment (FDI) on environmental quality. It emphasizes the importance of considering factors such as host country characteristics and environmental regulations as they mediate these relationships.

Capital adequacy, a crucial aspect of maintaining financial stability, is examined for its effects on economic growth and environmental quality. Research on the connection between capital adequacy and environmental sustainability sheds light on how financial institutions can promote green investments.

The review ends by discussing the current literature's gaps, limitations, and main findings, highlighting the importance of conducting empirical research to gain a deeper understanding of these intricate interactions. This thorough review will be used as a basis for forming hypotheses and directing the empirical investigation in the following chapters.

2.2 Literature survey

2.2.1 Financial development effects on EQ

There is a manifold study which exhibit the positive association between financial development and environmental quality. Cao et al. (2022) evaluates South Asian financial development, sustainable environmental-economic growth, and energy use. The study uses ARDL and panel data from 1980 to 2018 to show financial development boosts economic growth. Energy usage stimulates sustainable environmental-economic growth and environmental goals. Multiple panel data models show that energy consumption promotes sustainable economic growth. Also, Awosusi et al. (2022) reviews Uruguay's 1980–2018 time series dataset to explore how trade globalization, natural resource rents, economic growth, and financial development affect carbon emissions. Bounds testing, Autoregressive Distributed Lag estimator, and spectral causality tests show a long-term relationship between carbon emissions and these factors. Trade liberalization raises short- and long-term CO_2 emissions, economic growth strains the environment, and abundant natural resources degrade it. Financial progress doesn't affect environmental degradation. Reevaluating trade rules and restricting polluting commodity exports are recommended. Usman et al. (2021) investigates financial development, tourism, energy use, urbanization, and carbon emissions in 52 nations from 1995 to 2017. The PMG-ARDL model reveals that financial development improves environmental quality in industrialized countries but not underdeveloped ones. Higher tourism arrivals in affluent nations worsen tourism's adverse effects. Renewable energy improves environmental quality in both regions, whereas urbanization and primary energy use raise emissions. Panel causality studies show financial development, primary energy, and emissions are bidirectional. Urbanization causes emissions in wealthy countries, and tourism generates emissions and renewable energy in developing countries. The findings recommend improving the banking system and investing in green energy initiatives to enhance the environment. This paper by Baloch et al. (2021) employs the Pooled Mean Group Autoregressive Distributed Lag (PMG/ARDL) estimator to examine the relationship between financial development, economic growth, energy innovation, and environmental degradation (1990-2017) in OECD countries. The results indicate that financial development stimulates energy innovation and improves environmental quality. Globalization is associated with a reduction in greenhouse gas emissions. The environmental Kuznets curve is relevant in this context. In this study, Aluko and Obalade (2020) examined the relationship between financial development and environmental quality in sub-Saharan Africa (SSA). This study examines the technological impact of financial development on environmental quality and their causal relationship. A unique financial development composite index is used. The study uses 1985–2014 panel data from 35 SSA nations. Using the enhanced mean group estimator, we made numerous vital discoveries. First, financial development improves the environment and reduces CO2 emissions. Financial development has a negative technological impact on environmental quality. Finally, population, affluence, and technology increase environmental degradation. Our Dumitrescu-Hurlin panel causality test shows that financial progress causes CO2 emissions in both directions. These findings have policy implications from our study. Zafar et al. (2019) applies the Environmental Kuznets Curve concept to analyze how globalization and financial development affect environmental quality in selected OECD nations (1990–2014). Cross-sectional dependence and panel cointegration tests confirm cointegration. Long-term output elasticities are calculated using CUP-FM and CUP-BC. Evidence shows energy consumption contributes to CO2 emissions. The EKC hypothesis shows that globalization and financial development reduce CO2 emissions and improve the environment. Causal relationships show bidirectional effects between energy consumption and CO2 emissions, feedback effects between economic growth and emissions, and unidirectional influences from CO2 emissions to financial development, economic growth to energy consumption, energy consumption to financial development, globalization to energy consumption, and globalization to financial development. Technology transfer, renewable energy investment, and green infrastructure are policy proposals. In the same year, a study by Saud et al. (2019) assesses how financial development, foreign direct investment, economic growth, power consumption, and trade openness affect environmental quality in 59 Belt and Road Initiative (BRI) nations from 1980 to 2016. The study finds that the variables are stationary at first differences and cointegrated using CADF and Im, Pesaran, and Shin panel unit root tests, Westerlund cointegration test, DSUR approach, and Dumitrescu-Hurlin panel causality approach. Results show that financial development, foreign direct investment, and trade openness improve environmental quality, whereas economic expansion and electricity use degrade it. The study also demonstrates the environmental Kuznets curve (EKC) theory and bidirectional causality between economic growth, foreign direct investment, financial development, electricity consumption, trade openness, and environmental quality. Moghadam and Dehbashi (2018) examines Iran's environmental quality and economic growth through financial development and commerce. The 1970–2011 research uses an ARDL model to determine short- and long-term variable interactions. Financial development worsens the degradation of the environment. However, trade openness promotes it. As opposed to the EKC hypothesis, stability and imbalances are examined. Boutabba (2014) also explores India's carbon emissions, financial development, economic growth, energy consumption, and trade openness to discern long-term equilibrium and causal relationships using data from 1972 to 2008. It makes a distinctive contribution by investigating carbon emission determinants and emphasizing the role of financial development using country-specific data. The findings highlight the long-term and causal relationships between carbon emissions, economic development, income, energy consumption, and trade openness. Financial development positively affects carbon emissions, indicating an improvement in environmental degradation. The Granger causality analysis highlights the unidirectional relationship between financial development, carbon emissions, and energy consumption. The results advocate for environmentally conscious financial practices and informed energy policies in India's growth trajectory. An older study by Jalil and Feridun (2011) uses ARDL bounds testing to examine how financial development, economic expansion, and energy consumption affected environmental pollution in China from 1953 to 2006. The primary goal is to find the long-term equilibrium between financial development and environmental pollution. Financial development surprisingly has a negative coefficient, indicating it reduces pollution. The study found that wealth, energy consumption, and trade openness drive long-term carbon emissions. The analysis confirms China's Environmental Kuznets Curve.

In contrary to the above studies there also multiple studies which indicate the negative linkage between financial development and environmental quality. Jianguo et al. (2022) explores how institution quality, technological innovation, and financial development affect environmental quality in 37 OECD nations from 1998 to 2018. Cross-sectional dependence is measured using Lagrange multipliers. Panel unit root and cointegration tests evaluate unit-root properties and long-run linkages. The two-step SYS-GMM approach estimates coefficients. Results demonstrate financial development increases CO2 emissions. Institutional quality and technical innovation moderate financial development and CO2 emissions. These findings can help OECD officials create sustainable environmental policies. Also, Adebayo et al. (2021) focuses on how urbanization, economic expansion, energy consumption, and financial development affected Latin American CO2 emissions from 1980 to 2017. The research finds connections using panel econometric methods such as CIDF, panel unit tests, Westerlund panel cointegration, FMOLS, DOLS, and Dumitrescu Hurlin panel causality test. FMOLS and DOLS show that economic expansion, energy consumption, and urbanization reduce CO2 emissions. Financial development may not help the environment. According to causality tests, energy consumption and economic growth predict Latin American CO2 emissions. These findings emphasize the need for coordinated policy solutions to address the region's significant environmental degradation. In a similar way, Fang et al. (2020) classifies financial scale and securities size to account for the complex relationship between financial development and carbon emissions in China. Financial scale, securities size, urbanization, economic growth, trade openness, and China's carbon emission intensity are examined using a complete Autoregressive Distributed Lag-Error Correction Model (ARDL-ECM) from 1990 to 2016. Financial scale, economic expansion, and carbon emission intensity positively correlate short- and long term. Thus, while the current financial scale boosts economic growth, it also increases carbon emissions. However, securities size has little effect on carbon emission intensity, emphasizing the need to improve China's securities market systems for carbon regulation. Robustness tests enable policymakers to seek financial and low-carbon economic growth with these findings. This study by Ahmad et al. (2020) assesses how financial development (FD) and foreign direct investment (FDI) affect environmental quality in 90 Belt and Road nations from 1990 to 2017. The research uses the Driscoll-Kraay pooled ordinary least square approach to calculate FD using market access, depth, efficiency, and FDI. FDI enhances environmental quality, while FD increases CO2 emissions. The Environmental Kuznets Curve (EKC) hypothesis is supported by the inverted U-shape of economic growth (EG) and CO2 emissions. Energy consumption and urbanization degrade the environment, but trade openness improves it. The Dumitrescu-Hurlin panel causality test shows FD, trade openness, energy consumption, urbanization, and CO2 emissions are bidirectional. These findings inform policymakers and emphasize environmental protection. Ibrahiem (2020) covers Egypt's 1971–2014 carbon dioxide emissions, technological innovation, alternative energy resources, economic growth, and financial development. ARDL, FMOLS, DOLS, and Toda-Yamamoto techniques confirm variable cointegration. Technological innovation and alternative energy resources improve the environment, while financial development and economic growth harm the environment. According to Toda-Yamamoto, environmental degradation and economic expansion are mutually causative. Financial development affects environmental deterioration and economic growth, whereas technology innovation affects both. The report recommends renewable energy innovation policies to improve the environment. Shahbaz et al. (2016) evaluates Pakistan's 1985Q1–2014Q4 asymmetric financial development-environmental quality relationship. A comprehensive financial development index includes bank and stock market variables. The findings emphasize the environmental harm of energy inefficiency and encourage using energy-efficient technologies in production and consumption. This change could improve the environment, boost productivity, and save energy. Notably, bank-based financial development harms the environment. The report suggests that authorities encourage lenders to fund energy sector projects and eco-friendly businesses to improve the environment while reducing consumer lending. This study by Javid and Sharif (2016) also examined how financial development, per capita real income, squared real income, energy consumption, and openness affected Pakistani CO2 emissions (1972–2013). The bound F-test for cointegration showed a long-term link between these variables. In both short and long terms, results support an environmental Kuznets curve. This shows that early development CO2 levels rise with income until a threshold, beyond which infrastructure efficiency and energy-efficient technology begin to decrease association. The study also finds a positive coefficient for financial development, indicating it degrades the environment. Carbon emissions in Pakistan are driven by income, energy consumption, and financial development. Interestingly, openness has little effect on short-term or long-term carbon emissions This 1980–2010 study by Li et al. (2015) explores how institution quality, technological innovation, and financial development affect environmental quality in 102 OECD nations. Measure cross-sectional dependence with Lagrange multipliers. Panel and cointegration tests evaluate unit-root attributes and long-run linkages. Two-step SYS-GMM estimates coefficients that financial development increases CO_2 emissions. Innovation and institutional quality moderate the association between financial development and CO_2 emissions. These findings help OECD officials create sustainable environmental policies. This analysis by Moghadam and Lotfalipour (2014) discusses the disputed relationship between economic expansion and environmental degradation. The report examines Iran's financial progress and environmental quality from 1970 to 2011. The Auto Regression Model Distributed Lag (ARDL) explores short- and long-term variable relationships. Financial development increases environmental degradation, but trade openness reduces it. The error correction coefficient justified imbalances within each era by 53%, matching long-term trends. Structural stability tests verify coefficient stability over time.

There is a study which shows both positive and negative effect. This study by Acheampong (2019) employs the system-generalized moments approach to examine how financial development affects carbon emissions in 46 sub-Saharan African countries (2000–2015). Financial development indicators like comprehensive money and domestic credit are examined. Findings disclose that specific financial development methods increase carbon emissions while others do not. FDI slows economic growth to reduce emissions but not energy consumption. Moderation patterns vary, affecting sustainable development policies. The findings transcend knowledge borders and impact sustainable progress policymakers.

Also, few studies claim to have neutral or insignificant impact of financial development on environmental quality. Mesagan and Nwachukwu (2018) examines Nigerian environmental quality variables and financial development. ARDL bounds testing analyses 1981–2016 time series data on urbanization, per capita income, environmental degradation, energy consumption, trade intensity, and capital investment. The primary component analysis creates an environmental degradation index. Results show that income, financial development, energy use, and commerce explain environmental quality. Investment and urbanization are unimportant. Causality research shows no link between financial development, capital investment, and environmental quality. Urbanization and income cause degradation unidirectionally, while energy consumption causes degradation bidirectionally. Thorough investment proposal screening helps allocate finance to low-carbon enterprises. This study by Omri et al. (2015) uses simultaneous-equation panel data models to examine financial development, CO2 emissions, trade, and economic growth in 12 MENA nations from 1990 to 2011. Results show bidirectional causality between CO2 emissions and economic growth, and trade openness influences both. Feedback and neutrality assumptions are validated between trade openness, financial development, and carbon dioxide emissions and financial development. Financial development causes economic growth, and trade openness causes carbon dioxide emissions. Empirical results support an environmental Kuznets curve. These insights guide policymakers to sustainable economic growth and environmental improvement. Alam et al. (2015) examines Malaysia's financial progress and carbon emissions. From 1975–2013, environmental quality indicators, financial variables, and GMM estimations show that carbon emissions and financial indicators have initially been associated but become insignificant under GMM estimates. This indicates that Malaysian financial progress does not affect carbon emissions.

A paper also finds inverted U-shaped hypothesis. Charfeddine and Khediri (2016) uses cutting-edge unit root testing, numerous structural breaks, and regime-switching cointegration considering one and two unknown regime shifts, building on Shahbaz et al. (2014). This study examines the complex relationship between UAE carbon dioxide emissions, electricity consumption, economic growth, financial development, trade openness, and urbanization from 1975 to 2011. An Environmental Kuznets Curve (EKC) shows an inverted U-shaped link between financial progress and CO2 emissions.

Electricity usage, urbanization, and trade openness improve the environment. These empirical findings inform sustainable growth strategy discussions.

Finally, there is a study which has mixed findings. This study by Xu et al. (2021) applies a panel smooth transition regression model to evaluate how financial development affected Chinese provinces' environmental quality from 2001 to 2017. The study categorizes provinces by financial development to identify indirect environmental consequences through several channels. Financial development affects pollution pathways differently in regions with various financial development levels. Economic expansion and secondary/tertiary sector development might indirectly cause pollution in locations with low financial development. On the contrary, regions with more substantial financial development improve quality through technological innovation and foreign investment and decrease quality through secondary/tertiary industry assistance. Policymakers should consider regional financial development while crafting environmental policies.

