The Conditional Interplay of Green Finance and Governance in Shaping Carbon Emissions: Evidence from G7 Countries
UNITED KINGDOM, UNITED STATES OF AMERICA, JAPAN, CANADA, FRANCE, ITALY, GERMANY

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BY

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A final year project submitted in partial fulfilment of the requirement for the degree of

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LIST OF ABBREVIATIONS

BPLM	Breusch-Pagan Lagrangian Multiplier
CO_2	Carbon Dioxide
CS-ADRL	Cross Sectional Autoregressive Distributed Lag
CSD	Cross-sectional Dependence
EI	Energy Intensity
EIA	Energy Information Administration
ESG	Environmental, Social and Governance
ETS	Emissions Trading System
FEM	Fixed Effect Model
GDP	Gross Domestic Product
GF	Green Finance
GHG	Greenhouse Gas
GOV	Governance
IPCC	Intergovernmental Panel on Climate Change
KFW	Kreditanstalt für Wiederaufbau
LULUCF	Land Use, Land-Use Change, and Forestry
MT	Metric Tons
OLS	Ordinary Least Square
RD&D	Research, Development, and Demonstration
REM	Random Effect Model
RENE	Renewable
SDG	Sustainable Development Goals
UK	United Kingdom
US	United States of America

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PREFACE

In this research, we examine how two exogenous variables, such as green finance and the effectiveness of governance impact on the carbon (CO_2) emission in G7 countries which consists of Canada, France, Germany, Italy, Japan, the United Kingdom, and United States between the year 2000-2022. G7, as a cluster of developed economies, provides a significant contribution to CO_2 emissions in the world, with a huge portion of the cumulative industrial emissions. Their efforts and influence are thus important in developing global policies to curb environmental problems.

The necessity to mitigate the emission of CO_2 has been emphasized by such international organizations like the Intergovernmental Panel on Climate Change (IPCC), which insists on achieving net-zero emission by 2050 to curb global warming. In the case of the G7, this not only requires bold promises, but it entails practical and effective actions. It is against this background that two exogenous drivers such as green finance and governance are perceived to be critical. Green finance offers the funding of renewable energy, clean technology and low-carbon infrastructure while governance provides the rules and policies, and accountability structures needed to ensure it is successfully implemented.

The aim of this research is to investigate the interactive term between the two independent variables, and their effect on the CO_2 emission in the G7. By doing so, it fills the knowledge gap on whether financial flows to sustainability can meet their desired objectives with the support, or restriction, of governance structures.

ABSTRACT

This research examines the interactive between the two key factors which how green finance and governance impact on carbon (CO_2) emissions in the G7 nations, Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States between year 2000 and 2022. The dependent variable, CO_2 emissions has been one of the main concerns of the developed economies that are known to contribute a huge portion of the world emissions. The use of green bonds, sustainable investments and funds to finance renewable energy is considered as a financial instrument to speed up the decarbonization, whereas effective governance is the ability to offer the regulatory framework, transparency and policy implementation that will hold accountability and progress. The study investigates the effects of these variables separately and in combination on the CO_2 emissions and empirically examines the issue of whether effective governance can amplify the effect of green finance in reducing carbon emissions. It is aligned with the Sustainable Development Goals (SDG), specifically SDG 7 (Affordable and Clean Energy), and SDG 13 (Climate Action) as the purpose is to make an impact on the global debate on the ways of reducing emissions. These findings highlight that the interactive between finance, governance, and CO_2 emissions that requires specific measures depending on the emission reduction objectives.

Chapter 1: Introduction

1.0 Introduction

This research outlines the relationship between carbon dioxide emissions (CO_2) and the factors affecting among the G7 countries of Canada, France, Germany, Italy, Japan, the United Kingdom and the United States from the years 2000 until 2022. Chapter 1 consists of the research background mainly discussing about G7 countries with the concept of green finance and government effectiveness affecting CO_2 emissions and moving forwards to the problem statement, research objectives and research questions and significance of the study.

1.1 Research Background

Carbon dioxide (CO_2) emissions is one of the main factors contributing to the climate change making it a major issue in the 21st of century (National Aeronautics and Space Administration, 2024). CO_2 emissions is one of the greenhouse gases causing global warming, highlighting the G7 countries including Canada, France, Germany, Italy, Japan, the United Kingdom and the United States that consider to be a substantial part in global emissions through their large economies sector (Pata & Aydin, 2022). For the past 25 years, report show in the environmental, social and governance (ESG) data including CO_2 emissions has increase as most of the company are aware of the need to solve climate change issue (Amel-Zadeh & Serafeim, 2018). The urgency of reducing CO_2 emissions has bring up by the Intergovernmental Panel on Climate Change (Intergovernmental Panel on Climate Change, 2022), stating that to hold an average increase in global temperatures to rise 1.5°C to 2°C of net zero global emissions are to be reach by the year 2050. To meet the climate goals set by Intergovernmental Panel on Climate Change (IPCC), the world needs to cut CO_2 emissions by 45% before year 2030 compared to year 2010 of CO_2 emissions emitted (Zero Carbon Analytics, 2022). The research focuses on how CO_2 emissions are impact by two exogenous variables, green finance and governance effectiveness in the G7 countries and how these drivers work together to fuel decarbonization and reduce climate change. The research focuses on how CO_2 emissions impact by two exogenous variables, green finance and governance effectiveness in the G7 countries and how these drivers work together to fuel decarbonization and reduce climate change.

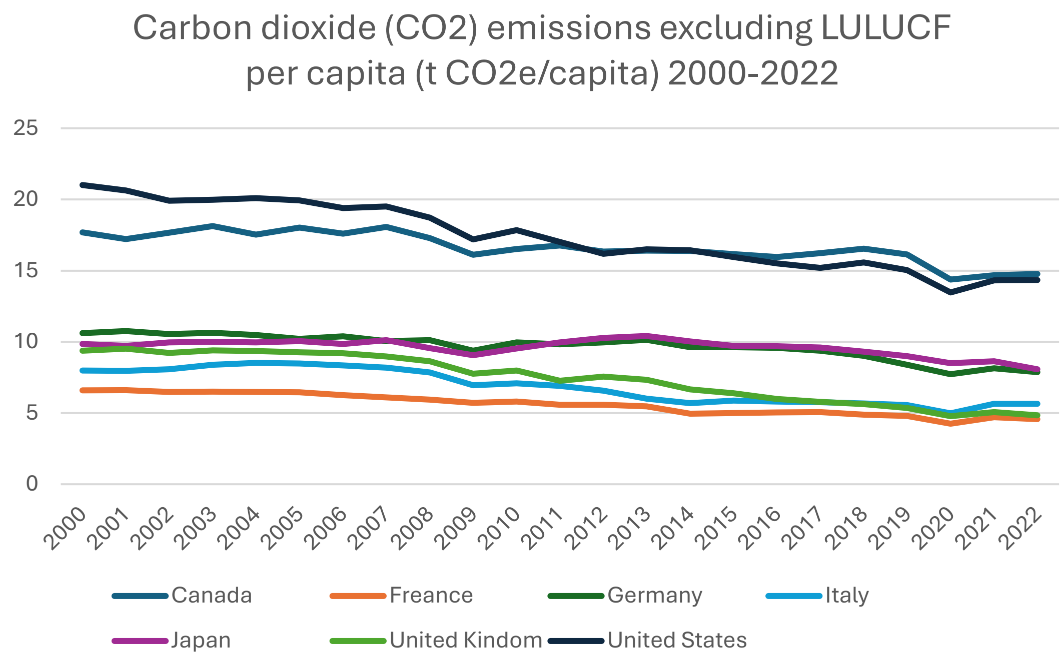

Figure 1.1 Carbon dioxide (CO_2) emissions (total) excluding LULUCF (Mt CO_2e) 2000-2022- United States, United Kingdom, Japan, Canada, France, Italy, Germany - Adapted from the Data World Bank (2025)