2.2.2 FDI and EQ

The conjunction of FDI and environmental quality is sometimes favorable. This study by Pujiati et al. (2023) explores the relationships between corruption (COR), energy consumption (ENY), foreign direct investment (FDI), and CO2 emissions in Indonesia over 36 years (1984-2020) using the autoregressive distributed lag (ARDL) method. Corruption and energy use can worsen environmental degradation over time, although FDI may mitigate it. Economic expansion and urbanization have diverse environmental effects. Indonesia, a fast-growing nation seeking sustainability, needs these data to shape its policies. JinRu et al. (2022) discusses how excellent governance, financial inclusion, and environmental quality affected FDI inflows in BRI nations from 1990 to 2020. Panel econometric approaches show a positive and statistically significant association between these parameters and FDI inflows. Effective governance, accessible financial services, and environmental concerns drive FDI, according to the research. The study also finds short-term bidirectional causality between these characteristics and FDI inflows. The study emphasizes these characteristics' importance in luring FDI to BRI nations. A study by Qamruzzaman (2021) also examined relationship between environmental quality

(EQ), industrial quality (IQ), and trade openness (TO) using FDI as a mediator. ARDL, CS-ARDL, and nonlinear ARDL were employed for 1982–2019 data for global sample. Using non-Granger causality tests, we also tested directional causality with symmetry and asymmetry for EQ, IQ, and FDI in the equations. ARDL and CS-ARDL showed long-term favorable connections between EQ, IQ, and FDI and trade openness. Asymmetric estimates showed that EQ, IQ, and FDI shocks increased trade openness, especially over time. Wald test showed an imbalance in long and short runs. Asymmetry tests demonstrated unidirectional causality from positive FDI shocks to trade openness, while symmetry tests suggested a feedback hypothesis for EQ and IQ's causal effects. Shabir et al. (2022) addresses how economic policy uncertainty and foreign direct investment affected CO2 emissions in 24 industrialized and developing nations from 2001 to 2019. Economic policy uncertainty, growth, trade, and energy consumption harm the environment, but foreign direct investment enhances the environmental quality. CO2 emissions, economic policy uncertainty, growth, trade, and energy consumption are interconnected. These findings suggest that policymakers should develop environmentally friendly trade policies, research renewable energy options, and apply green investment and financing initiatives to improve environmental conditions. Duodu et al. (2021) considers sustainable policies and institutions to assess FDI and environmental quality in 23 sub-Saharan African (SSA) nations. FDI improves environmental quality over time, according to system-GMM analysis of 2005–2019 data. Environmental sustainability policies and domestic investment enhance environmental quality in the short and long term. The study concludes that policies and institutions improve environmental quality in SSA and promote environmental sustainability. The data also show that such policies and FDI work together to improve the region's environment and that local investment is crucial. These findings suggest improving SSA environmental policies. Zafar et al. (2020) probes how foreign direct investment and education affect Asian environmental quality from 1990 to 2018, including income, energy consumption, and urbanization. The study establishes long-run variable associations using panel cointegration. Research shows that foreign direct investment, education, and urbanization affect environmental quality. Income and energy use emit CO2. Long-term causation exists for emissions-foreign direct investment, emissions-energy consumption, income-emissions, foreign direct investment-income, and energy-income correlations. Education and urbanization also cause pollution, foreign direct investment, income, and energy use. The findings include increasing education investment, green energy usage, FDI with eco-friendly technologies, and regulating urbanization's environmental impact. This study by Hao, Wu, et al. (2020) explores how technological innovation affects China's environmental pollution from FDI. Spatial econometric methods and data from 30 provinces from 1998 to 2016 show that higher FDI reduces environmental pollution, the "pollution halo hypothesis." Technological advancement reduces sulfur dioxide and smoke dust but increases chemical oxygen requirement. Foreign investment is suitable for sustainable growth, but authorities should prioritize environmentally benign, high-tech enterprises over high-pollution ones. Also, Ansari et al. (2019) analyses the relationship between foreign direct investment, energy consumption, economic growth, trade openness, and environmental degradation in 29 countries from 1994 to 2014. The study examines Asian sub-panels to validate the PHH. Unit root and cointegration tests showed stationary and cointegrated variables. FMOLS long-term findings show the PHH only in East Asia. Southeast Asia rejects the PHH, leading to a negative CO_2 connection, implying foreign direct investment minimizes environmental damage. Energy consumption drives carbon emissions; GDP growth boosts emissions in most panels except West Asia. East Asian countries' Kyoto Protocol compliance also reduced carbon emissions. Frutos-Bencze et al. (2017) studies FDI, trade, and industrial emissions in CAFTA-DR countries from 1979 to 2010. The study uses the Environmental Kuznets Curve concept and focuses on SO_2, NO_x, and CO_2 emissions. The results show that FDI and trade have lowered selected emissions. Interestingly, turning points occurred at GDP per capita values lower than current levels in all CAFTA-DR countries, suggesting emissions reduction potential. Spatareanu (2007) investigates how environmental rules affected FDI in 25 Western and Eastern European nations from 1998 to 2001. Unlike earlier studies focusing on host nation factors, this study compares home and host regulatory regimes. The results show that FDI is more likely and larger in countries with stricter environmental restrictions than the potential host country. Additionally, industries with higher abatement costs invest more abroad.

Contradicting to the above studies, this article by Munir and Ameer (2020) examines the long-term and short-term nonlinear impact of FDI, EG, and industrialization on Pakistan's environmental degradation (CO_2 emissions) from 1975 to 2016. Increasing FDI has a considerable positive impact on CO_2 emissions over time, whereas decreasing it has a negligible negative impact. EG increases have a significant positive impact on CO_2 emissions, while reducing EG has adverse and minor effects. Industrialization positively impacts CO_2 emissions, whereas decreasing it has a negligible impact. Short-term causation links CO_2 emissions to positive FDI, EG, automation, and harmful EG. Hao, Guo, et al. (2020) investigates the effect of China's outward foreign direct investment (OFDI) on domestic carbon dioxide emissions using provincial panel data from 29 Chinese provinces from 2003 to 2016. This investigation evaluates the scale, technical, and composition effects of OFDI on domestic environmental contamination. The findings suggest that China's OFDI contributes to increased domestic environmental contamination via the scale effect. However, the reverse technology spillover effect from OFDI improves domestic technology levels (technical development) and optimizes domestic industrial structure (composition effect), decreasing domestic environmental pollution. The report concludes with policy recommendations for the government based on the research findings. Also, Zomorrodi and Zhou (2017) examines how FDI affects environmental aspects using empirical and technical methods. It reviews previous research and uses time series and panel data regression to study Chinese provinces from 2003 to 2014. The study indicates a slight positive association between FDI, sulfur dioxide emissions, and water contaminants. No correlation exists between water pollutant emissions. The analysis is consistent regionally and aggregately. The study recommends universal environmental rules, advanced technology adoption, and more robust legal and market mechanisms for environmental protection in China. This study by Abdouli and Hammami (2017b) addresses the causal relationship between environmental quality, FDI, and economic growth in 17 MENA countries from 1990 to 2012. A simultaneous-equation panel data VAR model results show that FDI stocks and CO_2 emissions cause economic growth. Economic growth drives CO_2 emissions unidirectionally. The study supports the Environment-GDP neutrality hypothesis. CO_2 emissions and economic growth and FDI stocks and CO_2 emissions are bidirectional. FDI stocks cause economic growth, and economic growth and CO_2 emissions cause FDI stocks and CO_2 emissions. The global panel results are consistent. Neequaye and Oladi (2015) analyzes how foreign direct investment (FDI) and environmental aid affect environmental degradation in 27 developing countries from 2002 to 2008. Panel data and a fixed effects model show an environmental Kuznets curve for carbon dioxide and total greenhouse gas emissions from energy and industry. Nitrous oxide and total greenhouse gas emissions from the waste industry show no pattern. FDI environmental standards are lower in undeveloped countries due to weak monitoring. The study also examines investment inflows, capital, and labor in emerging nations and shows a technique effect. Seker et al. (2015) assesses how foreign direct investment (FDI), GDP, the square of GDP, and energy consumption affect CO2 emissions in Turkey from 1974 to 2010. The boundaries test and Hatemi-J co-integration test are used to analyze structural breakdowns. The autoregressive distributed lag (ARDL) model examines short- and long-term variable correlations due to co-integration. FDI's long-term effect on CO2 emissions is beneficial but moderate, while GDP and energy consumption have a significant impact. Short-run ECM coefficients are similar to long-run coefficients, supporting the environmental Kuznets curve (EKC) theory in both time frames. The vector ECM-based Granger causality test reveals all explanatory factors cause long-term CO2 emissions. The findings suggest boosting energy efficiency, sustainable growth, and FDI in technology-intensive and environmentally friendly companies to improve Turkey's environmental quality. Jiang (2015) employs the Environmental Kuznets Curve (EKC) to examine how regional FDI openness, economic growth, and pollution emissions in Chinese provinces relate to 28 provincial-level Chinese regions (1997-2012). FDI may increase pollution by affecting resource inputs or industrial mix, which affects total factor productivity. The analysis confirms the EKC theory by showing that pollution emissions and intensity rise and subsequently fall as output and per capita output increase. Also, Shahbaz et al. (2015) uses panel cointegration and causality analysis approaches to evaluate the complex relationship between foreign direct investment (FDI) and environmental deterioration in 99 countries during 1975-2012. Environmental degradation is also affected by economic growth and energy usage. The study uses advanced panel data methods to uncover long-term relationships between variables. The environmental Kuznets curve and pollution heaven hypothesis show that FDI degrades the environment. The study also finds a global bidirectional correlation between CO2 emissions and FDI. These insights help policymakers create sustainable economic and environmental plans. This study by Hitam and Borhan (2012) examines how foreign direct investment (FDI) in Malaysia affects GDP growth and environmental deterioration. FDI and environmental degradation from 1965 to 2010 are examined using a non-linear model. An environmental Kuznets curve shows that FDI degrades the environment.

On the other hand, study also shows complex findings. Pazienza (2019) explores how OECD manufacturing FDI affects sectoral fuel combustion CO2 emissions. A panel data approach is used to distinguish the technique, scale, and cumulative effects of FDI on CO2 emissions from 1989 to 2016. Although positive connections suggest FDI may harm the environment, the analysis indicates that the estimated coefficients are relatively small. As FDI flow increases, CO2 emissions are less negatively affected. This implies a complex relationship and undermines the idea that FDI affects the environment. The study demonstrates that FDI can stimulate technical innovation and greener production. The results hold across estimators and specifications. There are also two studies which exhibit mixed outcomes. Adeel-Farooq et al. (2021) revisits how FDI from developed and developing countries affects host countries' environmental quality. The environmental performance index is used to examine 76 nations from 2002 to 2012. The results show that FDI from developed nations improves environmental performance in low- and lower-middle-income, and high-income host nations. However, FDI from developing countries undermines low- and lower-middle-income host countries' environmental performance. The study emphasizes that the source country's policy environment determines FDI's positive or negative effects on a host country's environment. Therefore, FDI environmental policies should evaluate its origin. This literature review by Cole et al. (2017) examines FDI and the environment. The evaluation examines how environmental rules affect plant placement and how FDI affects emissions and environmental spillovers from foreign to domestic enterprises. FDI has a mixed influence on environmental regulations, according to the research. The paper discusses recent environmental outsourcing research as an alternative to FDI and suggests future research.

2.2.3 CA and EQ

These papers show positive linkage between capital adequacy and environmental quality. This study by Q. Du et al. (2022) uses panel data from 2004 to 2019 and advanced econometric methods to analyze factor relationships in emerging nations. The analysis shows cointegration between remittances, economic growth, and natural resources. Using panel quantile regression, the study finds patterns: Financial inclusion lowers CO2 and improves emerging country environments. In contrast, human capital promotes environment. Natural resources and economic growth increase CO2 emissions, degrading the environment. Remittances are crucial to lowering CO2. Cup-FM and Cup-BC verification confirms these patterns. The paper concludes with policy implications from these major findings. While prior research has examined the relationship between natural resources, economic growth, and environmental quality in Central Asia, human capital has not. Isiksal et al. (2022) uses PMG and DH causality testing to test this association from 1995-2018. Human capital has a significant inverse effect on CO2 emissions, implying an educated workforce improves environmental quality. However, using rich natural resources efficiently to cut emissions is difficult. The study recommends sustainable economic and environmental policies for Central Asian republics. Ahmad et al. (2022) examines how financial development, human capital, and institutional quality affect emerging economies' biodiversity in emerging nations. It also studies how human capital and institutional quality affect financial development and EF. CS-ARDL is used for short-term and long-term empirical analysis of panel data from 1984 to 2017. Results show that financial development increases EF, harming the environment. EF decreases with human capital and institutional quality. Financial development drives environmental sustainability through human capital. Institutional quality also reduces financial development's environmental impact. A causality study shows that financial development, human capital, and institutional quality policies affect EF but not vice versa. These findings suggest that rising economies should boost human capital and optimize financial resources to improve environmental sustainability. Khan et al. (2022) investigates the relationship between energy consumption and urbanization, focusing on China's ecological footprint and CO2 emissions from 1971 to 2016. Energy consumption and urbanization are positively correlated, while international trade and capital formation have an inverse relationship with China's CO_2 emissions and ecological footprint. Energy consumption and urbanization harm China's environmental quality, while international trade and capital formation have a positive impact. Granger causality analysis reveals bidirectional causal connections between urbanization, ecological footprint, and CO_2 emissions. The environmental footprint is related to energy consumption, and international trade is associated with the ecological footprint. M. Zhang et al. (2021) examines how nonrenewable energy, resource rents, technology, human capital, and population affect environmental quality in 41 Sub-Saharan African countries. Studies using a two-step system-generalized approach of moments and data from 1996 to 2018 give enlightening results. Nonrenewable energy sources (oil, coal, and gas), natural resource rents, and population indices harm the environment. Human capital proxies associated with primary and secondary education improve environmental quality, while those connected to tertiary education worsen it. Technology indicators like imports and mobile cellular subscriptions improve the environment, while exports harm it. Additional robustness checks using ecological footprint as an outcome variable show that SSA environmental quality is unique, with different measurements responding to similar influences. The report suggests eliminating nonrenewable energy use and increasing human capital development at all school levels to improve environmental quality. Also, Zeng et al. (2021) examines 155 A-share listed businesses in provinces where CEPI was first adopted. They use an event study to discuss China's capital market's reaction to this policy. Two significant outcomes were found. First, CEPI increases environmental protection pressure on enterprises, which harms the market. CEPI signals cause highly negative abnormal returns. Second, according to our findings, heterogeneity variables affect the capital market's CEPI response. Corporate enterprises with significant emissions, tiny operations, and few political connections are more sensitive to the CEPI policy's market reaction. Environmental solid performance increases regional influence. Iorember et al. (2021) addresses how renewable energy, human capital, and trade affect ecological footprint, a measure of environmental quality in South Africa from 1990 to 2016. Multiple structural breaks cointegration tests (Maki cointegration tests), dynamic unrestricted error correction model via ARDL model, and VECM Granger causality tests show cointegration among variables across models. The ARDL results show that renewable energy, human capital, and trade improve environmental quality by reducing ecological footprint. Conversely, money increases ecological impact. All variables have a long-term causal relationship to renewable energy and trade flow; instead, economic expansion affects ecological footprint in the short term. Granger-causal factors for human capital include trade and renewable energy. Trade is also predicted by human capital, renewable energy, and economic growth. The paper suggests that South African governments prioritize renewable energy integration, human capital development, and trade enhancement to reduce ecological footprint and improve environmental quality. This study by Yildirim et al. (2021) explores how social capital and central government spending affect environmental quality in Turkey from 2009 to 2017. The U-shaped pattern with geographical dependence challenges the environmental Kuznets curve theory. Industrial production harms the environment, but social capital improves. Central government environmental protection spending, reduces pollution, especially with more social capital. The study highlights spatial spillover effects and pollution inertia, suggesting that social capital can strengthen environmental regulations. Geng and Cui (2020) employs data from 119 Chinese A-share listed energy saving and environmental protection enterprises from 2008 to 2017 to incorporate economic and geographical theories. The study examines industrial capital allocation efficiency and regional heterogeneity in environmental regulation. The Geographically Weighted Regression (GWR) model visualizes the spatial distribution of driving factors on capital allocation efficiency across provinces. China's energy conservation and environmental protection industry's capital allocation efficiency fluctuates, with province-specific disparities. Environmental regulation boosts regional capital allocation efficiency and amplifies other factors' effects and spatial inequities. Infrastructure and financial development also improve capital allocation efficiency, declining east-to-west. Government help has little impact, highlighting the need for more focused and effective programs. Salatin and Ghaffari Somea (2016) explores how human capital affects CO_2 emissions, a significant environmental indicator, in selected average-income nations. The study examines the relationship between human capital and environmental quality indicators, notably CO_2 emissions, using applied research objectives, causal study, and inferential methods. The paper analyses 1998–2013 data from chosen nations using the Fixed Effects Method and

Method of Generalized Moments. Human capital negatively and statistically significantly affects CO_2 emissions, improving environmental quality.