Figure 1.1 shows total of each G7 countries contributes to CO_2 emissions from 2000 until 2022 and United States shows the highest CO_2 emission emitters. Although other G7 countries seems to have lower CO_2 emissions but the combination of all the G7 countries emits high CO_2 emissions. According to Isik et al. (2020), the G7 countries are the biggest emitters of CO_2, accounting for 33% of world emissions in year 2014 and 54% of overall since the year 1900 (Gil-Alana et al. 2017). In addition, in 2018 from the G7 countries itself contributes 26% of world emissions (Pata & Aydin, 2022). This indicate that G7 countries are the biggest emitter of the world emissions therefore by reducing CO_2 emissions among the G7 countries able to become an example that could be followed by other countries in reducing CO_2 emissions

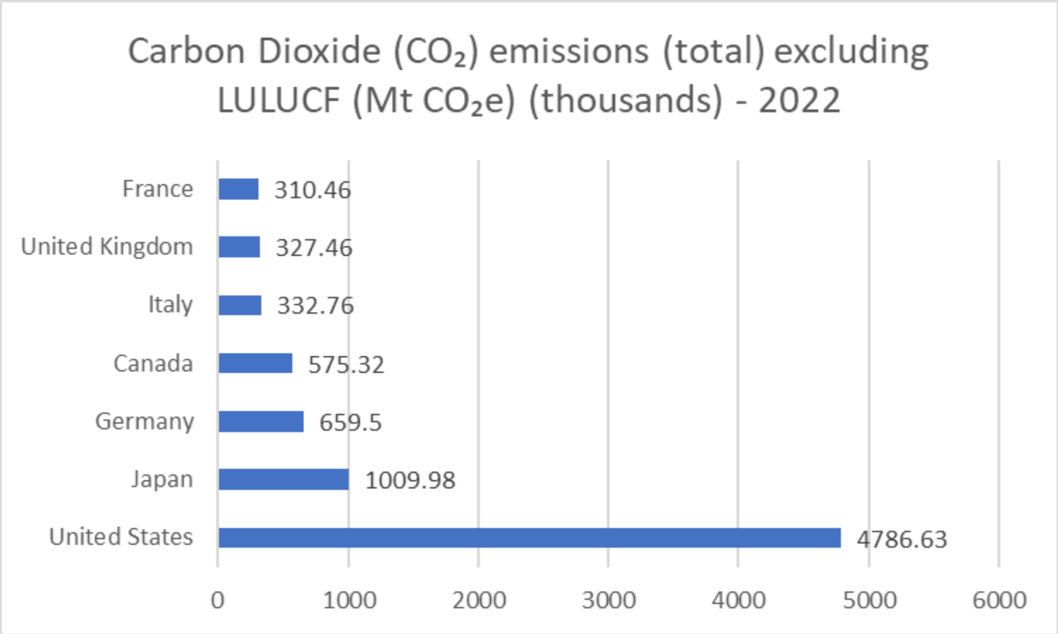

Figure 1.2 Carbon dioxide (CO_2) emissions (total) excluding LULUCF (Mt CO_2e)(thousands) – 2022; Adapted from the Data World Bank (2025) https://data.worldbank.org/indicator/EN.GHG.CO2.MT.CE.AR5?end=2022&locations=US-GB-IT-FR-JP-DE-CA&name_desc=false&start=2022&view=bar

Figure 1.2 above from data World Bank illustrates the total CO_2 emissions excluding LULUCF among G7, 2022. "LULUCF" refers to Land Use, Land-Use Change, and Forestry, a component of the greenhouse gas inventory that includes emissions and removals together with forestry and land management operations (Begum et al., 2020). Based on the year 2022 data, United States contributes the most CO_2 emissions which is 4786.6Mt followed by Japan the second highest contributor resulting of value at 1010Mt. Most of the other G7 countries contributes around 300Mt - 600Mt. Total CO_2 emissions contribute by G7 countries are 7342.7Mt in 2022.

The environmental and socioeconomic consequences of CO_2 emissions are profound and urgency issue. Global temperatures have risen up to 1.1°C above pre-industrial levels within the year 2011–2020 being the warmest decade on has ever been recorded (Climate Action, 2022). Global warming has intensified extreme weather events such as hurricanes in the US and floods in Germany which cost billions annually to repair the damages such as human accident and infrastructure

(Dharmarathne et al., 2024). An increase in CO_2 emissions not only causes global warming but causes ocean acidification as well where it affects the marine ecosystems and fisheries in countries like Canada and Japan (Limtara, 2023). Other than that, air pollution from CO_2 emission through fossil fuel combustion resulting in 6.7 million premature deaths from respiratory illnesses in Tokyo (World Health Organization, 2021). The impact of CO_2 emissions drives climate change which significantly disrupts the agricultural systems, infrastructure, and labour productivity amounting the annual costs of 240 billion dollar towards U.S. in the late century without intervention (United Nations Secretary-General, 2018). These underline a serious urgency, and action needs to be taken before the problem become more serious. By doing so, green finance and governance effectiveness shows a mechanism in reducing CO_2 emissions.

Green finance is off based the theoretical foundation, absorbing the environmental externalities and internalizing the markets in addition to eliminating carbon intensive activities while promoting low carbon technologies (Mavlutova et al., 2023). The G7 has seize on green finance to achieve the Paris Agreement's objectives by reallocating financial flows from the green finance to achieve climate goals and achieve net zero emissions by the year 2050 except for hard to abate emissions that are difficult to lower their greenhouse gases emission (Xiao & Tabish, 2025). G7 countries have shown their initiatives in reducing investing green finance as an example green bonds guided by the Green Bond Principles in 2021 has issued 200 billion dollars in G7 countries while Germany and UK issued sovereign green bonds to finance renewable energy (International Capital Market Association, 2021). In addition, France's Eco-PT zero interest eco-loan program has support over 300,000 energy retrofit projects since the year 2009 while Japan and the U.S. invest in the hydrogen and electric vehicle start-ups (Giraudet et al, 2020; Secretariat, 2019).

Diverse policy frameworks and market dynamics shows the adoption patterns of green finance vary across the G7 countries. As an example, UK's 2019 Green Finance Strategy mobilized 10 billion euros in sustainable investments during the year 2020 for wind and solar projects (Government United Kingdom, 2023). Germany's Kreditanstalt für Wiederaufbau (KFW) has issued 16.2 billion euros in green bonds in year 2021, while France's second sovereign green bond raised 7 billion euros for biodiversity and climate adaptation (Trésor, 2021). Japan aims to mobilize 150 trillion Yens in private financing for decarbonization, and the US issued 40 billion dollars in sustainable bonds in year 2021, with US leading at 20 billion dollars (World Bank Group, 2024). Canada's green bond market reached 8 billion dollars in year 2021 focusing on hydropower, while Italy issued 55.7 billion euros for sustainable infrastructure (Canada, 2022; Edoardo, 2022).

Green finance and International Finance Corporation serves as an instrument to help in the reduction of CO_2 emissions, is foreseen progress with the aid of governance. In terms of G7 countries, governance is defined as a tool and procedure for equalizing the use and enforcement of the laws and resources (Armitage et al., 2020). Good governance is defined by its transparency, obligation and powerful establishments, setting the 'rules of game' for financial action, control carbon pricing, supervising high-emission industries while promoting the adoption of renewable energy sources (Mahmod, 2013; World Bank, 2024). G7 governance frameworks align with the Paris Agreement and are supposed to support low carbon transitions but their effectiveness is to a different degree according to how well policies are coherent as stated in Xiao & Tabish (2025).