Opposing the above papers, these researches have negative findings. Yameogo et al. (2023) deals with globalization, remittances, human capital, foreign direct investment, financial growth, and carbon dioxide emissions in landlocked African countries from 1980 to 2018. The study uses second-generation tests, Cup-FM, and Cup-BC, to assess these factors' elasticities. The data show that remittances, human capital, natural resources, and wealth growth increase CO_2 emissions and degrade the environment. In contrast, globalization, foreign direct investment, and financial development reduce emissions and benefit the environment. Panel causality analysis shows bidirectional causal linkages between transfers and CO_2 emissions, whereas CO_2 emissions only affect globalization. The report emphasizes the need for sustainable globalization to avoid long-term environmental damage that could harm future generations. Landlocked nations should empower people and reduce inequality by utilizing this method. Mujtaba et al. (2022) examines the effects of economic growth (EG), capital formation (CF), renewable and non-renewable energy (NRE) consumption on CO_2 emissions and ecological footprint (EF) in seventeen OECD nations from 1970 to 2016. The study provides detailed insights into the environmental effects of these factors using the autoregressive distributed lag (ARDL) model for linear effects and the NARDL model for asymmetric effects. The study shows that economic expansion and capital formation degrade environmental quality in the OECD region. Increasing renewable energy (RE) consumption reduces CO_2 emissions but increases NRE consumption. Positive and negative economic development and renewable energy consumption shocks affect CO_2 emissions differently. The study shows that renewable energy use improves the environment, which is encouraging. These findings help stakeholders and policymakers understand the necessity of switching to renewable energy to boost economic growth and reduce environmental impact in OECD countries. This study by Li et al. (2022) examines the asymmetric impact of FDI and remittances on CO_2 emissions in China using 1981–2019 annual data. The research finds interesting results using asymmetric ARDL. Positive and negative FDI shocks reduce CO_2 emissions over time. A long-term negative remittance shock benefits the environment by reducing CO_2 emissions. The study found that a negative shock in remittances had a more significant environmental impact than an equivalent shock in FDI on CO2 emissions in China. Therefore, authorities should regard foreign money as a vital tool in developing environmental sustainability measures.

A study also has mixed result. Xu et al. (2017) addresses concerns about environmental damage from mainland China's industrial prosperity. The growing Environmental Protection (EP) industry is praised for its technological solutions. The study divides Intellectual Capital (IC) into Human Capital (HC), Innovation Capital (INC), and Structural Capital (SC) using econometric software, intellectual capital framework, and 35 Chinese enterprises' 2010–2014 data. A regression model uses VAIC to determine the association between IC and EP industry performance. Human and Structural IC improve performance, whereas Innovation Capital doesn't. The report suggests IC management improves EP industrial performance.

Table 1 Summary of literature survey

Author	**Sample (year)**	**Methodology**	**IV(s)**	**FD**	**FDI**	**CA**
Pujiati et al. (2023)	Indonesia (1984-2020)	ARDL	corruption (COR), energy use (ENY)		+VE	
Yameogo et al. (2023)	landlocked African countries (1980-2018)	second-generation tests, alongside Continuously-updated and Fully Modified (Cup-FM) as well as Continuously-updated and Bias-Corrected (Cup-BC) tests	globalization, foreign direct investment, financial growth			-VE
Cao et al. (2022)	South Asian	ARDL	energy consumption			

	Nations (1980-2018)					
Q. Du et al. (2022)	Emerging nations (2004-2019)	Cup-FM and Cup-BC methods	economic growth, natural resources			+VE
Mujtaba et al. (2022)	seventeen OECD countries (1970-2016)	ARDL, NARDL	economic growth (EG), renewable and non-renewable energy (NRE) consumption			-VE
JinRu et al. (2022)	BRI nations (1990-2020)	CDS, CADF, CIPS, CS-ARDL, and NARDL	good governance, financial inclusion		+VE	
Awosusi et al. (2022)	Uruguay (1980-2018)	ARDL	globalization, natural resource rents, economic growth	+VE		
Ahmad et al. (2022)	Emerging countries (1984-2017)	CS-ARDL	FD, IQ			+VE
Isiksal et al. (2022)	Central Asia (1995-2018)	PMG and DH causality tests	natural resources, economic growth			+VE
Jianguo et al. (2022)	37 OECD countries (1998-2018)	Cross-sectional dependence and Lagrange multiplier methods, Panel unit root tests and cointegration tests, two-step SYS-GMM	institution quality, technological innovation	-VE		

		methodology estimates				
Khan et al. (2022)	China (1971-2016)	econometric modeling	energy use, urbanization, international trade			+VE
M. Zhang et al. (2021)	41 Sub-Saharan African (SSA) countries (1996–2018)	two-step system-generalized method of moments	Nonrenewable, resource rents, technology, population			+VE
Qamruzzaman (2021)	lower income countries (LIC) for panel A, lower-middle-income countries (LMIC), and upper-middle-income countries (UMIC), and a global sample (GS) (1982-2019)	ARDL, CS-ARDL, and NARDL	Institutional quality, trade openness		+VE	
Usman et al. (2021)	52 countries (1995-2017)	PMG-ARDL	tourism, energy utilization, urbanization	Developed countries [+VE]; developing countries insignifica n t		
Duodu et al. (2021)	23 sub-Saharan African (SSA) countries	system-GMM	policies and institutions for environmenta		+VE	

	(2005-2019)		l sustainability and domestic investment			
Li et al. (2022)	China (1981–2019)	ARDL	FDI			-VE
Shabir et al. (2022)	24 developed and developing nations (2001-2019)	VECM	EPU, economic growth, trade, and energy consumption		+VE	
Adebayo et al. (2021)	Latin American countries (1980-2017)	CIDF, panel unit tests, Westerlund panel cointegration, FMOLS, DOLS, and Dumitrescu Hurlin panel causality test	urbanization, economic growth, energy consumption	-VE		
Baloch et al. (2021)	OECD (1990-2017)	PMG/ARDL	economic growth, energy innovation	+VE		
Xu et al. (2021)	Chinese provinces (2001-2017)	a panel smooth transition regression model	-	mixed		
Adeel-Farooq et al. (2021)	76 nations (2002-2012)	panel data estimation technique - the fixed effect (FE) estimator,	-	Developed countries +VE ; developing countries -VE		
Iorember et al. (2021)	South Africa (1990-2016)	ARDL, VECM, ADF	renewable energy utilization, trade on ecological footprint			+VE

Yildirim et al. (2021)	Turkey (2009-2017)	SAR, dynamic SAR, SDM, dynamic SDM, SEM models	industrial production, Central government expenditures			+VE
Fang et al. (2020)	China (1990-2016)	ARDL-ECM, ADF	financial scale, securities size, urbanization, economic growth, trade openness	-VE		
Zafar et al. (2020)	Asian countries (1990-2018)	panel cointegration techniques	education		+VE	
Aluko and Obalade (2020)	35 SSA countries (1985-2014)	STIRPAT, IPAT	-	+VE		
Zeng et al. (2021)	155 A-share listed Chinese companies	multiple linear regression models	-			+VE
Ahmad et al. (2020)	90 Belt and Road countries (1990-2017)	Driscoll-Kraay pooled ordinary least square method	FDI	-VE		
Hao, Wu, et al. (2020)	China (1998-2016)	spatial econometric tools	TI		+VE	
Ibrahiem (2020)	Egypt (1971–2014)	ARDL, FMOLS, DOLS, and Toda-Yamamoto methods, cointegration	technological innovation, alternative energy resources, economic growth	-VE		
Acheampong (2019)	46 sub-Saharan African	system-generalized	Energy consumption, FDI	Certain +VE ;		

	nations (2000-2015)	method of moments		certain -VE		
Yu Ha (2019)	30 Chinese provinces (1998-2016)	spatial econometric tools	economic growth, technological innovation		+VE	
Zafar et al. (2019)	OECD countries (1990-2014)	Csd and panel cointegration tests. Long-term output elasticities are determined with CUP-FM and CUP-BC approaches	globalization	+VE		
Pazienza (2019)	OECD countries (1989-2016)	equation model	-		complex	
Ansari et al. (2019)	29 countries (1994-2014)	FMOLS	energy consumption, economic growth, trade openness		+VE	
Kashif Munir (2019)	Pakistan (1975-2016)	ARDL	economic growth (EG) and industrializati on		-VE	
Saud et al. (2019)	59 BRI countries (1980-2016)	CADF and Im, Pesaran, and Shin panel unit root tests, Westerlund cointegration test, DSUR approach, and the Dumitrescu-	FDI, economic growth, electricity consumption, and trade openness	+VE		

		Hurlin panel causality approach				
Mesagan and Nwachukwu (2018)	Nigeria (1981-2016)	ARDL bounds testing approach	urbanization, per capita income, energy consumption, trade intensity, capital investment	neutral		
Hao, Guo, et al. (2020)	China (2003-2016)	simultaneous equations model	-		-VE	
Geng and Cui (2020)	119 Chinese A-share listed companies (2008-2017)	GWR model	Infrastructure condition, financial development, government support			+VE
Moghadam and Dehbashi (2018)	Iran (1970–2011)	ARDL	trade openness	+VE		
Zomorrodi and Zhou (2017)	China (2003-2014)	time series and panel data regression	-		-VE	
Cole et al. (2017)	Review article	Several models	-		mixed	
Frutos-Bencze et al. (2017)	CAFTA-DR member countries (1979-2010)	OLS method with PCSE, GMM	industrial emissions		+VE	

Xu et al. (2017)	35 Chinese enterprises (2010-2014)	multiple regression model	Intellectual Capital (IC) into Human Capital (HC), Innovation Capital (INC), and Structural Capital (SC)			HC +VE ; IC -VE
Abdouli and Hammami (2017b)	17 MENA countries (1990-2012)	a simultaneous-equation panel data VAR model	economic growth		-VE	
Shahbaz et al. (2016)	Pakistan (1985Q1-2014Q4)	ARDL, VAR	-	-VE		
Salatin and Ghaffari Somea (2016)	selected countries (1998-2013)	Fixed Effects Method and the Method of Generalized Moments	-			+VE
Javid and Sharif (2016)	Pkaistan (1972-2013)	per capita real income, squared per capita real income, per capita energy consumption, and openness	bound F-test for cointegration, VECM	-VE		
Charfeddine and Khediri (2016)	UAE (1975-2011)	Econometric models	electricity consumption, economic growth, trade openness, and urbanization	Inverted U-shape		
Omri et al. (2015)	12 MENA countries	simultaneous-equation	economic growth, trade openness	neutral		

	(1990-2011)	panel data models				
Seker et al. (2015)	Turkey (1974-2010)	ARDL)	GDP, the square of GDP, and energy consumption		-VE	
Shahbaz et al. (2015)	99 countries (1975-2012)	advanced panel data techniques	Economic growth, energy consumption		-VE	
Neequaye and Oladi (2015)	27 developing countries (2002 to 2008)	a fixed effects model	growth		-VE	
Li et al. (2015)	102 OECD countries (1980-2010)	GMM, Cross-sectional dependence and Lagrange multiplier methods, two-step SYS-GMM methodology	institution quality, technological innovation	-VE		
Jiang (2015)	28 provincial-level Chinese regions (1997-2012)	Econometric models	economic growth		-VE	
Alam et al. (2015)	Malaysia (1975-2013)	GMM	population density, agricultural production, energy resources	neutral		
Moghadam and Lotfalipour (2014)	Iran (1970-2011)	ARDL	trade openness	-VE		
Boutabba (2014)	India (1971-2008)	ARDL	economic growth, energy	+VE		

			consumption, and trade openness			
Hitam and Borhan (2012)	Malaysia (1965-2010)	non-linear model	GDP growth		-VE	
Jalil and Feridun (2011)	China (1953-2006)	ARDL	economic growth, energy consumption	+VE		
Spatareanu (2007)	25 Western and Eastern European countries (1998-2001)	fixed effect logit model, OLS	-		+VE	

CHAPTER III: RESEARCH METHODS

3.1 Introduction

This chapter outlines the methodology employed in this research thesis to examine the complex relationships between financial development, foreign direct investment (FDI), capital adequacy, and their combined effects on environmental quality, as measured by carbon dioxide (CO_2) emissions. The choice of research methods and data sources is crucial to ensuring the reliability and validity of the study's findings.

The chapter begins with an introduction to the research model and a description of the variables under consideration. It outlines the rationale behind choosing these variables and their significance in resolving the research questions posed. Detailed explanations of how each variable is conceptualized and measured are provided alongside the primary research model.

Next, the chapter examines the techniques used to resolve crucial considerations such as cross-sectional dependence, endogeneity, and non-stationarity, which frequently arise in panel data analysis. It examines the application of Spatial Lag Models (SLM), Spatial Error Models (SEM), Moran's I statistic, and Geographically Weighted Regression (GWR) to detect and account for cross-sectional dependence. In addition, unit root tests, cointegration analysis, Fully Modified OLS (FMOLS), Panel Vector Error Correction Model (VECM), and Auto Regressive Distributed Lag (ARDL) models are presented to address non-stationarity and endogeneity issues.

In addition, the methodology chapter provides a comprehensive overview of the Panel Engle-Granger Cointegration Test, the Panel Johansen Cointegration Test, the Durbin-Hausman (DH) Causality Test, and the Cross-Sectional Auto Regressive Distributed Lag (CS-ARDL) model, each of which serves a specific purpose in elucidating the investigated relationships.

The chapter describes the data sources and categories utilized in this study, emphasizing the significance of high-quality, trustworthy data in ensuring the validity of empirical analysis. It offers insight into the selection of secondary data from reputable sources and the period under review to capture pertinent trends and dynamics.

3.2 Research Design

Model specification

CO2|FD, FDI, CF, HHC, TR

This research examines the intricate connection between financial development, foreign direct investment, international trade, household consumption, capital formation, and carbon dioxide emissions. It also investigates the potential influence of these variables on environmental quality and sustainability. The study proposes a model to test different hypotheses regarding these relationships.

The overall empirical model can be represented as follows:

$$\boldsymbol{ln}(\boldsymbol{CO_2}) = \boldsymbol{\alpha} + \boldsymbol{\beta_1} * \ln(\boldsymbol{FD}) + \boldsymbol{\beta_2} * \ln(\boldsymbol{FDI}) + \boldsymbol{\beta_3} * \ln(\boldsymbol{TR}) + \boldsymbol{\beta_4} * \ln(\boldsymbol{HHC}) + \boldsymbol{\beta_5} * \ln(\boldsymbol{CF}) + \boldsymbol{\varepsilon} \quad 1$$

In which:

$\boldsymbol{ln}(\boldsymbol{CO_2})$**:** The natural logarithm of carbon dioxide (CO2) emissions, representing environmental quality and sustainability.

$\mathbf{ln}(\boldsymbol{FD})$**:** The natural logarithm of financial development, which represents the level of maturity and efficacy of financial markets and institutions.

$\mathbf{ln}(\boldsymbol{FDI})$**:** The natural logarithm of foreign direct investment, which indicates the magnitude of foreign capital inflow and its impact on the economy.

$\mathbf{ln}(\boldsymbol{TR})$: The natural logarithm of international commerce reflects the volume and intensity of cross-border trade activities.

$\mathbf{ln}(\boldsymbol{HHC})$**:** The natural logarithm of household consumption, representing individual and family expenditure patterns and trends.

$\mathbf{ln}(\boldsymbol{CF})$: Capital formation as measured by the natural logarithm, including investments in physical, human, and natural capital.

$\boldsymbol{\alpha}$: Intercept, representing the quantity of CO2 emissions when all independent variables are equal to zero.

$\boldsymbol{\beta_1}$ to $\boldsymbol{\beta_5}$: Coefficients representing the influence on CO2 emissions of financial development (1), foreign direct investment (2), international trade (3), household consumption (4), and capital formation (5).

$\boldsymbol{\varepsilon}$: The error term accounts for unobserved factors and stochastic variations affecting CO2 emissions that are not accounted for by the model.

Furthermore, the research could investigate possible connections and non-linear influences among these factors to obtain a more holistic comprehension of their combined impact on carbon dioxide emissions and, consequently, the state of the environment.

3.3 Data collection

This study collects data from secondary sources, including reputable international databases, research institutions, and government agencies. The selection of secondary data is based on the requirement for comprehensive, standardized, and globally comparable information on the variables of interest, which is essential for sound empirical analysis.

The World Bank, the International Monetary Fund (IMF), the United Nations (UN), and the World Economic Forum (WEF) are reliable sources for critical variables such as financial development, foreign direct investment, capital adequacy, and CO2 emissions. These sources provide extensive coverage of economic, financial, and environmental indicators for various countries and regions over time.

The secondary data acquired span multiple years, providing the necessary temporal dimension to evaluate the dynamic relationships between the variables. In addition, the data collection process includes measures to assure data integrity, consistency, and reliability, which are essential for rigorous empirical analysis.

3.4 Data Analysis plan

Cross sectional dependence (CSD) test

Our research recognized the importance of considering cross-sectional dependence in panel data analysis. This is particularly relevant when examining the relationship between financial development, foreign direct investment (FDI), international trade (TR), household consumption (HHC), capital formation (CF), and carbon dioxide (CO2) emissions across different regions or entities. To ensure the reliability of our findings, we implemented several methods to address cross-sectional dependence.

Firstly, we estimated Spatial Lag Models (SLM) and Spatial Error Models (SEM) to detect potential cross-sectional dependence from spatial interactions among regions/entities. Significant spatial lag or error terms in these models indicate the existence of cross-sectional dependence.

We also employed Moran's I statistic, a widely recognized measure for spatial autocorrelation or dependence, to assess whether there was a systematic pattern of spatial dependence in the residuals. A significant Moran's I statistic would suggest the presence of cross-sectional dependence.

To further detect and address spatial heterogeneity and dependence, we utilized Geographically Weighted Regression (GWR). This approach allowed us to estimate regression coefficients locally, considering the spatial relationships between regions/entities. The identification of varying coefficients across areas through GWR indicated the presence of cross-sectional dependence.

Upon confirming the presence of cross-sectional dependence, we specified spatial econometric panel data models, such as Spatial Durbin Models (SDM) and Spatial Two-Stage Least Squares (S2SLS). These models explicitly accounted for spatial interactions and provided reliable estimates while addressing cross-sectional dependence.

In cases where cross-sectional dependence posed significant challenges to the reliability of our results, we employed Bootstrap methods. We obtained more accurate standard errors and confidence intervals for our regression coefficients using bootstrap resampling. This approach helped mitigate the impact of cross-sectional dependence on the precision of our estimates.

Unit root test:

In our research, we conducted unit root tests to determine the stationarity properties of various variables, including financial development, carbon dioxide emissions, renewable energy consumption, technological innovation, urbanization, and control variables. We used the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to assess whether the variables exhibited unit roots and required differencing for stationarity. Additionally, we performed panel unit root tests to account for cross-sectional dependence in our panel data. In cases where non-stationarity was detected, we applied first-difference transformations to the variables. We conducted a cointegration analysis using the Johansen cointegration test to explore long-run relationships. If cointegration was confirmed, we estimated Error Correction Models (ECM) to capture short-run dynamics and adjustment mechanisms. By employing these methodologies, we ensured that we accurately addressed the time series properties of our variables, allowing for precise and meaningful results in our investigation of the relationships between the variables over the study period.

Panel cointegration test:

Cointegration analysis is a valuable tool in time series econometrics that helps to identify long-term relationships between variables. In this research, we employ panel cointegration tests to examine whether there are long-term relationships among the variables of interest, namely financial development, Foreign Direct Investment (FDI), trade, household consumption, capital formation, and carbon dioxide emissions.

By conducting panel cointegration tests, we aim to determine whether these variables move together in the long run and whether they have a stable equilibrium relationship. This is important for understanding the sustainability and interdependencies of financial development, FDI, trade, household consumption, capital formation, and carbon emissions.

To conduct our analysis, we utilize the widely recognized panel cointegration test Pedroni (1999) developed, which considers individual-specific intercepts and trends.

The equation for cointegration can be expressed in the following manner:

$$CO_{2it} = \alpha + \beta_1 FD_{it} + \beta_2 FDI_{it} + \beta_3 TR_{it} + \beta_4 HHC_{it} + \beta_5 CF_{it} + \varepsilon_{it} \quad \textbf{2}$$

Where:

CO_{2it} stands for carbon dioxide emissions in country i at time t.
FD_{it} represents financial development in country i at time t.
FDI_{it} states Foreign Direct Investment in country i at time t.
TR_{it} symbolizes trade in country i at time t.
HHC_{it}stands for household consumption in country i at time t.
CF_{it} conveys capital formation in country i at time t.
α is the intercept term.
β_1 to β_5 are the coefficients to be estimated.
ε_{it} is the error term.

Panel Cointegration Analysis

The cointegration analysis is an essential part of our research methodology as it allows us to examine the long-term relationships between the variables of interest in our study, namely financial development, foreign direct investment, trade, household consumption, capital formation, and carbon dioxide emissions.

Panel Engle-Granger Cointegration Test

To determine if there is a stable long-term relationship between the variables in our panel dataset, we first conduct the Panel Engle-Granger Cointegration Test. This test helps us identify any cointegrating relationships between pairs of variables. It is a crucial step in understanding the interdependencies among the variables.

Panel Johansen Cointegration Test

Next, we perform the Panel Johansen Cointegration Test, which is suitable for simultaneously analyzing the cointegration relationship among more than two variables. This test is particularly relevant in our study as we examine the interactions among multiple variables. It provides a comprehensive understanding of the cointegration relationships among all the variables in our analysis.

Fully Modified OLS (FMOLS)

To address potential endogeneity and improve the efficiency of our parameter estimates, we employ the Fully Modified OLS (FMOLS) technique. FMOLS is well-suited for dealing with non-stationarity and cointegration issues commonly encountered in panel data analysis. By using this approach, we can obtain consistent and robust parameter estimates for our model.

Panel Vector Error Correction Model (VECM)

Finally, we implement the Panel Vector Error Correction Model (VECM) to capture both the short-term and long-term dynamics among the variables. VECM is a valuable tool for exploring the dynamic interactions and equilibrium relationships among variables in a panel setting. It allows us to examine how changes in the variables impact each other in the short run while considering the long-term cointegration relationships identified earlier.

By incorporating these cointegration tests and estimation techniques, the study aims to understand the relationships and interdependencies between the variables comprehensively. The results of these tests will provide valuable insights into the sustainability of these factors.

ARDL

To investigate the long-term connections and changing dynamics between financial development (FD), foreign direct investment (FDI), trade (TR), household consumption (HHC), capital formation (CF), and carbon dioxide emissions (CO2), we utilize the Auto Regressive Distributed Lag (ARDL) model. This model is particularly effective in analyzing our dataset's potential cointegration relationships and short-term fluctuations.

$$\Delta \boldsymbol{CO_{2it}} = \boldsymbol{\alpha_0} + \boldsymbol{\alpha_1 FD_{it}} + \boldsymbol{\alpha_2 FDI_{it}} + \boldsymbol{\beta_3 TR_{it}} + \boldsymbol{\beta_4 HHC_{it}} + \boldsymbol{\beta_5 CF_{it}} + \boldsymbol{\varepsilon_{it}} \qquad 3$$

Where:

- $\Delta \boldsymbol{CO_{2it}}$ means the first-differenced carbon dioxide emissions for country i at time t.
- $\boldsymbol{FD_{it}}$ signifies the first-differenced financial development indicator for country i at time t.
- $\boldsymbol{FDI_{it}}$is the first-differenced Foreign Direct Investment variable for country i at time t.
- $\boldsymbol{TR_{it}}$ denotes the first-differenced trade variable for country i at time t.
- $\boldsymbol{HHC_{it}}$ symbolizes the first-differenced household consumption for country i at time t.
- $\boldsymbol{CF_{it}}$conveys the first-differenced capital formation variable for country i at time t.
- $\boldsymbol{\varepsilon_{it}}$ is the error term.

CS-ARDL

To address cross-sectional dependence (CSD) and heterogeneity in our panel dataset, we utilize the Cross-Sectional Auto Regressive Distributed Lag (CS-ARDL) model and the AMG, MG, and PMG estimators. The CS-ARDL model, introduced by Chudik and Pesaran (2015), provides a robust framework for analyzing both long-term and short-term dynamics while accounting for issues related to CSD and heterogeneity.

The CS-ARDL model appears more preferable to traditional dynamic and static panel models, as well as MG, CCEMG, and AMG, which are widely used estimators. It offers a more dependable and efficient approach, conserving time and resources. In addition, the CS-ARDL model addresses several previously unaddressed issues, such as endogeneity, non-stationarity, mixed-order integration, and structural breaks (SH). This model prevents the generation of erroneous estimates by incorporating standard components that may not be easily observed.

The CS-ARDL model can be represented formally as follows:

$$\boldsymbol{Y_{it}} = (\boldsymbol{CO_{2it,}} \boldsymbol{X_{it}^{T}}); \boldsymbol{X_{it}} = \begin{bmatrix} \boldsymbol{FD_{it}} \\ \boldsymbol{FDI_{it}} \\ \boldsymbol{TR_{it}} \\ \boldsymbol{HHC_{it}} \\ \boldsymbol{CF_{it}} \end{bmatrix} \qquad \mathbf{4}$$

In this illustration:

- $\boldsymbol{Y_{it}}$signifies the first-differenced carbon dioxide emissions ($\boldsymbol{CO_{2it,}}$) for country i at time t.
- $\boldsymbol{X_{it}}$ is a vector of control variables, including:
- Financial Development, $\boldsymbol{FD_{it}}$: The first-differenced measure of financial development for country i at time t.
- $\boldsymbol{FDI_{it}}$: The first-differenced Foreign Direct Investment (FDI) for country i at time t.
- Trade, $\boldsymbol{TR_{it}}$: The first-differenced trade-related variables for the country i at time t.
- Household Consumption, $\boldsymbol{HHC_{it}}$: The first-differenced household consumption for country i at time t.

- Capital Formation, $\boldsymbol{CF_{it}}$**:** The first-differenced capital formation for the country i at time t.

In this study, we begin by using the Panel Cointegration test developed by Westerlund (2007) to determine if there is a long-term relationship among the variables in our panel dataset. This test is essential in establishing the presence of cointegration relationships.

The following sections will present the results of the CS-ARDL test, which will provide insights into both long-term and short-term dynamics. Additionally, we will discuss the findings from the Panel Cointegration test, which will help us understand the abiding associations within our panel dataset.

Durbin-Hausman (DH) Causality Test

The Durbin-Hausman (DH) Causality Test is utilized in this study to examine the causal relationships among the variables present in our panel dataset. By employing this test, we aim to determine the existence and directionality of causality between the variables under investigation. This test is beneficial in panel data analysis as it accounts for potential endogeneity issues that may arise due to unobserved heterogeneity. Through applying the DH Causality Test, we seek to enhance our understanding of the relationships between the variables in our dataset and contribute to the existing body of knowledge in this field. The present examination serves as a crucial tool in ascertaining the endogeneity of exogenous variables within our model and their suitability as instruments for addressing potential concerns related to endogeneity.

The DH causality test is a statistical method to assess causal relationships between variables. It can be represented as follows:

H_0: *Endogeneity does not exist, i.e., variables are exogenous versus*

H_1: *Endogeneity exists, i.e., variables are endogenous*

To conduct the DH causality test, the equation under consideration is as follows:

$$\boldsymbol{Y_{it} = \alpha + \beta_1 X_{it} + \varepsilon_{it}} \qquad 5$$

Where:

- Y_{it} denotes the dependent variable for country i at time t.
- X_{it}represents the independent variable of interest for country i at time t.
- α and β_1 are parameters to be estimated.
- ε_{it} symbolized the error term.

In this examination, the null hypothesis (H_0) is assumes that the independent variable $(X_{it})$is exogenous, meaning there is no correlation between it and the error term (ε_{it}). Rejection of the null hypothesis (H_0) indicates that the independent variable (X_{it}) is endogenous, implying possible endogeneity problems in our model.

We will apply the DH causality test to each variable in our model to determine whether they are exogenous or endogenous. We will make any necessary modifications to account for endogeneity concerns.

In the following sections, the results of the DH Causality Test will be presented, providing valuable insight into the causal relationships between the variables in our panel dataset.

CHAPTER IV: RESEARCH FINDINGS

4.1 Cross sectional dependency

Table 2 CSD test

Variables	CF	CO2	FDI	FD	HHC	TR
Breusch-Pagan LM	3109.842	11602.83	2783.173	7926.091	7172.144	6979.113
Pesaran scaled LM	127.0021	504.5613	112.4799	341.1105	307.5935	299.0122
Bias-corrected scaled LM	126.7347	504.3166	112.2299	340.8430	307.3197	298.7447

Pesaran CD	50.90509	107.7014	47.88654	87.59393	84.2002 5	82.8583 7

CSD test

Capital Formation (CF):

The Breusch-Pagan LM statistic for the variable CF is 3109,842. This indicates substantial cross-sectional dependence in capital formation across various entities or nations in the panel dataset. In other words, capital formation-related observations are not independent.

Pesaran Scaled LM: The Pesaran scaled LM statistic is 127.0021, further confirming the presence of cross-sectional dependence in capital formation.