Mechanisms will include the UK's Climate Change Act of 2008 which commits carbon budgets of 50 million tonnes of CO_2 by year 2020 (Carbon Gap - Policy Tracker, 2025). Germany's 2019 Climate Action Law targets a 55% emissions reduction by year 2030 supported by the Emissions Trading System (ETS) (Umweltbundesamt, 2025). France's carbon tax rising from 7 euros in year 2014 to 44.60 euros by year 2018 aims for 100 euros by year 2030, where challenges occur as the protest by the public towards this issue (Bureau et al., 2019). Japan's green growth strategy and industry agreements target a 46% emissions reduction by year 2030, while Canada's 2021 Net-Zero Emissions Accountability Act mandates five-year reduction targets (Ozawa et al., 2022; Service Canada, 2022). The U.S. operates a decentralized model with federal policies like the Clean Air Act complemented by state-level initiatives (California Air Resources Board, 2021).

In summary, the interplay between CO_2 emissions, green finance, and governance in the G7 countries is dynamic and interdependent. Green finance channels capital into low-carbon projects, directly reducing emissions by scaling renewables and energy efficiency, as seen in the UK's wind capacity and Germany's solar investments. Governance provides the regulatory and policy frameworks that enable green finance such as carbon pricing and renewable subsidies to ensure better implementation of policy in reducing CO_2 emissions while enforcing emissions targets as evidenced like Canada's accountability act and France's carbon tax. Together, these variables solve the structural and financial barriers to decarbonization though their effectiveness that is constrained by economic dependencies such as Canada's oil sands and Japan's fossil fuel reliance, and political inconsistencies such as U.S. policy shifts. The G7's commitment to net-zero by year 2050 reinforced by the Paris Agreement and G7 summits, underscores the need for integrated strategies. For instance, in 2021, G7 summit pledged 100 billion dollars annually for global climate action, highlighting the synergy between green finance and governance (Pauw et al., 2022). This research evaluates how green finance and governance interact to influence CO_2 emissions, providing insights into the G7's climate leadership and the broader global transition to a low-carbon future.

1.2 Problem Statement

The goal in reducing CO_2 emissions has become a global priority due to their direct effects towards climate change. This is a problem of seemingly important and yet difficult to be faced by the G7 countries of France, Germany, Japan, Italy, Canada, United Kingdom and United States, accounting for much of the world's cumulative industrial emissions, while committed to achieve net-zero emissions by 2050 (Office, 2021). While achieving these targets remains a significant challenge, it necessitates a critical examination of green finance mechanisms and governance frameworks to facilitate a smooth progress of reducing CO_2 emissions.

While pursuing emissions reduction goals, questions raised on what is happening in G7 countries addressing the CO_2 emission continue to face challenges in transitioning from established fossil fuel systems to cleaner energy solutions eventually raising questions about their decarbonization pathways. Based on Energy Information Administration (EIA) (2024), oil and gas are important in the US and Canada for buildings and vehicles. Meanwhile, Germany has announced ambitious plans to phase out coal as stated in British Broadcasting Corporation News (2025), while Japan continues to rely on coal-powered generation despite its technological advancements (Take, 2023). Although some countries seem to have trouble transitioning from using fossil fuels to renewable energy sources but country like UK's energy supply more sustainable due to energy mix as stated in Jobling (2025) and France with nuclear power shown in World Nuclear Association (2025), and Italy following Europe's lead in terms of climate rules and policy. Hence, it is inevitable that CO_2 emissions are impacting all around the globe and the efforts made by the countries do see some improvement hence, constant tracking and efforts is important to tackle the issue. Though each of the nations have their own ways in resolving the issues, it is important for all the G7 countries to cooperate at once together. Exploring deeper into green finance and governance, questions arises whereby if both variables can reduce CO_2 emissions.

Regardless, green finance, one of the main tools implemented in reducing CO_2 emissions, is all about financing things that are more to renewable and sustainable energy such as wind farms, solar panels or non-energy using projects. These indicates the example of how G7 countries can utilize the funds from green finance. For instance, wind turbines are built off the UK's coast stated by GreenMatch (2024), solar panels are installed in Germany according to Clean Energy Wire (2024), while Japan is experimenting with green hydrogen production as stated in the studies by Wen & Aziz (2023), waterpower usage in Canada as shown in Carrieann (2024), low carbon buildings in France stated by Assuncao (2024), and Italy contributes its share of green projects (Stiftung, 2024). Expectation from this contribution is closing a big pollution tap, contributing a reduction in CO_2 emissions. However, problems may arise when more investments on renewable energy sources causes a significant shift in the employment sector. Hence, some workers may be laid off or may not be able to get a job due to their different in expertise. As an example in US, as stated in Statista (2024), having huge oil field where many of the workers work in the sector, but if green finance were to fund renewable energy sources, people may lose job in the oil sector. Issues emerged, questioning whether green finance is actually carrying out its expected task to reduce CO_2 emissions. Perhaps it is not only about money and more on the contributions, but how a country composes with governance to project what might be seemingly possible in ensuring that employment would not be a barrier to stop green finance from funding those clean energy.

Secondly, countries use governance to regulate rules and policy to make decision for example, laws, plans or deals with businesses for cutting emissions. As an example, UK's centralized approach cut emissions by 49.7% from year 1990 to year 2020 while Germany's Emissions Trading Systems (ETS) and renewable laws achieved a 35.7% reduction (Government United Kingdom, 2024; Umweltbundesamt, 2025). Canada's carbon pricing framework targets a 40% reduction by year 2030, but oil and sands emissions offset gains (Service Canada, 2024). France keeps things well by staying clean with smart policies. Japan works with companies to deal with CO_2 emissions issues based on Sodali & Co. (2024), In addition, Canada penalizes with carbon tax which have been stated by Legislative Services Branch (2025), Italy follows Europe's rules, and the US changes the regulation and policy many times based on who leads as stated by the New York Times news which showing the inconsistency of US's federal policies has limit the reductions to 13% from year 2005 to year 2019 though state-level efforts show promise (Energy Information Administration, 2024).

Other challenges like policy fragmentation which happen in US federal-state divides, economic trade-offs in Germany's coal phase-out delays, and public resistance in France's gilets jaunes protests (Kramer, 2020; Baron & Bartl, 2024; Encompass, 2019). In fact, these rules and ideas help in reducing CO_2 emissions, despite the policy and regulation not impactful enough. Combination of both green finance and governance expected to show a greater impact on CO_2 emissions reductions but due to different regulatory and framework on each G7 countries and different green finance operation may cause some difficulty for G7 to cooperate together as one.

Considering other challenges when implementing the strategies which include before, after or during implementing the strategies. The challenge here is what matters in green finance and governance conjoined the G7. Governance steers the ship decide where the green finance cash is going to be utilized. For instance, the UK, having few barriers when the green projects are soaring currently stated by Kenway & Kenway (2023) or the US back and forth restricting them to utilised funds from green finance. Is Germany's plan for green money are better than in other cases or will Japan's business deals with the company lead to bringing in extra funds? Further research is required to determine the matter of each planning in G7 countries. Other than that, challenges such as high costs of green technologies, market fragmentation, policy uncertainty such as the US exit from the Paris Agreement, and fossil fuel subsidies in Japan such as 11 trillion Yens since year 2022 hinder the progress of achieving the goals (Institute for Energy Economics and Financial Analysis, 2024; Climate Crisis, 2025). Despite these obstacles, green finances have the potential to reduce CO_2 emissions, especially when incorporate with robust governance as stated by Energy Information Administration (2024).

It is surprising that the G7 countries maintains its current position given the circumstances of how unexpected or unlikely they are. Each of the G7 countries shows different reliance on energy as well as different sector. Example be seen in Canada where the use of more carbon, oil and other natural resources due to its abundant of those resources shown in Canada (2025), France relies on nuclear power according to World Nuclear Association (2025), the UK is a service nation as almost the majority of their GDP comes from the services sector. In terms of governance, inconsistency of framework and policy of each country could be reason of hindering governance effectiveness to solve CO_2 emissions issue. Example shows like UK's rules work quite differently and stricter compared to US where the regulations are looser. The inconsistency of policy and frameworks raised question like "Could green finance and governance look in each place as a single unified solution?" One country's way might contribute some ideas for another or perhaps their own problems might bring new ideas that will give impact in solving CO_2 emissions issue.