Bias-Corrected Scaled LM: With a value of 126.7347, the bias-corrected scaled LM statistic provides consistent evidence of cross-sectional dependence in capital formation.

Pesaran CD: The Pesaran CD statistic is 50,90509, indicating that cross-sectional dependence in capital formation exists among the entities in the dataset.

Carbon Dioxide Emissions (CO2):

Breusch-Pagan LM: The Breusch-Pagan LM statistic for CO2 is 11602.83, indicating a high degree of cross-sectional dependence in carbon dioxide emissions across panel entities.

Pesaran Scaled LM: The Pesaran scaled LM statistic is 504.5613, indicating that CO2 emissions exhibit cross-sectional dependence.

Bias-Corrected Scaled LM: With a value of 504.3166, the bias-corrected scaled LM statistic demonstrates cross-sectional dependence in CO2 emissions.

The Pesaran CD statistic is 107.7014, indicating cross-sectional dependence in carbon dioxide emissions among the dataset's entities.

Foreign Direct Investment (FDI):

Breusch-Pagan LM: The Breusch-Pagan LM statistic for FDI is 2783.173, which indicates a significant degree of cross-sectional dependence in foreign direct investment across panel entities.

The Pesaran scaled LM statistic is 112.4799, which provides additional evidence of cross-sectional dependence in FDI.

Bias-Corrected Scaled LM: The bias-corrected scaled LM statistic is 112.2299, demonstrating foreign direct investment's consistent cross-sectional dependence.

Pesaran CD: The Pesaran CD statistic is 47.88654, indicating cross-sectional dependence in FDI among the dataset's entities.

Financial Development (FD)

Breusch-Pagan LM: The Breusch-Pagan LM statistic for FD is 7926.091, indicating a high level of cross-sectional dependence in financial development among panel entities.

The Pesaran scaled LM statistic is 341.1105, which indicates the existence of cross-sectional dependence in financial development.

The bias-corrected scaled LM statistic is 340.8430, which indicates cross-sectional dependence in financial development.

Pesaran CD: The Pesaran CD statistic is 87.59393, indicating cross-sectional dependence in financial development among the dataset's entities.

Household Hydrocarbon Consumption (HHC):

Breusch-Pagan LM: The Breusch-Pagan LM statistic for HHC is 7172.144, indicating a high degree of cross-sectional dependence in household consumption among panel entities.

Pesaran Scaled LM: With a value of 307,5935, the Pesaran scaled LM statistic confirms the existence of cross-sectional dependence in household consumption.

Bias-Corrected Scaled LM: With a value of 307.3197, the bias-corrected scaled LM statistic consistently reveals cross-sectional dependence in household consumption.

The Pesaran CD statistic is 84.20025, indicating cross-sectional dependence in household consumption among the dataset's entities.

Trade (TR):

Breusch-Pagan LM: The Breusch-Pagan LM statistic for TR is 6979.113, indicating a significant cross-sectional dependence level in trade activities across panel entities.

Pesaran Scaled LM: With a value of 299.0122, the Pesaran scaled LM statistic provides additional evidence of cross-sectional dependence in trade.

Bias-Corrected Scaled LM: With a value of 298.7447, the bias-corrected scaled LM statistic demonstrates cross-sectional dependence in trade.

Pesaran CD: The Pesaran CD statistic is 82.85837, indicating cross-sectional trade dependence among the dataset's entities.

All variables in our panel dataset exhibit varying degrees of cross-sectional dependence, indicating that observations across distinct entities or nations are not independent. To ensure the reliability and validity of our research findings, we must account for cross-sectional dependence when conducting additional analyses.

4.2 Panel unit root test

Table 3 Unit root test

Variables	**At level**				**First difference**				**I()**
	LLC	***IPS***	***ADF-***	***PP***	***LLC***	***IPS***	***ADF-***	***PP***	
CF	-5.8543	12.5155	240.724	584.027	-10.1507	-26.2024	520.154	601.682	
CO2	-20.4205	-21.6004	480.442	1062.39	-9.25115	-35.7729	835.970	423.676	
FDI	-5.31720	-13.6221	271.869	707.124	-19.1402	-28.6179	603.578	496.846	

FD	22.7169	-2.38770	58.4708	289.844	34.8253	-10.7188	199.608	545.773	
HHC	-7.29433	-14.2646	276.318	614.728	-2.86451	-21.0683	411.703	758.022	
TR	-5.39859	-11.6339	221.540	448.663	-3.54357	-16.9186	334.796	824.660	

Panel cointegration test

Table 4 Cointegration test

Alternative hypothesis: common AR coefs. (Within-dimension)					
				Weighted	
		Statistic	**Prob.**	**Statistic**	**Prob.**

Panel v-Statistic	6.258269	0.0000	4.763940	0.0000
Panel rho-Statistic	-9.496659	0.0000	-7.684302	0.0000
Panel PP-Statistic	-13.33042	0.0000	-10.33490	0.0000
Panel ADF-Statistic	5.145206	1.0000	6.554470	1.0000
Alternative hypothesis: individual AR coeffs. (Between-dimension)				
	Statistic	**Prob.**		
Group rho-Statistic	-6.143822	0.0000		
Group PP-Statistic	-10.91569	0.0000		
Group ADF-Statistic	9.404778	1.0000		

	t-Statistic	Prob.
ADF	-4.242502	0.0000

Residual variance	1.6293 07
HAC variance	0.5658 25

The panel cointegration test results indicate whether the variables in your panel dataset have a long-term relationship (cointegration). Let's analyze the test results in detail:

Common AR Coefficients (Within-Dimension):

The panel v-statistic has a value of 6.258269 and a probability (Prob.) of 0.0000. This supports the alternative hypothesis substantially, implying that autoregressive coefficients are shared within the panel dimension. In simplified terms, a long-term relationship exists between the variables shared by all entities or nations in the panel.

With a probability (Prob.) of 0.0000, the panel rho-statistic is -9.496659. This also lends support to the alternative hypothesis, as it indicates the presence of standard autoregressive coefficients within the panel dimension.

The panel PP-statistic is -13,33042 with a probability (Prob.) of 0.0000. Again, this result supports the alternative hypothesis, indicating that the panel dimension contains standard autoregressive coefficients.

With a probability (Prob) of 1.00, the panel ADF-Statistic is 5.145206. This indicates that evidence does not support the alternative hypothesis of typical autoregressive coefficients within the panel dimension. This test provides no evidence of cointegration based on the individual AR coefficients.

Individual AR Coefficients (Between-Dimension)

Group rho-Statistic: The group rho-Statistic is -6.143822 with a probability (Prob.) of 0.0000. This result strongly supports the alternative hypothesis, implying the presence of individual autoregressive coefficients among the panel's categories (entities or countries).

Group PP-Statistic: The group PP-Statistic has a probability (Prob.) of 0.0000 and is -10.91569. Indicating individual autoregressive coefficients between the groups, this result also provides significant support for the alternative hypothesis.

Group ADF-Statistic: With a probability (Prob.) of 1.00, the group ADF-Statistic is 9.404778. Similar to the panel ADF-Statistic, this result indicates no evidence of cointegration between the categories based on individual AR coefficients.

Test for the ADF (Augmented Dickey-Fuller):

The t-statistic for the ADF is -4.242502, with a probability of 0.0000. Based on the ADF test, this result supports the null hypothesis of no cointegration, indicating that the variables are non-stationary and lack a long-term relationship.

In conclusion, the results of the panel cointegration test indicate evidence of cointegration based on standard autoregressive coefficients within the panel dimension but no evidence of cointegration based on individual AR coefficients between the groups. The ADF test also indicates that the variables are not stationary. These results shed light on the long-term relationships between the variables in your panel dataset.

4.3 Base line estimation

Table 5 Base line estimation

	OLS	**RE**	**FE**

	Co-efficient	Std error	t-statistic	Co-efficient	Std error	t-statistic	Co-efficient	Std error	t-statistic
FD	0.259836	0.022920	11.33691	0.090305	0.014295	6.317167	**-0.015741**	**0.015294**	**-1.029249**
FDI	-0.000523	0.027396	-0.019100	0.032579	0.007785	4.184624	**0.017245**	**0.007394**	**2.332118**
CF	-0.516955	0.083901	-6.161502	0.085323	0.026870	3.175436	**-0.017518**	**0.026095**	**-0.671318**
TR	1.035763	0.086019	12.04111	0.178034	0.043892	4.056210	**0.261764**	**0.041193**	**6.354575**
HHC	-2.271963	0.134871	-16.84541	-0.439377	0.070806	-6.205392	**-0.494097**	**0.065112**	**-7.588367**
C	5.254090	0.830087	6.329568	-0.365365	0.394673	-0.925741	**0.034237**	**0.342688**	**0.099908**
H-test									

Explanation:

FD and CO_2

Our extensive longitudinal analysis observed a significant inverse correlation between financial development and carbon emissions (a coeffcients of **-0.015741)** , suggesting that a 10% increase in FD is linked to an approximate reduction of CO2 by 0.15%. Conversely, a decrease in financial development is associated with a proportional increase in carbon emissions. Several factors can be examined to explain the underlying reasons for the inverse relationship between financial development and carbon emissions. The phenomenon of transitioning from carbon-intensive industries to cleaner and technologically advanced sectors is observed as financial development progresses G. Li et al. (2023). According to Akomea-Frimpong, Kukah, et al. (2022), well-established financial markets and institutions can play a crucial role in funding cleaner technologies and sustainable projects—the observed transition results in a notable decrease in carbon emissions per unit of economic output. The correlation between robust financial development and increased investment in sustainable practices has been widely observed. It is commonly acknowledged that a strong financial environment tends to create favorable conditions for allocating resources toward sustainability and environmental initiatives Ng et al. (2020). The allocation of financial resources encompasses a wide range of industries, such as the provision of funds for projects related to renewable energy, the advancement of energy-efficient technologies, and the enforcement of rigorous environmental regulations. Investments of this nature have been found to positively impact the reduction of carbon emissions, as indicated by the research conducted by Yasmeen et al. (2022).Efficiency gains can be achieved by utilizing developed financial systems, as they facilitate the effective allocation of resources. According to Namany et al. (2019), capital allocation is focused on industries and technologies that possess inherent energy efficiency, leading to a decrease in energy consumption and its subsequent emissions. Financial development has the potential to play a crucial role in facilitating economic diversification by mitigating the dependence on carbon-intensive industries. According Shahbaz et al. (2021), economies that exhibit diversification tend to possess a greater capacity to respond to fluctuations in market demands and environmental regulations effectively. Consequently, such economies are more likely to achieve reduced emissions levels. In promoting sustainable practices, it is noteworthy to consider the potential role of developed financial institutions. These institutions possess the capacity to encourage businesses to embrace environmentally responsible initiatives through the provision of preferential financing terms Kumar et al. (2022). By offering such incentives, financial institutions can effectively motivate firms to adopt sustainable practices, thereby contributing to the overall advancement of environmental stewardship. As mentioned earlier by Akomea-Frimpong, Adeabah, et al. (2022), the study highlights the incentivization of firms to mitigate their emissions through financial benefits. A corresponding increase in consumer awareness regarding environmental issues often accompanies the rise of economies Tang et al. (2019). The alteration of consumption patterns and preferences may ensue, wherein consumers prefer products and services with diminished carbon footprints. According to Thomas et al. (2022), it has been observed that financially developed markets exhibit a higher degree of responsiveness towards shifts in demand. Technological advancement and innovation are pivotal in fostering enhanced financial development facilitating improved access to capital markets. This, in turn, enables the allocation of investments toward research, development, and the adoption of cleaner and more energy-efficient technologies Yu and Latif (2023). Reducing carbon emissions is facilitated by implementing sustainable practices across various sectors, as highlighted by Chun and Bharur (2023). The growing global concern over climate change and the need to transition to a more sustainable and environmentally friendly energy system has increased support for renewable energy and sustainable projects Soundarrajan and Vivek (2016). This support stems from the recognition that traditional fossil fuel-based energy sources are finite and contribute significantly to greenhouse gas emissions and other detrimental environmental impacts. Renew Financial systems that have undergone significant development demonstrate a heightened capacity to allocate funds towards various endeavors, including renewable energy projects, energy efficiency initiatives, and sustainable infrastructure. According to Hassan et al. (2022), the investments mentioned above have the potential to decrease dependence on fossil fuels and positively contribute to reducing emissions. Financial development facilitates efficient resource allocation, which effectively channels investments toward industries and technologies that exhibit a lower carbon intensity. Consequently, optimizing energy consumption leads to enhanced efficiency, thereby reducing emissions per unit of economic activity, as noted by Ren et al. (2022a).

FDI and CO_2

There is a significant and positive correlation between Foreign Direct Investment (FDI) and carbon emissions, with a 10% increase in FDI leading to a 0.17% increase in carbon emissions and vice versa.

FDI frequently results in heightened levels of industrialization within the host countries. The phenomenon under discussion, namely the stimulation of economic growth and job creation, has been observed to often coincide with a notable increase in manufacturing and energy-intensive production processes. This, in turn, leads to a consequential rise in carbon emissions, as highlighted by L. Du et al. (2022). Foreign investors often tend to allocate their investments towards sectors that require substantial energy, such as heavy manufacturing or resource extraction, within their countries Chiriluș and Costea (2023). According to Balsalobre-Lorente et al. (2023), it has been observed that specific industries exhibit a relatively larger carbon footprint as a result of their heavy dependence on fossil fuels and energy-intensive operations. In certain instances, foreign direct investment (FDI) tends towards host countries with comparatively less rigorous environmental regulations Santos and Forte (2021). According to Hassan et al. (2023), it is plausible that certain countries exhibit a diminished inclination or obligatory measures for foreign investors to embrace environmentally friendly and sustainable production methods. This could potentially result in elevated emissions levels within these countries. Infrastructure development is a crucial aspect of Foreign Direct Investment (FDI), as it frequently entails substantial investments in various forms of infrastructure, such as transportation networks, ports, and energy facilities. The construction and subsequent functioning of such infrastructure possess the potential to give rise to escalated emissions, particularly in cases where these projects are dependent on fossil fuels as their primary energy source Zhuang et al. (2022).

CF and CO_2

Long-term observations show a strong and opposite correlation between capital formation and carbon emissions, with a 10% increase in capital formation leading to a 0.18% decrease in carbon emissions and vice versa.

A trend of heightened capital formation frequently entails allocating financial resources toward developing and enhancing physical infrastructure, technological advancements, and industrial procedures Abbas et al. (2020). When a substantial proportion of the available capital is directed towards investments in clean and energy-efficient technologies, the outcome is a discernible decrease in carbon emissions. The effect in question is positively influenced by investments in renewable energy, energy-efficient buildings, and sustainable transportation systems, as stated by Liu et al. (2023). Energy efficiency improvements can be facilitated by allocating capital resources, which can effectively support adopting and implementing energy-efficient practices in diverse sectors. According to Sorrell et al. (2010), implementing investments in machinery and equipment that exhibit reduced energy consumption, enhancing industrial processes, and adopting energy-efficient technologies collectively contribute to a decrease in overall energy consumption. As a result, this reduction in energy consumption leads to a subsequent decrease in carbon emissions (Gao et al., 2020). The transition towards low-carbon infrastructure is frequently propelled by the capital formation process, which plays a pivotal role in facilitating the advancement of various sustainable initiatives. This includes developing public transportation systems, green buildings, and sustainable urban planning. These investments have been found to reduce emissions through their support of cleaner and more sustainable development practices Hepburn et al. (2021). The impact of governmental policies and incentives on capital formation can be observed in certain instances, particularly concerning reducing carbon emissions. According to Zhang et al. (2022) implementing procedures such as carbon pricing, emission reduction targets, and tax incentives for green investments can effectively channel capital toward low-carbon projects.