At the very least if no further action taken is by the G7 nations, the worsen of CO_2 emissions will impact more on climate change could require higher cost to resolve the issue, become a threat to the health of citizen, or nature take a hit due to environment degradation could be seen (Intergovernmental Panel on Climate Change, 2022). The focus is not on criticizing or stating what is wrong, but on what it might be. To reduce CO_2 emissions, we test on using and implementing the governance and green finance together. To prove both variables can affect CO_2 emissions might actually dive into these few questions such as "Could sound regulations lead to better green money management and its use to be put to its best purposes?", "Can green finance help to strengthen the regulations propose by the governance, but also bring a rigidity to CO_2?" and "What occurs when they decide to do or not in such crucial countries?"

In summary, this research will explore further on how green finance, and governance may interact to reduce CO_2 emissions in the G7. However, there are still other factors that can lower CO_2 emissions, not only green finance and governance. It is not about having all the answers yet but about asking questions and imagining what might happen to these nations with all their strengths in ensuing this issue can be solved by 2050 and considering different kinds of observations.

1.3 Research Objectives

1.3.1 General Objective

In this research, we investigate the possibilities by which green finance and governance may perform together to impact CO_2 emissions in the G7 countries which are Canada, France, Germany, Italy, Japan, the UK and the US. We want to examine how green finance such as fund green projects and governance such as rules and regulation may affect CO_2 emissions. This is aimed at understanding what their roles are, seeing how they might vary across these nations and thinking about how they could assist the G7 in cutting CO_2 emissions and bringing about a cleaner future.

1.3.2 Specific Objectives

1. To investigate the green finance impact on CO_2 emissions in the G7 countries.
2. To examine the governance impact on CO_2 emissions in the G7.
3. To investigate the green finance and governance impact on CO_2 emissions in the G7.

1.4 Research Questions

1. Does green finance influence CO_2 emissions in the G7 countries?
2. Does governance influence CO_2 emissions in the G7 countries?
3. Do green finance and governance work together in affecting CO_2 emissions in the G7 countries?

1.5 Significance of Study

This study encompasses its focus on how green finance and governance are able to reduce CO_2 emissions in the developed countries of Canada, France, Germany, Italy, Japan, the UK and United States. By incorporating Sustainable Development Goals (SDG), focusing on SDG 13 (Climate Action) and SDG 7 (Affordable and Clean Energy) are our main goals, in hopes to achieve a greener environment.

Over the years, the increase in CO_2 emissions due to the rise in temperature, has not only abruptly harmed the ecosystem of nature but also the entire world population, leading to the worsening of climate change. Nonetheless, G7 countries have pledged to pursue net-zero emissions by year 2050, but these past years concluded otherwise, where large amounts of emissions have been emitted. Hence, using SDGs as an indicator, we further explore whether incorporating green finance and governance as a tool are able tackle these problems.

Though the key components of these SDGs are to reduce CO_2 emissions, it does not entirely ensure a full successful implementation. Green governance such as legislation or carbon fees in addition to green finance such as funding solar and wind projects may be the key to achieve the goals. This study ponders on how two such disparate nations could possibly work together. Perhaps the British regulations are stringent that it forces green energy projects to bloom, or Japan's business plans will toughen with more funds. In this study, we aim to discover and ascertain ideas that are 'outside the box' in hopes of reducing CO_2 emissions, in alignment of our studies.

In addition, these approaches offer valuable models for lower-income nations, such as demonstrating how Canada's integration of green finance with effective policy frameworks and Germany's successful renewable energy transition can inform sustainable development strategies. This is significant for the living beings and the planet of our ecosystem while CO_2 emissions matters include clean air safe and reduce air pollution. Combining green finance and governance could be a contributor that could reduce CO_2 emissions which leads to less polluted air by using renewable energy like solar or wind.

In summary, this is an important study that is vital in combining green finance and governance together significantly. "Is it better to analyse governance and green finance together rather than separating it?" Through thorough inspection, we may be able to find some valuable insight that relate to SDG 13 and SDG 7 to help reduce CO_2 emissions which eventually will tackle climate change issue. As stated, there are still other factors that can reduce CO_2 emissions which will be discussed further. As G7 countries are considered as a big and developed country, it significantly influences other countries to do the same thing, in hopes of contributing positive impacts to the world.

Chapter 2: Literature Review

2.0 Introduction

Chapter two will first show the theories used to construct dependent and independent variables and how they are interconnected. Following the review of variables, whereby dependent variables will be discussed first, followed by independent variables, and then control variables. After reviewing the variables, empirical review of the variables are showcased. A conceptual framework is formed after the review of variables and theories. Lastly, hypothesis formed between the variables based on past studies and theories are presented.

2.1 Underlying theories

2.1.1 Governance Theory

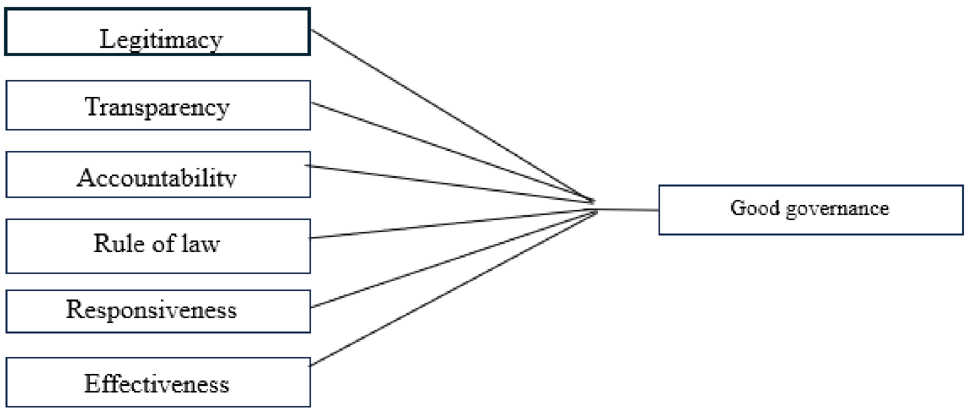

Figure 2.1 Six essentials of good governance. Adapted from Keping (2017).

Governance theory came from a set of institutions and actors from the government, where governance is beyond the governmental power that includes self-governing network, blurring of boundaries and responsibility with the society, and policy. In addition to all of these, the individuals and institutions, public and private are collaborated to solve the issue (Keping, 2017). In essence, some researchers do consider governance to be closely identified with the government (Pierre, 2000). The role of the government plays an important role influencing economic growth.

The World Bank Group also stated that good governance is important for the development of the country (World Bank Group, 2025). When the economic growth of a country increases, the carbon emissions will increase. The Alaganthiran & Anaba (2022) study shows that a 1% rise in economic development increases the carbon dioxide emission level by approximately 0.02%. This is where the governance plays a vital role whereby few researchers have stated that the contribution of institutions and governance in lowering national emissions and improving environmental quality as noted by Matsuo (1998), Rentz (1998), Rose (1990), cited in Halkos & Tzeremes (2013).

Evidently, Keping (2017) noted as in **figure 2.1** illustrates that good governance can be shown in six ways which are the legitimacy, transparency, accountability, rule of law, responsiveness and effectiveness. The context where the focus will be mainly on the government effectiveness, implies the theory is particularly directed to the application in environmental policy, providing a view on how a country manages and regulates renewable energy investments and policy (Yadav et al., 2024). Increase in renewable energy consumption shows the consumption of fossil fuels decrease. For instance, Chen et al. (2025) highlights that G7 countries on the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change or also known as COP28 has sets an ambitious hope in aiming to achieve net zero emissions, increasing transparency and consumption climate of the schedules and emphasis on reducing dependence on fossil fuels. Therefore, this theory able to study the how does government effectiveness able to reduce carbon emissions.