Trade and CO2

Based on long-term estimations, a robust and positive correlation has been identified between trade and carbon emissions. Specifically, it has been observed that a 10%

increase in trade is associated with an approximate 2.62% increase in carbon emissions. Conversely, a decrease in trade exhibits a corresponding reduction in carbon emissions. The development of international trade expansion has resulted in the progressive globalization of supply chains Gereffi et al. (2021). Consequently, the production of goods occurs in various global regions and necessitates extensive transportation, frequently reliant on non-renewable energy sources such as fossil fuels. The emissions associated with transportation and logistics activities are heightened due to the elongated supply chain, as Liu et al. (2020) highlighted. The trend of heightened consumption of carbon-intensive goods can be attributed to the facilitation provided by international trade, which enables nations to acquire diverse goods and resources from various corners of the globe. In certain instances, it has been observed that this phenomenon can result in a notable escalation in the utilization of carbon-intensive commodities, including but not limited to fossil fuels, heavy machinery, and energy-intensive manufactured goods. According to G. Hu et al. (2020) importing such goods has the potential to lead to increased emissions within the importing country. Many nations tend to specialize in manufacturing and exporting energy-intensive commodities, including but not limited to steel, cement, and chemicals. The industries above play a substantial role in generating emissions within national borders and globally Rahman et al. (2022). According to Muhammad et al. (2020), an escalation in the trade of these particular products can result in elevated levels of carbon emissions. Indirect emissions stemming from trade activities are commonly referred to as "embodied emissions." The phenomenon under consideration pertains to the situation wherein a nation imports commodities manufactured or produced in a foreign country with a significant level of greenhouse gas emissions. The inclusion of indirect emissions in the carbon footprint assessment of the importing country has been highlighted by (Yang et al., 2022).

HCC and CO2

Our long-term estimates show a statistically significant negative link between household consumption and carbon emissions. When household consumption rises 10%, carbon emissions fall 4.94%, and vice versa.

With the increase in household consumption, consumers are displaying a growing inclination towards environmental consciousness and a heightened awareness of the carbon footprint associated with their purchases. Increased awareness among consumers about the environmental impact of their choices can result in a shift towards products and services with lower carbon emissions Bülbül et al. (2020). According to a study by Heidenreich et al. (2017) there is a positive relationship between the increased demand for eco-friendly products and reduced emissions. The adoption of energy-efficient technologies and appliances, such as LED lighting, energy-efficient heating and cooling systems, and electric vehicles, can be influenced by increased household consumption Moglia et al. (2017). Certain technologies have been found to effectively decrease energy consumption and decrease the carbon emissions linked to household energy usage Wakeel et al. (2016). A shift towards sustainable lifestyles may accompany the trend of increased household consumption. This shift involves adopting recycling, composting, and reducing water and energy usage, engaging in sustainable behaviors can help reduce carbon emissions Fiksel et al. (2021). To mitigate household carbon emissions, governments and policymakers often employ a combination of incentives and regulations. These measures are designed to encourage individuals to adopt more sustainable practices. One common approach is the implementation of tax incentives, which provide financial benefits to households that invest in renewable energy installations or make energy-efficient upgrades to their homes. By offering these incentives, governments aim to promote the adoption of cleaner and more efficient technologies, ultimately reducing carbon emissions at the household level Zhang and Wang (2017).

4.4 ARDL-PMG

Table 6 ARDL-PMG

Long Run Equation

FD	0.071920	0.063263	1.136846
FDI	-0.065607	0.042220	-1.553935
CF	-0.111219	0.132698	-0.838135
TR	0.556231	0.105490	5.272846
HHC	-2.177159	0.200330	-10.86788
	Short Run Equation		
COINTEQ01	-1.027204	0.054612	-18.80899
D(FD)	0.104898	0.026394	3.974272
D(FDI)	-0.025953	0.024827	-1.045350
D(CF)	-0.403365	0.078010	-5.170715
D(TR)	0.538118	0.100104	5.375584
D(HHC)	-0.154866	0.186228	-0.831592
C	6.218049	0.349734	17.77934

Financial development and carbon emission

The impact of financial development on carbon emissions is a topic of interest in both the short- and long-term Shahzad et al. (2017). Financial development is frequently viewed as a positive force, yet let's recognize the negative consequences it can have on electricity consumption. In the short run, increased financial development can result in a surge in carbon emissions. The detrimental effect of financial development on carbon emissions in high-energy industries, including manufacturing, transportation, and construction, is significant in the short run Zhou et al. (2019). We must address this concerning trend and find ways to mitigate it Tao et al. (2023) & Hussain et al. (2023). Continuous financial development perpetuates consumption-driven growth models that prioritize short-term economic gains at the expense of environmental sustainability. This theory aligns with the works of Hammett (2023) on the effects of financial institutions. Financial institutions prioritize investments in carbon-intensive sectors, such as fossil fuels, despite the undeniable fact that these industries contribute significantly to greenhouse gas emissions (GHGs). This pursuit of higher returns demonstrates a blatant disregard for the environmental consequences and the urgent need to transition to more sustainable alternatives. The supposed preference for riskier assets is supposedly supported by specific findings in the literature, as demonstrated by Curtin et al. (2019). Undeniably, an increase in consumer spending is directly linked to financial development. However, this seemingly positive correlation comes at a significant cost - greater energy consumption and a subsequent surge in carbon emissions. This alarming consequence cannot be ignored or downplayed, as it poses a severe threat to our environment and exacerbates the already pressing issue of climate change. We must address and rectify this unsustainable consumption pattern before it irreversibly damages our planet. The claim that high consumer spending is a well-documented consequence of financial development driven by increased access to credit is highly questionable. The study conducted by Han et al. (2022) provided substantial evidence to support this assertion. Additionally, numerous factors contribute to consumer spending, and it is overly simplistic to attribute it solely to financial development and credit accessibility. Also, in the long-run, the impact of financial development on carbon dioxide emissions exhibits a non-linear relationship Duan et al. (2022). According to this existing research, it has been observed that financial development can contribute to increased CO_2 emissions. The alleged positive effect of financial development on carbon emissions is merely a result of the scale and structural effects, which can easily be argued as insignificant. On the other hand, the negative impact is undoubtedly significant and cannot be overlooked, as it occurs through technological implications. Therefore, despite its alleged benefits in promoting technological progress and innovation, financial development can also be attributed to the widespread adoption of carbon-intensive technologies and practices. Amin et al. (2022). A study published in Frontiers by Onofrei et al. (2022) revealed a significant finding regarding the relationship between economic growth and CO2 emissions in European Union (EU) countries. The study indicates that these two variables, namely economic growth and CO2 emissions, exhibit cointegration. This implies a long-term equilibrium relationship between the two factors, suggesting that financial development may positively influence carbon emissions within these countries. The presence of a robust financial sector has the potential to wield significant political influence and engage in lobbying activities aimed at mitigating the implementation of stringent environmental regulations. The phenomenon commonly referred to as "regulatory capture" has the potential to impede endeavors aimed at mitigating carbon emissions over an extended period Pagliari and Young (2016).

FDI and carbon emission

A shift towards services driven by FDI may be linked to a decrease in emissions. Conversely, a shift towards heavy manufacturing, influenced by FDI, can exacerbate emissions Szalavetz (2022). FDI frequently facilitates the transfer of advanced technologies and best practices, potentially augmenting domestic industries' energy efficiency. The research conducted by Ren et al. (2022b) and Fan and Hao (2020) have provided evidence to support the notion that foreign direct investment (FDI) inflows have a positive impact on the adoption of cleaner technologies within the host countries. Additionally, in the long-run FDI has the potential to play a significant role in facilitating the structural transformation of economies. This transformation entails shifting away from carbon-intensive industries towards more environmentally friendly and sustainable sectors. The reallocation of resources has the potential to exert long-term impacts on emissions. Foreign investors often place high importance on sustainability and environmental responsibility when conducting their operations. Also, they can invest in renewable energy projects such as solar, wind, or hydroelectric power generation. These projects can substitute traditional fossil fuel-based energy sources, consequently leading to a reduction in carbon emissions. The phenomenon above results in the allocation of resources towards developing and implementing more environmentally friendly production methods and utilizing sustainable energy sources. Consequently, this leads to a notable decrease in the emission of carbon dioxide and other greenhouse gases into the atmosphere Balcilar et al. (2023). FDI has the potential to facilitate the diffusion of knowledge and technology to domestic firms, thereby fostering the adoption of environmentally friendly practices. According to Fauzel et al. (2017) empirical study, evidence indicates that foreign direct investment (FDI) has the potential to influence domestic firms' environmental performance positively. Host countries frequently adopt measures to enhance their environmental regulations to attract FDI, aligning them with international standards. This strategic approach often yields immediate positive outcomes, such as notable pollution levels and carbon emissions reductions Marques and Caetano (2020). Throughout a prolonged period, foreign direct investment (FDI) has the potential to facilitate the advancement of green finance mechanisms and stimulate the emergence of novel clean technologies. The assertion made by the authors is substantiated by existing scholarly literature that examines the correlation between foreign direct investment (FDI) and green finance Alharbi et al. (2023) & S. Zhang et al. (2021).

Household consumption and carbon emission

Energy-efficient technologies and sustainable practices can reduce carbon emissions in households promptly. This method reduces residential energy consumption's environmental impact. Low-energy light bulbs and energy-saving appliances can help families reduce their carbon footprint. Proper insulation, efficient heating and cooling, and water conservation can further reduce carbon emissions. However, the long-term effectiveness of these measures may depend on factors like the availability and affordability of energy-efficient technologies, household willingness to adopt sustainable practices and energy consumption. ENERGY STAR appliances reduce energy consumption and emissions compared to less efficient devices. These appliances optimize energy use, reducing waste and carbon footprint Mustaffa and Kudus (2022). LED lighting has also reduced energy use and emissions. LED lights use less energy than incandescent bulbs but provide comparable or better lighting. Smart thermostats also improve heating and cooling system control, reducing energy use and emissions. These technologies allow individuals and households to contribute Sugsaisakon and Kittipongvises (2021). In the context of long-term implications, sustainable household consumption can transform consumer preferences, favoring the adoption of environmentally friendly products and services. The observed shift in consumer preferences towards environmentally friendly products has the potential to impact market demand significantly. As consumers increasingly prioritize sustainability, companies must adapt their production strategies to meet this evolving demand. Consequently, this shift can serve as a driving force for companies to invest in developing and producing greener alternatives Tran et al. (2022). The adoption of sustainable consumption practices, which encompass reducing, reusing, and recycling, has been widely recognized as a means to achieve immediate reductions in waste sent to landfills and the subsequent emissions associated with such waste disposal ÖZTÜRK and ASGHAR (2023). Sustainable consumption practices within households can generate spillover effects that may influence others in the community to adopt similar behaviors. This phenomenon can lead to a ripple effect characterized by reduced emissions and a more sustainable lifestyle overtime Frezza et al. (2019). Research suggests that households have the potential to mitigate carbon emissions by adopting various transportation strategies. Public transportation, carpooling, and electric vehicles are commonly recommended options that can significantly contribute to emission reduction in the short term Shaheen and Chan (2016). Consumers who prioritize environmental concerns frequently participate in advocacy efforts and support policies that foster sustainability. Such people often endorse measures such as carbon pricing and incentives for renewable energy sources. The potential outcome of this phenomenon is the initiation of enduring systemic transformations inclined towards reducing emissions. The authors Rabbani et al. (2023) argue that a rise in consumer demand for sustainable products and services has the potential to drive innovation. This increased demand can catalyze the development of cleaner technologies and environmentally friendly solutions. Promoting sustainable consumption has the potential to drive the adoption of circular economy practices, including but not limited to product sharing, remanufacturing, and waste-to-energy technologies. These practices aim to minimize resource extraction, reduce waste generation, and maximize the utilization of materials throughout their lifecycle. By encouraging individuals and businesses to consume more sustainably, we can create a shift towards a circular economy model that prioritizes resource efficiency and environmental preservation. In the opinion of Puntillo (2023), implementing these practices has the potential to result in long-term decreases in resource consumption and emissions.

Trade and carbon emission

The expansion of trade frequently requires the movement of goods across greater distances, leading to increased emissions from various modes of transportation, such as shipping, airfreight, and road transportation Ganapati and Wong (2023). The observed phenomenon exhibits a significant level of prominence in the immediate timeframe, characterized by a substantial increase in trade volumes. The trade phenomenon has been observed to incentivize countries to allocate their resources towards carbon-intensive industries to maintain their competitiveness within the global market. The phenomenon called "carbon lock-in" has a well-documented long-term effect Acemoglu et al. (2012). In response to global demand, nations may increase production levels in energy-intensive sectors, including manufacturing and mining. However, such a course of action can significantly increase emissions Meng et al. (2018). The presence of trade can potentially hinder the progress towards adopting cleaner and more sustainable technologies. Countries may persist in dependence on carbon-intensive technologies if they can import goods manufactured at lower production costs, which can be attributed to the lenient environmental standards implemented in foreign countries Kuo and Chou (2023). In the short term, trade can potentially lead to carbon leakage. This phenomenon occurs when emissions are reduced in one country due to decreased domestic production but simultaneously increase in another due to the amplified output in response to international demand Li et al. (2021). Over time, it has been observed that trade can create a strong motivation for countries abundant in natural resources to engage in the extraction and exportation of these resources at a pace that is not environmentally sustainable. This can result in detrimental consequences such as deforestation, loss of habitats, and increased emissions due to changes in land use Cong and Ren (2023). Moreover, it is worth noting that trade has the potential to result in emissions becoming "embodied" in the traded goods. This phenomenon occurs when a substantial proportion of emissions generated during the production process in one country are ascribed to the consumption of those goods in another country. The observed phenomenon leads to a persistent disconnection between the emissions accounting based on production and consumption Fu et al. (2021). Globalization has led to the expansion of supply chains, primarily driven by international trade. This intricate network of supply chains can contribute to long-term emissions increases—companies often source materials and components from various regions globally, each with its unique carbon footprint Cui et al. (2023) & Rehman et al. (2021).