2.1.2 Green Finance Development Theory

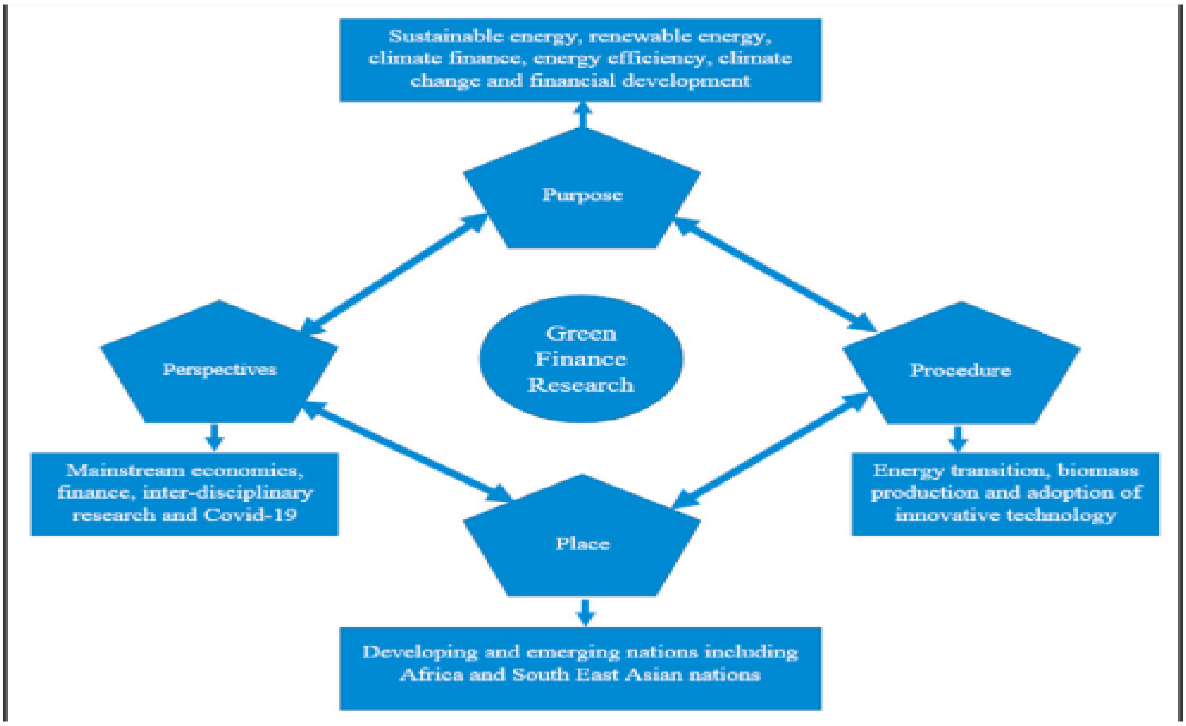

Figure 2.2 Framework of Green Finance Development Theory. Adapted from Sharma et al. (2022)

Green finance is an extending financial service in the form of structural financial activity that can be a loan or investment to finance environmental activities that aim to reduce climate change or emissions. In addition, it addresses other environmental concerns such as industrial pollution control and waste management (Sharma et al., 2022). Green finance mainly focusses in promoting a green economy whereby the funding from the green finance able to fund the industrial sector to use more renewable energy to reduce the emissions (Chang et al., 2024). The term often mixed with other terms like climate finance and sustainable finance which it becomes a debate from different stakeholders as they have different perspectives on the 'green' in finance (Dörry & Schulz, 2018; Zhang et al., 2019, as cited in Lazaro et al., 2023). In any way, supporters of green finance recognize that green finance will impact the environment positively with sustainable economic (Lazaro et al., 2023). In addition, private companies are also involving and contributing to the green finance funding to promote more sustainable economic (Omri et al., 2024). According to Sharma et al. (2022), green finance supposedly able to promote more sustainable energy where energy transition take place using more renewable energy from the green finance funding which anticipate being able to reduce the carbon emission. Hence, this theory able to study how does green finance able to reduce carbon emissions.

2.2 Review of Literature

2.2.1 Dependent Variable

Variable	Theoretical Role	Measurement	Supporting Study
CO_2 Emissions ($lnCO_2$)	The outcome variable, representing environmental degradation.	Log of metric tons per capita.	Stern (2017)

2.2.2 Independent Variables

Variable	Theoretical Role	Supporting Study
Green Finance (lnGF)	Measures fiscal policies (e.g., environmental taxes) that funds clean energy	Zhang et al. (2021): GF lowers CO_2 in high-GDP nations.
Governance (GOV)	Captures institutional quality (e.g., policy enforcement).	Bhattacharya et al. (2018): WGI improves climate outcomes.
lnGF × GOV Interaction	Tests synergy between GF and governance.	Dikau & Volz (2021): GF's CO_2 reduction effect is twice as strong in countries with top-quartile governance.

2.2.3 Control Variables

Variable	Theoretical Role	Supporting Study
Energy Intensity (lnEI)	Energy efficiency of the economy.	Wooldridge (2015): Controls for industrial structure.
GDP (lnGDP)	GDP (constant 2015)	(Yadav et al., 2024): Effects of GDP on CO_2 through Gf and GE
Renewables (lnRENE)	% of energy from renewables.	Dikau & Volz (2021): Renewables amplify GF effects.

2.3 Empirical Review

2.3.1 Definition of a Literature Review – Carbon Emissions

The world has emitted CO_2 since decades and it still increases till this very day. According to Our World in Data by Ritchie & Roser (2020), it was estimated around 6 billion tonnes of CO_2 in 1950, that these figures will keep rising and it was estimated that each year the world emits 35 billion tonnes. Carbon emissions is one of the greenhouse gases (GHG) that are known to absorb the sun's radiation and convert it to heat which cause the rises in temperature (Mohammed & Mansoori, 2017). In addition, it was acknowledged in the scientific community that CO_2 is indeed the main cause for global warming (Zeng & Chen, 2016 as cited in Dong et al., 2018). Another main contributor factor that causes the rise in carbon emissions is human activities account for at least 95% of the total increase (Dong et al., 2018).

According to Intergovernmental Panel on Climate Change (IPCC) on the Climate Change 2023 Synthesis Report have stated that from the human activities itself have causes global surface temperature reaching 1.1°C above 1850-1900 in 2011-2020 (IPCC, 2022). To have a better understanding of carbon emissions, where carbon emissions divides into two types which are natural and anthropogenic (Mohammed & Mansoori, 2017). GHG emissions consider as natural when it involved forest fires, volcanoes and earthquake (Yue & Gao, 2018). Anthropogenic GHG emissions is what seems that cause by human activities where Redlin & Gries (2021) stated that in industrialization sector where the use fossil fuels, inefficient energy which causes anthropogenic GHG emissions. As an example of human activities is industrial evolution especially in the developed countries which can be seen in the G7 countries where increase the use of fossil fuels to produce energy in production (Duan et al., 2022). As the carbon emissions keep on rising, soon it has become one of the major contributors to global warming which causes climate change. Climate changes have become a serious issue as in the Sustainable Development Goals (SDG) have mentioned in SDG 13 which are the climate change (World Health Organization, 2024). Further into this literature review will discuss more on the factors that would actually reduce the carbon emissions.

2.3.2 Empirical Study of Green Finance and Carbon Emissions

As the advancement of technology and industrialization take over the world of economics, the financial sector has always been behind the scenes to support this advancement. However, some authors argue that limited efforts have been made to integrate environmental concern into financial sectors Su et al., 2022, as cited in Wang et al., 2023; Wang et al., 2022, as cited in Wang et al., 2023). Consequently, people's perspective change over time when the increase of CO_2 emission impacted the climate change or specifically anthropogenic global warming which eventually leading to environment concern (Wang et al., 2023). The term of anthropogenic showcases the CO_2 emissions from human activities that have impacted the environmental quality. This raises concern when the financial sector starts to intensify their focus on green finance. Falcone et al., (2017) stated that Green Finance (GF) is the toolkit for climate change mitigation efforts. Another author by Omri et al., (2024) has also observed the connection between CO_2 emissions and GF. Though there are still some researchers stating that the main concept of GF is ambiguous and has not reached an ominous conclusion about its definition (Zhang et al., 2019, as cited in Khan et al., 2021). Under green finance policy, the financial sector usually provides green credit, loans and investment Sadiq et al (2023) whereby the financial flows from the green finance may flow into green activities that aim to eliminate greenhouse gases emissions.

Some researchers have stated the importance of green finance and green growth especially through Research, Development, and Demonstration (RD&D) as stated by Gu et al., (2023) as cited in (Qin et al., 2023; Wang & He, 2022). It is as stated that developed nation like G7 countries have been investing in RD&D field which focuses on green industries investment such as low carbon technologies. According to Gu et al., (2023) RD&D instruments include renewable energy, energy efficiency and total budget which is total investment for RD&D hence stating more attention needs to be in these aspects despite other research focusing on other green finance instruments.

The relationship between GF and carbon emissions, nonetheless, shows that 1% increase in GF will significantly affect an increase in CO_2 emissions in the short run but in the long run it was expected than the GF will reduce CO_2 emissions by using the Cross Sectional Cross-Sectional Autoregressive Distributed Lag (CS-ARDL) (Yadav et al., 2024). To enhance the efficiency of CS-ARDL, some researcher will use it with Cross-Sectional Dependence (CSD) Test as the Sadiq et al. (2023) stated that most of research using CS-ARDL but cannot identify CSD error. In addition, the test result from using together with CSD test also shows that as GF increase, CO_2 will decrease.

2.3.3 Empirical Study of Renewable Energy Consumption and Carbon Emissions

The Industrial Revolution increased the burning of fossil fuels for the use of generating heat and electricity to produce goods and raw materials. Based on World Nuclear Association (2024) stated that at least 40% of energy related CO_2 emissions are because of burning fossil fuels for electricity generation. Fossil fuels is one of the non-renewable energies which are causing global warming (Justice et al., 2024). The result of excessive burning fossil fuels has resulted in three-quarters of global GHG emissions according to Our World in Data. (Ritchie et al., 2020). Firms and citizen are shifting the use of carbon emitting fossil fuels to renewable energy as a way to reduce carbon emissions in a way that is align with the Paris Agreement (Paris, 2017 as cited in Somosi et al., 2023). This agreement is mainly about policymakers accepted to maintain the global surface temperature increases well below 2◦C with a view of reducing the increase to 1.5◦C to reduce the climate change become worser (Kahia et al., 2020).

The relationship between the renewable energy consumption and carbon emissions shows an inverse relationship is tested using CS-ADRL whereby it also shows the result of 1% increase in the consumption of renewable energy will 0.005% decrease in CO_2 emissions and in the long run the higher the renewable energy consumption the lower the CO_2 emissions (Yadav et al., 2024). However there some debates regarding the linkage between renewable energy consumption and carbon emissions (Chontanawat, 2019); where the nonlinear relationship that exists between both of the variables and the existence of capital market between them. All of this debate is summarised by one of authors stated Ofori-Sasu et al. (2023) that the relationship between the renewable energy consumption and carbon emissions shows that it should not be a one way but instead it spread into these three definitions which are bidirectional, non-linear and the existence of capital market between both of the variables. This statement is proven with another test that is tested by Szetela et al. (2022) by using Ordinary Least Square (OLS), Fixed Effect (FE), Generalized Least Square (GLS) and two step GMM estimator which show 1% increase in renewable energy consumption will reduce CO_2 emissions by 1.25% but this result varies depending on the country that have good governance will reduce more of the CO_2 emissions comparing to countries that have poor governance. This shows when the country has good governance, the capital market will be more effective on the renewable energy consumption.

2.3.4 Empirical Study of Governance Effectiveness and Carbon Emissions

As years pass by, rapid economic growth and urbanization will impact on the environment which causes global warming due to huge energy consumption that creates carbon emission. Government is defined as the ability to gather opinions from the standard of public services, standard of civil service and to the extent of its independence from political pressures, the standard of policy formulation and implementation with the government ability to make use of the policy (Kaufmann et al., 2011 as cited in Chen et al., 2022). After the announcement of the reduction of the global temperature by the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, this is where government plays an important role to able achieve the goals. A major mechanism for government to intervene in this matter is improving the quality of country governance (Sweet & Sandholtz, 2022).

Most of the studies such as Elsayih et al. (2021) focus on how corporate governance impacts carbon emissions. The study of country governance is much less compared to corporate governance (Ernstberger & Grüning, 2013). Corporate governance mainly focuses on scope 1 and scope 2 emissions while they are not so motivated in terms of scope 3 emissions. These scopes use the alternative carbon performance proxy for the scope as scope 1 is direct emissions from the firms, scope 2 is indirect emissions while scope 3 emissions are harder to define due to a broader reach (He et al., 2013). This sparks an argument as government intervention is still needed for scope 3 emissions to be reduced (Oyewo et al., 2024). Scope 3 emissions are important as 70% of carbon footprint comes from the greenhouse gases emissions and cost reduction opportunities that fall out from their operations for most of the firms (Oyewo et al., 2024). Although there are limited empirical studies on how country governance mechanism impact carbon emissions but based on Oyewo et al. (2024) as cited shows that a country would not achieve the net zero emissions if scope 3 emissions did not take into account.

Another study showcases the sound management of governance effectiveness through the operation of renewable energy and investment policy, which can be seen BRICS nation (Yadav et al., 2024). An example taken from the studies the governance structure in Russia have impact the country in the implementation of renewable energy initiatives, where it focuses more on robust policy frameworks and transparent regulations (Chebotareva et al., 2020). The study uses CS-ADRL model to test the relationship between government effectiveness and carbon emissions, where in short run, government effectiveness positively affects carbon emissions indicating less impact on carbon emissions whereas in long run, the increase in environment degradation reduces at higher income levels (Yadav et al., 2024). This observation is supported by Fan et al. (2020) where the increase in carbon emissions in the short run may be caused by policy lags, political and economic pressures. X. Wang et al. (2025) stated that countries with high government effectiveness tend to manage carbon emissions well as compared to countries that having lower governance effectiveness. This shows that ineffective government may have difficulty implementing the policy and framework to control carbon emissions (Dincă et al., 2022).

2.3.5 Empirical Study of Energy Intensity and Carbon Emissions

Each country has their own goals in achieving high economic growth using both renewable and non-renewable energy sources. Due to climate change, the urgency of focusing issue on energy consumption, technological innovation, and environmental sustainability (Dunyo et al., 2024). Increase in technological adoption does not work alone and it is accompanied with energy intensity that measures the amount of energy consumed per unit of economic output indicating that high energy intensity shows the inefficiency use of energy (Dunyo et al., 2024). When the country has a higher economic growth, energy consumption increases which leads to higher CO_2 emissions (Waheed et al., 2019). Economic and political uncertainty have a linkage towards energy intensity and CO_2 emissions where Su et al. (2022) stated that when they invest to reduce the cost and ensure less economic policy uncertainty (EPU) may lead to lower energy intensity and reduced CO_2 emissions as the government's policy supports, subsidies and tax incentives rely on EPU. The uncertainty from EPU is expected to positively impact the relationship between energy intensity and carbon emissions by increasing the use of technological innovations, but in the time when uncertainty occurs, they look for initiatives to address these challenges (Su et al., 2022).