Capital formation and Carbon emission

The phenomenon of capital formation has the potential to induce short-term declines in carbon emissions by its ability to facilitate investments in energy-efficient technologies and infrastructure. The investments made in these initiatives have been found to reduce energy consumption and emissions per unit of output significantly Ullah et al. (2023). Capital formation plays a crucial role in driving technological innovation. This can potentially bring about the emergence of cleaner and more sustainable technologies in the long run. The potential impact of these innovations across multiple sectors suggests the possibility of achieving long-term emissions reductions Sun (2022). In the short term, it is asserted that capital formation plays a crucial role in enhancing industrial processes and substituting obsolete machinery with more energy-efficient alternatives. This, in turn, is believed to result in immediate reductions in emissions Fragkos et al. (2017). Capital formation has the potential to facilitate the development and implementation of renewable energy infrastructure, including wind farms and solar power plants. Throughout a period, these investments gradually decrease the dependence on energy sources that have a high carbon content Mendoza and Ibarra (2023). In line with Mehndi and Chakraborty (2020), capital formation has the potential to facilitate the implementation of building retrofits and energy-efficient construction practices. This, in turn, can lead to decreased emissions associated with heating, cooling, and electricity consumption in both residential and commercial buildings. The capital formation process can bolster a society's ability to withstand and adapt to climate-related challenges, particularly those stemming from extreme weather events. According to the Intergovernmental Panel on Climate Change (IPCC, 2018), implementing resilient infrastructure and disaster preparedness measures can mitigate the long-term carbon footprint linked to recovery and adaptation endeavors. Investments in education and skill development are often regarded as a means of capital formation, potentially yielding a more educated and environmentally conscious workforce. This assertion is based on the understanding that education equips individuals with the knowledge and skills to navigate complex environmental challenges. By fostering a deeper understanding of environmental issues, such investments can contribute to developing a workforce better equipped to address and mitigate environmental concerns. However, it is essential to note that the extent to which investments in education and skill development directly translate into a more environmentally aware workforce may vary depending on various contextual factors, such as the quality of education provided and the availability of resources for environmental education. Further research is needed to comprehensively assess the impact of such investments on workforce environmental awareness. The phenomenon above has the potential to induce enduring alterations in behavior and promote decision-making that prioritizes environmental responsibility Sharma (2016).

Causality test: DH causality test

Table 7 DH causality test

Null Hypothesis:	**W-Stat.**	**Z bar-Stat.**	**Prob.**	**Remarks**	

FD does not homogeneously cause CO2	0.43223	-1.91948	0.0549	FD □□ CO2	
CO2 does not homogeneously cause FD	0.44547	-1.87876	0.0603		
FDI does not homogeneously cause CO2	0.91127	-0.43944	0.6603	FDI □□ CO2	
CO2 does not homogeneously cause FDI	0.74632	-0.94928	0.3425		
FDB does not homogeneously cause CO2	0.43764	-1.90369	0.0570	FDB □□ CO2	
CO2 does not homogeneously cause FDB	0.63844	-1.28122	0.2001		
HHC does not homogeneously cause CO2	0.81361	-0.75193	0.4521	HHC □□ CO2	

CO2 does not homogeneously cause HHC	0.33684	-2.21046	0.0271	
CF does not homogeneously cause CO2	0.94899	-0.33420	0.7382	CF □□ CO2
CO2 does not homogeneously cause CF	1.13851	0.24701	0.8049	
TR does not homogeneously cause CO2	0.62808	-1.31668	0.1879	TR □□ CO2
CO2 does not homogeneously cause TR	0.54290	-1.57888	0.1144	
FDI does not homogeneously cause FD	0.31908	-2.26398	0.0236	FDI □□ FD
FD does not homogeneously cause FDI	3.64839	7.90406	3.E-15	

FDB does not homogeneously cause FD	0.58083	-1.46223	0.1437	FDB □□ FD	
FD does not homogeneously cause FDB	0.55907	-1.52917	0.1262		
HHC does not homogeneously cause FD	0.36595	-2.11676	0.0343	HHC □□ FD	
FD does not homogeneously cause HHC	0.32011	-2.25516	0.0241		
CF does not homogeneously cause FD	0.43387	-1.91224	0.0558	CF □□ FD	
FD does not homogeneously cause CF	3.54163	7.50562	6.E-14		
TR does not homogeneously cause FD	0.29844	-2.32364	0.0201	TR □□ FD	
FD does not homogeneously cause TR	1.70156	1.93561	0.0529		

FDB does not homogeneously cause FDI	3.72942	8.22818	2.E-16	FDB □□ FDI	
FDI does not homogeneously cause FDB	0.32209	-2.25848	0.0239		
HHC does not homogeneously cause FDI	2.16676	3.34692	0.0008	HHC □□ FDI	
FDI does not homogeneously cause HHC	0.72585	-1.02626	0.3048		
CF does not homogeneously cause FDI	1.06441	0.00519	0.9959	CF □□ FDI	
FDI does not homogeneously cause CF	0.38265	-2.06863	0.0386		
TR does not homogeneously cause FDI	0.58476	-1.45249	0.1464	TR □□ FDI	

FDI does not homogeneously cause TR	0.92390	-0.41631	0.6772		
HHC does not homogeneously cause FDB	0.37128	-2.10356	0.0354	HHC □□ FDB	
FDB does not homogeneously cause HHC	0.41554	-1.96879	0.0490		
CF does not homogeneously cause FDB	0.47915	-1.77512	0.0759	CF □□ FDB	
FDB does not homogeneously cause CF	3.53991	7.57419	4.E-14		
TR does not homogeneously cause FDB	0.07757	-3.00558	0.0027	TR □□ FDB	
FDB does not homogeneously cause TR	1.26297	0.62640	0.5311		

CF does not homogeneously cause HHC	1.54587	1.48522	0.1375	CF □□ HHC	
HHC does not homogeneously cause CF	0.36125	-2.13548	0.0327		
TR does not homogeneously cause HHC	0.57159	-1.49232	0.1356	TR □□ HHC	
HHC does not homogeneously cause TR	3.20049	6.55000	6.E-11		
TR does not homogeneously cause CF	0.38155	-2.07445	0.0380	TR □□ CF	
CF does not homogeneously cause TR	5.38181	13.2604	0.0000		

Explanation:

1. **FD and CO2**

Our extensive longitudinal analysis observed a significant inverse correlation between financial development and carbon emissions. The finding suggests that a 10% increase in financial development is linked to an approximate reduction of 0.15% in carbon emissions. Conversely, a decrease in financial development is associated with a proportional increase in carbon emissions. Several factors can be examined to explain the underlying reasons for the inverse relationship between financial development and carbon emissions. The phenomenon of transitioning from carbon-intensive industries to cleaner and technologically advanced sectors is observed as financial development progresses [Li, Wu [20]]. According to Akomea-Frimpong, Kukah [21], well-established financial markets and institutions can play a crucial role in funding cleaner technologies and sustainable projects—the observed transition results in a notable decrease in carbon emissions per unit of economic output. The correlation between robust financial development and increased investment in sustainable practices has been widely observed. It is commonly acknowledged that a strong financial environment tends to create favorable conditions for allocating resources toward sustainability and environmental initiatives [Ng, Lye [22]]. The allocation of financial resources encompasses a wide range of industries, such as the provision of funds for projects related to renewable energy, the advancement of energy-efficient technologies, and the enforcement of rigorous environmental regulations. Investments of this nature have been found to positively impact the reduction of carbon emissions, as indicated by the research conducted by Yasmeen, Yao [23].Efficiency gains can be achieved by utilizing developed financial systems, as they facilitate the effective allocation of resources. According to Namany, Al-Ansari [24], capital allocation is focused on industries and technologies that possess inherent energy efficiency, leading to a decrease in energy consumption and its subsequent emissions. Financial development has the potential to play a crucial role in facilitating economic diversification by mitigating the dependence on carbon-intensive industries. According Shahbaz, Topcu [25], economies that exhibit diversification tend to possess a greater capacity to respond to fluctuations in market demands and environmental regulations effectively. Consequently, such economies are more likely to achieve reduced emissions levels. In promoting sustainable practices, it is noteworthy to consider the potential role of developed financial institutions. These institutions possess the capacity to encourage businesses to embrace environmentally responsible initiatives through the provision of preferential financing terms [Kumar, Nadeem [26]] . By offering such incentives, financial institutions can effectively motivate firms to adopt sustainable practices, thereby contributing to the overall advancement of environmental stewardship. As mentioned earlier by Akomea-Frimpong, Adeabah [27], the study highlights the incentivization of firms to mitigate their emissions through financial benefits. A corresponding increase in consumer awareness regarding environmental issues often accompanies the rise of economies [Tang, Zhang [28]]. The alteration of consumption patterns and preferences may ensue, wherein consumers prefer products and services with diminished carbon footprints. According to Thomas, Murfield [29], it has been observed that financially developed markets exhibit a higher degree of responsiveness towards shifts in demand. Technological advancement and innovation are pivotal in fostering enhanced financial development facilitating improved access to capital markets. This, in turn, enables the allocation of investments toward research, development, and the adoption of cleaner and more energy-efficient technologies [Yu and Latif [30]]. Reducing carbon emissions is facilitated by implementing sustainable practices across various sectors, as highlighted by Chun and Bharur [31]. The growing global concern over climate change and the need to transition to a more sustainable and environmentally friendly energy system has increased support for renewable energy and sustainable projects [Soundarrajan and Vivek [32]]. This support stems from the recognition that traditional fossil fuel-based energy sources are finite and contribute significantly to greenhouse gas emissions and other detrimental environmental impacts. Renew Financial systems that have undergone significant development demonstrate a heightened capacity to allocate funds towards various endeavors, including renewable energy projects, energy efficiency initiatives, and sustainable infrastructure. According to Hassan, Batool [33], the investments mentioned above have the potential to decrease dependence on fossil fuels and positively contribute to reducing emissions. Financial development facilitates efficient resource allocation, which effectively channels investments toward industries and technologies that exhibit a lower carbon intensity. Consequently, optimizing energy consumption leads to enhanced efficiency, thereby reducing emissions per unit of economic activity, as noted by Ren, Hao [34].

The affinity between financial development and carbon dioxide emissions is complex, as financial development can both influence and be influenced by CO2 emissions.

Efficient financial markets and institutions are often associated with financial development. This development can support and promote investment in green and sustainable technologies. The allocation of funds to renewable energy projects, energy-efficient technologies, and other clean initiatives has been found to have the potential to reduce CO2 emissions, as suggested by Du et al. (2023). Resource allocation is crucial to economic systems, particularly in addressing environmental concerns such as carbon emissions. Developed financial systems have the potential to play a significant role in this process by efficiently allocating resources. By directing capital away from carbon-intensive industries and towards cleaner and more sustainable sectors, these systems can contribute to the transition towards a low-carbon economy. This reallocation of resources is essential for mitigating the negative environmental impacts associated with carbon-intensive industries and promoting the development of sustainable alternatives. The reallocation of resources has the potential to play a role in reducing emissions in the long run Dikau and Volz (2023). The relationship between financial development and economic growth is frequently observed and studied in economics. It is commonly believed that financial development plays a significant role in fostering economic growth. Although rapid economic growth is often associated with increased emissions due to more significant industrial activity and energy consumption, it is crucial to consider the potential role of financial development in facilitating the transition to cleaner technologies. This transition can ultimately lead to reductions in emissions Moghadam and Dehbashi (2018).

FD□CO2

The presence of elevated levels of carbon dioxide (CO2) emissions and the subsequent degradation of the environment has the potential to introduce various risks to financial institutions and markets. The value of investments and financial assets can be influenced by multiple events, including extreme weather, resource scarcity, and regulatory changes that aim to mitigate emissions Park and Kim (2020). Implementing policies designed to mitigate CO_2 emissions, such as carbon pricing mechanisms, has the potential to influence financial markets and institutions. The authors Song et al. (2019) suggest that there is a possibility for the creation of novel financial instruments, such as carbon credits, which could impact investment choices. This influence on investment decisions may result in a redistribution of capital away from industries heavily reliant on carbon emissions. The transition to a low-carbon economy poses potential risks for financial institutions. According to Monnin (2018) and Semieniuk et al. (2021), it has been observed that investments made in carbon-intensive industries have the potential to become stranded assets. This occurs when changing regulations or market dynamics render these investments obsolete or unprofitable. Consequently, individuals or organizations that have invested in such industries may experience significant financial losses. The heightened recognition of climate-related risks has resulted in a surge in the need for climate-related financial disclosure. Financial institutions face increasing scrutiny for disclosing their exposure to climate risks, which can significantly affect their ability to secure capital and maintain investor confidence Zitti and Guttormsen (2023).

2. FDI□□CO2

The connection between Foreign Direct Investment (FDI) and carbon dioxide (CO_2) emissions is complex, as FDI can affect and be affected by CO_2 emissions, with various factors influencing this relationship.

FDI□CO2

Foreign direct investment (FDI) frequently encompasses the transmission of sophisticated technologies and optimal operational methods from economically advanced nations to less developed countries. The adoption of cleaner and more energy-efficient production methods as a result of technology transfer has the potential to reduce CO_2 emissions Dahlman and Westphal (2019). Foreign investors often prefer allocating their investments towards green and sustainable projects in host countries. This inclination towards environmentally friendly initiatives can be attributed to various factors, such as the growing global awareness of climate change and the increasing demand for sustainable solutions. By prioritizing green investments, foreign investors aim to align their financial interests with environmental objectives, thereby contributing to the transition towards a more sustainable and low-carbon economy. Investments in various initiatives such as renewable energy projects, energy-efficient manufacturing, and eco-friendly infrastructure have been suggested as potential strategies to reduce emissions Ye and Dela (2023). Host countries' implementation of stringent environmental standards can be seen as a strategic move to attract foreign direct investment (FDI). By aligning their regulations and standards with global norms, these countries aim to create a favorable business environment that appeals to multinational corporations seeking to invest in environmentally responsible practices. This approach recognizes the increasing importance of sustainability and environmental stewardship in the global business landscape. According to Coenen et al. (2021), implementing stricter environmental requirements can result in immediate reductions in emissions by prompting industries to comply with these regulations.

FDI□CO_2

The presence of elevated levels of carbon dioxide (CO_2) emissions and the associated environmental concerns holds the potential to generate regulatory risks for foreign investors Hussain et al. (2020). The profitability of carbon-intensive investments may be influenced by host countries' imposition of stricter emissions regulations or carbon pricing mechanisms Bose et al. (2021). Foreign investors are potentially exposed to transition risks that arise from the process of transitioning to a low-carbon economy. The potential for investments in carbon-intensive industries to become stranded assets is a concern that has been highlighted by Semieniuk et al. (2021). This concern arises from the changing regulatory and market dynamics surrounding carbon emissions. As governments and international bodies increasingly prioritize climate change mitigation, there is a growing likelihood of stricter regulations being imposed on carbon-intensive industries. Such laws could significantly impact the profitability and viability of these industries, potentially rendering their assets stranded. Market dynamics are also shifting as investors and consumers become more conscious of the environmental impact of their choices. This shift in preferences could decrease demand for products and services offered by carbon-intensive industries, further exacerbating the risk of stranded assets. Therefore, investors must assess the long-term viability of investments in carbon-intensive carefully Bos and Gupta (2019). The increasing recognition of environmental concerns and the impact of climate change can shape consumer preferences and subsequently affect the demand for sustainable products Yu et al. (2017). The alignment of foreign investors' operations with environmentally conscious consumer preferences can be incentivized, as suggested by Tran et al. (2020). The prominence of climate-related risks and emissions reporting requirements is increasing Braasch and Velte (2023). Foreign investors may encounter various challenges when disclosing their exposure to climate risks. These challenges can arise from stakeholders, who may demand greater transparency and accountability, as well as regulatory authorities, who may impose stricter disclosure requirements. The pressure to disclose climate risks can have significant implications for foreign investors, potentially influencing their investment decisions. This underscores the importance of considering climate risks as crucial in investment strategies and decision-making processes Nowiski (2018) & Cadez et al. (2019).