Yadav et al. (2024) have used the CS-ADRL model to test the relationship between energy intensity and carbon emissions in the BRICS nation where it tested that energy intensity positively impact the carbon emissions as it shows 1 % increase in energy intensity, will increase 0.021% increase in CO_2 emissions indicating more effort are needed to put on energy efficiency. Another test from Rahman et al. (2021) uses the ADRL model and shows the similar result where it is significant and positively affect the carbon emissions. In addition, promoting green technologies and applying clean energy will ensure the efficiency of energy use while reducing traditional energy intensity (Y. Wang et al., 2021).

2.3.6 Empirical Study of Gross domestic product and Carbon Emissions

The economic growth GDP shows a significant and positive effect on environmental degradation, indicating that environmental quality will always be at cost in exchange for better economic growth (Ullah et al., 2021). This foresees that more fossil fuels are to be utilized, and higher energy consumption will lead higher CO_2 emissions. Number of studies have stated the relationship between the economic growth GDP and carbon emissions are inseparable (Marjanović et al., 2016). Other studies by Govindaraju & Tang (2012) have stated that there will be a long-run relationship between both of the variables. The result shown will be inconclusive depending on the time period used and the method. For instance, Fei et al. (2010) uses data from 30 states in China, which include panel unit root, heterogeneous panel cointegration and OLS where the result shown there is positive long run relationship between the GDP, CO_2 emissions and energy consumption. It shows a 1% increase GDP per capita; energy consumption will increase by 0.5 % and CO_2 emissions will increase by 0.43%. A study has uses the ADF and Ng–Perron unit root tests and another unit roots test known as Lumsdaine and Papell with two structural breaks to test the China and India (citation 9). The result shown further testify thr long-run relationship between GDP and CO_2 emissions for China but not in the case for India as the access of energy are limited to the majority of their population (Govindaraju & Tang, 2012).

2.4 Conceptual Framework

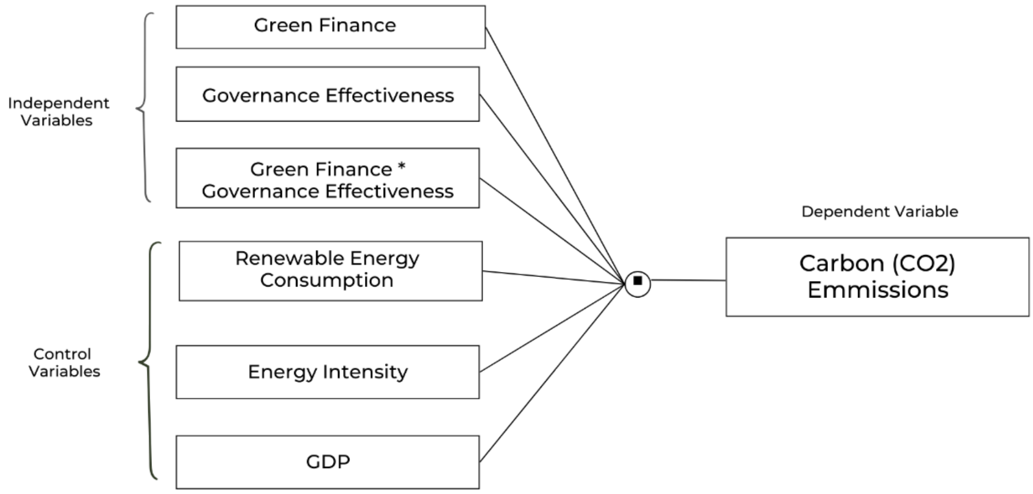

Figure 2.3 Conceptual Framework

Figure 2.3 illustrates green finance, renewable energy consumption, governance effectiveness, energy intensity and gross domestic product (GDP) The variable for renewable energy consumption, energy intensity and GDP will be the control variables in this model to ensure the accuracy of the result. According to, the journal of Wooldridge (2015) emphasizes the importance of including control variables to account for external influences, allowing researchers to isolate the effects of key independent variables such as Green Finance (GF) or Governance Effectiveness (GE). For instance, while energy intensity (EI) may influence CO_2 emissions, it is not the primary focus of the study; therefore, controlling for EI helps clarify the distinct impact of GF on emissions.

After researching and reviewing the studies of other literature, these 6 variables will have an impact on carbon emissions on the G7 countries. Additional variables of the interactive term of green finance and governance effectiveness were added to test whether the combination both variables will significantly affect CO_2 emissions.

2.5 Hypotheses Development

2.5.1 Green Finance and Carbon Emissions

Green finance using RD&D investment as the proxy can significantly affect carbon emissions. There are some studies that show that using RD&D investment able to reduce the implication of energy use (Gu et al., 2023). In addition, combination green finance using RD&D are the keys to using renewable energy more efficiently as shown by Dong et al (2023) as cited in (Gu et al., 2023). This result has shown that RD&D investment is able to reduce emissions and Gu et al (2023) are confident that green finance are the keys factors in affecting carbon emissions due to an increase in 1% of green able to reduce carbon emissions. Other than using RD&D as proxy for green finance, other researchers indeed show how green finance able to impact carbon emissions (Zhang et al., 2025; Dhayal et al., 2025). Hence, the first hypothesis developed is:

H1: There is a significant relationship of green finance on carbon emissions in the G7 countries.

2.5.2 Renewable Energy Consumption and Carbon Emissions

The findings have shown that an increase in renewable energy consumption is able to reduce carbon emissions. Renewable energy consumption is expected to significantly affect carbon emissions. These issues have been a debate across the researcher such as (Taha et al., 2023; Haldar & Sethi, 2023) show if renewable energy consumption increases means that the use of nonrenewable energy has decreased. A study conducted by Ofori-Sasu et al. (2023) shows that renewable energy has a negative and significant impact on carbon emissions. This draws a small conclusion that when a country's carbon emissions increase, less consumption of renewable energy which will lead to environment deterioration. Thus, the second hypothesis development will be:

H2: There is a significant relationship of renewable energy consumption on carbon emissions in the G7 countries

2.5.3 Government Effectiveness and Carbon Emissions

Government effectiveness also significantly affects carbon emission. According to Yadav et al., (2024), it shows significant effect of government effectiveness, implanting well in its policy and framework to tackle carbon emissions. Another study by Cheng et al. (2024) shows that a proper policy such as carbon emissions trading policy significantly reduces carbon emissions. Thus, the third hypotheses development is:

H3: There is a significant relationship of government effectiveness on carbon emissions in the G7 countries

2.5.4 Green Finance*Governance Effectiveness (GF*GOV) and Carbon Emissions

The combination of these two variables tests whether both variables combined have a significant impact on carbon emissions. Most tests have tested these variables individually. In this case, Yadav et al (2024) studies the impact for both variables individually affecting carbon emissions. Adequately, the combination for both of the variables on carbon emissions will be studied in this research as mentioned in the research objective. Hence, the fourth hypotheses development is formed as such:

H4: There is a significant relationship between Green Finance*Governance Effectiveness on carbon emissions in the G7 countries

2.5.5 Energy Intensity and Carbon Emissions

Energy intensity shows how much energy is efficiently used and how it will significantly affect carbon emissions. A study from Y. Wang et al. (2021) shows that applying green technology can reduce energy intensive technology. By improving energy intensity, it is able to steer onto more sustainable economic as higher energy intensity posits higher carbon emissions (Zhang et al., 2023). Another study by Rahman et al. (2021) tests the role of energy intensity on 25 emerging countries, indicating that energy intensity will positively impact in the long run. Thus, the fifth hypotheses development is:

H5: There is a significant relationship of energy intensity on carbon emissions in the G7 countries

2.5.6 Gross Domestic Product (GDP) and Carbon Emissions

GDP is amongst the significant contributor affecting carbon emissions. From here, it is presumed as the GDP of a country shows a higher carbon emissions due to the increase in energy consumption. The study from Yang et al. (2021) shows that rise in GDP not only will increase the income but it will affect the CO_2 emissions. Hence, the last hypotheses development is:

H6: There is a significant relationship between GDP and carbon emissions among the G7 countries

2.6 Research Gap

Rising concern of the increase in CO_2 emissions showing the state of urgency to proactive action to solve the issue. CO_2 emissions be constantly increase if no action is taken. It to be said that green finance and governance effectiveness are the key elements in reducing CO_2 emissions. Green finance are tools that include many types of green financial instruments. It is noticed that most of green finance instrument are usually green bond, green credit and green funds which stated by (Zhang et al., 2025). Researcher Gu et al. (2023) stated limited researcher have conduct green finance investment using RD&D investment whereby he stated attention of other researcher and policy makers to look in these matters.