3. TR□□CO2

The connection between international trade and carbon dioxide emissions is intricate, as trade can impact emissions, and emissions can, in turn, affect trade dynamics.

TR□CO2

According to Du et al. (2020), there is evidence to suggest that increased international trade has the potential to stimulate economic growth. This growth, in turn, can lead to higher industrial activity and energy consumption. However, it is essential to note that this initial surge in economic activity and energy consumption may also result in higher CO2 emissions. The phenomenon of emissions being "embodied" in trade refers to the situation where a considerable proportion of emissions generated during the production process in one country are assigned to the consumption activities in another country. The phenomenon being discussed has potentially led to increased emissions in countries that heavily depend on importing carbon-intensive goods, as highlighted by Kirikkaleli and Oyebanji (2022).

Efficiency gains are achieved through trade, enabling countries to allocate resources towards producing goods with a comparative advantage Mutreja et al. (2018). This concept of comparative advantage suggests that governments should focus on delivering goods in which they are relatively more efficient, thereby maximizing their overall productivity and output. Countries specializing in producing these goods can enhance their efficiency levels and ultimately benefit from increased economic growth and welfare. The findings of Ike et al. (2020) suggest that implementing this approach could improve resource allocation efficiency and potentially reduce emissions per unit of output.

The process of technology transfer through trade has the potential to enable the dissemination of cleaner and more energy-efficient technologies from advanced economies to developing nations Alam and Murad (2020). According to Ahakwa et al. (2023), the transfer of technology has the potential to play a significant role in reducing emissions in recipient countries.

TR□CO2

Implementing more stringent environmental regulations, such as emissions limits and carbon pricing mechanisms, can impact the production costs of industries heavily relying on carbon-intensive processes. The impact of this phenomenon on the competitiveness of goods in international markets and its potential to influence trade patterns has been highlighted by Xu et al. (2022). Consumer preferences can change due to increased awareness of climate change and environmental issues. The growing recognition of these concerns may prompt individuals to reevaluate their consumption patterns and prioritize products and services that align with their ecological values. This shift in preferences can be attributed to a heightened sense of responsibility toward mitigating the negative impacts of human activities on the environment. As consumers become more informed about the consequences of their choices, they may exhibit a greater inclination towards sustainable and eco-friendly options Kurowski et al. (2022). Consequently, businesses and industries must adapt to these evolving preferences to remain competitive in the market. Consumers' choice of eco-friendly and low-carbon products has the potential to impact trade dynamics. This is because such consumer preferences can increase demand for sustainable goods (Ihemezie et al., 2018). Trade barriers, such as tariffs, can be implemented by certain countries to address high emissions associated with the production of goods Balistreri et al. (2019). This approach, often called carbon border adjustment, aims to promote environmental objectives. The impact of policies on the flow of goods in international trade has been extensively studied by Goulder and Schein (2013). Their research highlights the potential consequences of such policies on the efficiency and effectiveness of global trade.

4. **HHC□□CO2**

The relationship between household consumption and CO2 emissions is vital for understanding how individual choices can impact climate change, as consumption patterns can influence emissions, and emissions can affect consumption.

HHC□CO2

The decision-making process regarding consumption choices is fundamental to households' behavior. Within this context, families are faced with the task of determining what products and services to purchase and how to utilize them effectively. This process involves a series of considerations, such as evaluating the benefits and costs associated with different options, assessing the quality and durability of products, and considering the potential impact on the environment and society. By analyzing these factors, households aim to make informed decisions that align with their preferences, needs, and budget constraints Schanes et al. (2016). Consequently, understanding the dynamics of consumption choices is crucial for researchers and policymakers alike, as it sheds light on the underlying drivers of consumer behavior and its implications for various economic and social outcomes. The choices made by individuals can directly impact emissions, as there is evidence to suggest that certain products and activities are associated with higher carbon footprints. According to Wiedenhofer et al. (2018), adopting practices such as selecting energy-efficient appliances, reducing driving frequency, and decreasing meat consumption can reduce emissions. The consumption of energy in households, encompassing electricity and heating, has been identified as a substantial factor in generating carbon dioxide (CO2) emissions Yang and Liu (2017). Implementing energy-efficient practices, such as the utilization of LED lighting, improved insulation, and the adoption of programmable thermostats, has been found to significantly reduce energy consumption and emissions, as highlighted by IEA (2016). The choices individuals make regarding transportation have a substantial influence on emissions. Factors such as car ownership, mode of travel, and commuting habits all play a role in determining the level of emissions produced Ding et al. (2018). According to Ercan et al. (2022), households can choose public transportation, carpooling, biking, or walking as means of transportation, potentially reducing their carbon footprint. The generation of waste is a multifaceted issue that necessitates careful consideration of waste management and disposal choices. According to Alhazmi et al. (2021), reducing, reusing, and recycling products has been identified as a potential strategy to mitigate the emissions of landfilling and waste incineration.

HHC□TR

The relationship between higher energy costs and increased CO2 emissions has been widely acknowledged and studied. It is well-established that burning fossil fuels, such as coal and oil, for energy production releases significant amounts of CO2 into the atmosphere. This, in turn, contributes to the greenhouse effect and climate change. As energy costs rise, households may experience a direct impact on their consumption patterns. The increased expenses associated with energy consumption can lead to changes in behavior and decision-making processes Razmjoo et al. (2021). For instance, individuals may opt for energy-efficient appliances and implement energy-saving practices. The increase in energy costs has been observed to drive households to embrace energy-saving technologies and adopt behaviors that promote energy efficiency. For instance, research conducted by Wittenberg and Matthies (2016) suggests that households may opt to install solar panels or utilize energy-efficient appliances to respond to rising energy bills. The impacts of climate change, particularly in the form of extreme weather events, have the potential to affect household consumption patterns significantly Batten et al. (2020). One potential outcome of heightened awareness regarding the potential hazards of climate change is that households may allocate resources toward acquiring climate-resilient infrastructure or insurance Li and Grant (2022). Regulatory changes, precisely policies designed to mitigate emissions, such as implementing carbon pricing mechanisms, have the potential to influence the cost and accessibility of specific products and services Zakeri et al. (2015). The alterations mentioned can impact household consumption as individuals actively pursue options with lower carbon footprints Štreimikienė (2014). Consumer preferences can be influenced by the increasing awareness and concern regarding environmental issues, particularly climate change. This growing consciousness among consumers has the potential to significantly impact their preferences when it comes to purchasing goods and services. The selection of eco-friendly and sustainable products by households has been observed to have a significant impact on the demand for low-carbon goods and services Zeng et al. (2023). Households implement adaptation measures in response to the impacts of climate change. These measures aim to influence consumption patterns to mitigate the effects of climate change. The adoption of flood-resistant housing and drought-tolerant landscaping is likely to increase, as suggested by Song (2022).

5. CF□□CO2

The connection between capital formation and CO2 emissions is intricate, as capital formation affects emissions, and emissions, in turn, affect capital formation.

CF□CO2

The capital formation process encompasses allocating resources towards investments in physical, human, and natural capital. The allocation of capital towards green and sustainable technologies, such as renewable energy and energy-efficient infrastructure, has been found to have the potential to result in a reduction of CO_2 emissions, as Pazowski (2015) highlighted. The implementation of energy-efficient technologies and practices in industries and buildings can be supported by capital formation. According to Kamal et al. (2021), evidence suggests that these investments can decrease energy consumption and, as a result, reduce emissions.

The transition to low-carbon infrastructure is a complex process that requires careful consideration of various factors. One key driver of this transition is capital formation, which is crucial in facilitating the development of low-carbon transportation, urban planning, and manufacturing infrastructure Cao et al. (2020). By allocating financial resources to these areas, we can effectively address the challenges associated with high carbon emissions and promote sustainable development. However, it is essential to critically analyze the potential impacts and limitations of capital formation in driving this transition and consider alternative approaches that may complement or enhance its effectiveness. According to the Intergovernmental Panel on Climate Change Abubakar and Dano (2020), investments in sustainable transportation and urban design have the potential to reduce emissions. This implies that by adopting such measures, it is possible to mitigate the environmental impact associated with transportation and urban development. However, it is essential to note that further research and analysis are required to understand the extent of this impact fully and to determine the most effective strategies for achieving emission reductions in these areas.

CF□CO2

The increase in carbon dioxide (CO_2) emissions and the subsequent environmental concerns can prompt the implementation of more stringent regulations to reduce emissions. According to Chen et al. (2023), capital-intensive industries could encounter higher compliance costs and increased uncertainty, which may affect their investment decisions Dorsey (2019). Implementing carbon pricing mechanisms, such as carbon taxes or cap-and-trade systems, can significantly influence the financial viability of projects that rely heavily on carbon-intensive activities X. Hu et al. (2020). By imposing a cost on carbon emissions, these mechanisms aim to internalize the negative externalities associated with greenhouse gas emissions and incentivize adopting cleaner and more sustainable practices. As a result, companies engaged in carbon-intensive projects may face increased costs and reduced profitability, as they must account for the carbon emissions associated with their activities. This can create a financial disincentive for such projects and encourage businesses to explore alternative, less carbon-intensive options. The impact of carbon pricing on profitability is a crucial consideration for policymakers and stakeholders when designing and implementing these mechanisms, as it can influence the overall effectiveness and acceptance of carbon pricing policies. According to Louche et al. (2019), there is a possibility that companies might reassess their capital allocation strategies and show a preference for investments that are aligned with low-carbon objectives. Transition risks can arise for companies with significant investments in carbon-intensive industries, which may face challenges in the future due to evolving market dynamics and regulatory changes. These risks stem from the potential decrease in the viability and profitability of such industries due to shifting consumer preferences, advancements in clean technologies, and stricter environmental regulations Semieniuk et al. (2021). Consequently, companies heavily reliant on carbon-intensive sectors may need help adapting to these changes and may experience financial losses or diminished market competitiveness. The presence of stranded assets and subsequent financial losses has been identified as a potential consequence. Consumers' awareness of climate change and environmental issues can significantly influence their preferences and choices when purchasing products and services. This increased awareness can increase demand for sustainable and low-carbon options Liu et al. (2017). As consumers become more informed about the environmental impact of their consumption patterns, they are likely to prioritize products and services that align with their values and contribute to mitigating climate change. This shift in consumer preferences can affect businesses, as they may need to adapt their offerings to meet the growing demand for sustainable and low-carbon alternatives. The potential response of capital formation to changing preferences is explored by Eckersley (2020), who suggest that investments may be redirected towards greener options.

The pressing need to mitigate CO2 emissions has the potential to spur advancements in low-carbon technologies He (2016). According to Hansen (2018), the capital formation process can facilitate research and development activities in various domains. This can contribute to the advancement of technology and the emergence of fresh investment prospects.

CHAPTER V: DISCUSSION

5.1 Conclusions

The research paper investigated the connections between financial development, carbon dioxide emissions, foreign direct investment, international trade, household consumption, and capital formation. The study aimed to understand how these variables interact and influence each other in the context of environmental sustainability and economic growth.

The findings revealed that financial development has a complex relationship with CO2 emissions. Developed financial systems can facilitate the transition to a low-carbon economy by efficiently allocating resources away from carbon-intensive industries and towards sustainable alternatives. This reallocation of resources is crucial for mitigating the negative environmental impacts of CO2 emissions. Additionally, financial development can promote economic growth, which can reduce emissions when coupled with investments in green technologies.

FDI was found to have a significant impact on CO2 emissions. It can promote cleaner and more energy-efficient technologies in host countries, aligning financial interests with environmental objectives. However, foreign investors may face regulatory risks and potentially stranded assets in carbon-intensive industries. International trade can stimulate economic growth and increase emissions, especially in countries that heavily import carbon-intensive goods. However, trade can drive efficiency gains and encourage the allocation of resources to produce goods with a comparative advantage, which may reduce emissions per unit of output. Household consumption patterns were identified as a crucial factor influencing emissions. Choices related to energy consumption, transportation, and waste management can significantly impact a household's carbon footprint. Rising energy costs and climate change awareness can drive households to adopt energy-efficient practices and sustainable behaviors. Capital formation is pivotal in reducing CO2 emissions by allocating resources to green and sustainable technologies.

Investments in low-carbon infrastructure and technology development can enhance energy efficiency and contribute to emissions reduction.

To conclude, this study highlights the intricate relationships between financial development, foreign direct investment, international trade, household consumption, capital formation, and CO_2 emissions. While each variable has its unique impact, the overall message is clear: proactive measures and policies are necessary to harness these relationships for sustainable economic growth and environmental conservation.

5.2 Suggestions for Future Research

This research paper provides several policy suggestions to promote sustainable economic growth and environmental conservation. These suggestions include:

1. Promoting green investments: Governments should incentivize financial institutions to prioritize green and sustainable technology investments through tax incentives, subsidies, and preferential loan terms.

2. Implementing stricter emissions regulations: Governments should enforce stringent emissions regulations and carbon pricing mechanisms such as carbon taxes, cap-and-trade systems, and emissions limits to discourage carbon-intensive industries.

3. Encouraging technology transfer and capacity building: Governments should support technology transfer from developed to developing nations through foreign direct investment and provide capacity building to adopt cleaner and more energy-efficient technologies effectively.

4. Launching consumer education campaigns: Public awareness campaigns should be launched to educate consumers about the environmental impact of their consumption choices and empower them to make eco-friendly decisions.

5. Promoting transportation and energy efficiency: Governments should promote energy-efficient transportation options, incentivize electric vehicles, and invest in clean public transportation infrastructure. They should also encourage households and businesses to adopt energy-saving technologies and practices.

6. Implementing waste management and recycling programs: Governments should implement waste reduction, recycling, and composting programs to minimize landfilling and waste incineration. They should set recycling targets and provide support for recycling facilities and initiatives.

7. Enforcing climate-related financial disclosure: Governments should enforce climate-related financial disclosure requirements for financial institutions and corporations to promote transparency and responsible investment choices.

8. Allocating funding for research and development: Resources should be allocated to research and development efforts focused on low-carbon technologies to foster innovation in sectors such as renewable energy, energy-efficient manufacturing, and sustainable urban planning.

9. Considering carbon border adjustment mechanisms: Governments should consider implementing carbon border adjustment mechanisms to address emissions associated with imported goods and promote international trade in low-carbon products.

10. Supporting climate resilience initiatives: Governments should support climate resilience initiatives at the household level by offering incentives for climate-resilient infrastructure and insurance to help vulnerable communities adapt to climate change impacts.

11. Developing long-term planning strategies: Governments should develop comprehensive, long-term strategies that integrate economic growth and emissions reduction goals, engaging stakeholders from the public and private sectors.

12. Establishing monitoring and evaluation systems: Governments should establish robust monitoring and evaluation systems to track the effectiveness of policies in reducing CO_2 emissions and promoting sustainable economic growth, making adjustments based on data-driven insights.

The proposed policies tackle the intricate connections between financial development, foreign direct investment, international trade, household consumption, capital formation, and carbon dioxide emissions. By adopting a mix of these policies, governments, and institutions can simultaneously strive for economic growth and environmental preservation.

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