In addition, we also combined the variables of green finance and governance effectiveness due to its unique in in influencing carbon emissions. Whether both combinations together will reduce greater carbon emissions is depends on and is one of our research objectives and significant of studies.

Chapter 3: Methodology

3.0 Introduction

The primary aim of this chapter is to examine the impact of green finance and governance effectiveness on CO_2 emissions in United States, United Kingdom, Canada, Japan, Germany, France and Italy countries from the years of 2000 till 2022. In order to achieve this objective, conduct of research methodology will be carried out to examine the data design.

3.1 Research Design

3.1.1 Econometrics Model

The basic econometric model written is stated as in Eq. (1):

$$\ln CO_{2_{it}} = \beta_0 + \beta_1 \ln GF_{it} + \beta_2 GOV_{it} + \beta_3 \ln RENE_{it} + \beta_4 \ln EI_{it} + \beta_5 \ln GDP_{it} + \beta_6 (\ln GF_{it} * GOV_{it}) + \mu_{it} \quad (1)$$

The model above shows the mixture of the lognormal model, where CO_2 denotes as total carbon emissions measured in million metric tons; GF representing the Public Energy of Research, Development, and Demonstration (RD&D) of green finance measured by the renewable energy sources; GOV (governance) obtained from World Bank's Worldwide Governance Indicators (WGI) score. i indicates 7 countries from developing nations of Canada, France, Germany, Italy, Japan, United Kingdom and United States while t indicates time period ranging from the years of 2000 till 2022.

Controlled variables account for secondary factors to ensure GF and GOV are unbiased. RENE representing total energy from renewables (%), EI measured in millijoule energy use per economic output (MJ/USD), serves as a control for differences in energy efficiency across countries. Economies with higher energy efficiency may emit less CO_2 even at similar income levels, so including EI isolates its effect from other variables. While GDP constant controls for economic development's non-linear impact on emissions. Without these variables, the estimated effects on CO_2 emissions could be biased due to omitted factors like economic development or energy efficiency. By holding these influences constant, the model more accurately isolates the impact of the key explanatory variables.

For further investigation, data descriptive was performed in the initial level. This step was essential as it allowed the authors to assess the data more effectively by identifying the strengths and weaknesses among the variables.

Further assessing the consistency and efficiency of the test result, Pooled OLS, Fixed Effects Model (FEM), and Random Effects Model (REM) were tested. Driscoll-Kraay test further emits out any violations of the classical regression assumptions in existence.

Moreover, cross-sectional dependency (CSD) test by Sadiq et al. (2023), was scrutinized as one of the diagnostic tests, revealing its appropriateness and reliability of the test. The equation is given as in Eq. (2):

$$\rho W_{it=}\left[\frac{IT(T-1)}{2}\right]^{\frac{1}{2}}\hat{\rho}_t \quad (2)$$

$\hat{\rho}_t$ denotes the pair-wise correlation coefficient, while t refers to the time period, and i represents the cross-sectional units while T shows time, and I show the cross-section units.

3.2 Data Description

In this study, a panel data is collected compromising of seven countries from the G7 countries. The study encompasses from the period of 2000 to 2022.

3.2.1 Measurement of Variables & its Expected Effect

Variable	**Description**	**Measurement**	**Expected Effect**	**Explanation**
CO_2 (Carbon dioxide emission)	Total carbon emissions	Mt CO_2 eq (million metric tons of carbon	– *(Depende*	–

		dioxide equivalent)	*nt variable)*	
GF (Green Finance)	Proxy measurement using Renewable Energy Sources	Public Energy of RD&D in Million USD	**Negative** (–) β_1<0	Higher investments in green techs displaces fossil fuels, reducing CO_2.
GOV (Governance)	Government effectiveness (WGI score)	WGI score of -2.5 to +2.5	**Negative** (–) β_2<0	Effective governance policy enforcement reduces CO_2.
RENE (Renewables)	Renewable energy consumption	% equivalent primary energy	**Negative** (–) β_3<0	Renewables (solar, wind, hydro) displace fossil fuels, cutting down CO_2.
EI (Energy Intensity)	Ratio between energy supply & measured at purchasing power parity	MJ (millijoules) per USD	**Positive** (+) β_4 >0	Inefficiency leads to more energy use, increasing

				the carbon emissions
GDP (Gross Domestic Production)	GDP (constant USD)	Constant USD using either of the approaches: -expenditure approach -income approach -production approach	**Positive (+)** $\beta_5 > 0$	More economic activity requires the adoption of fossil fuel energy, leading to more carbon emissions
GF*GOV	Interaction: Green Finance × Governance	GF (million USD) × GG (score)	**Negative (-)** $\beta_6 < 0$	Good governance is necessary for green finance to be fully effective. Poor governance weakens its impact

Notes: Some variables are taken in the form of ln *in lognormal model*

3.3 Model Estimation

In this study, it is essential to understand the importance of employing multiple panel data models' estimation techniques to capture the relationship of carbon emissions with the independent variables. The Pooled Ordinary Least Squares (Pooled OLS), Fixed Effects Model (FEM), and Random Effects Model (REM) each have their own distinctive assumptions and limitations thus, we aim to derive reliable and meaningful conclusions.

3.3.1 Pooled Ordinary Least Squares (Pooled OLS)

Pooled OLS concept will be explained within the context of panel data analysis. Its is considered to be the simplest method to estimate panel data and treats all the observation from a single cross sectional while ignoring time series or entity-specific effect. Assumption of Pooled OLS assumes cross sectional unit are homogeneity, data considered to have same characteristics and perform under the classical assumption of Ordinary Least Squares (OLS) (GeeksforGeeks, 2025).

The classical assumption of OLS relies on 5 core assumptions as stated by (Wooldridge, 2010). The first assumption the parameters needs to be a linear function of the independent variables and error terms. Second assumption is exogeneity where the independent variables should not be correlated with the error term which the value of error term is zero. As for the third assumption, there should be no multicollinearity whereby the independent variable should not be highly correlated with each other. Homoscedasticity of disturbances will be the fourth assumption of OLS whereby having a constant variance across the observation. The last assumption is the error term must be normally distributed to ensure unbiased and reliable result.

Below shows the equation for Pooled Ordinary Least Squares (POLS):

$$Y_{it} = \beta_0 + \beta_1 X_{1,it} + \beta_2 X_{2,it} + \cdots + \beta_k X_{k,it} + \mu_{it}$$

Where Y_{it} is the dependent variable for unit i at time t,

β_0 is the intercept,

$\beta_1, \beta_2, \ldots, \beta_k$ are the coefficients to be estimated,

$X_{1,it}, X_{2,it} \ldots, X_{k,it}$ are the independent variables for unit i at time t,

μ_{it} is the error term.

According to Wooldridge (2010), Pooled Ols assumed that all cross-sectional units are homogeneity but in real world there will be unobserved individual effects (heterogeneity) that may influence the dependent variable which leads to omitted variable bias. Moreover, Pooled OLS does not account for autocorrelation which may leads to inconsistent of the standard errors. This could cause an issue whereby panel data where observations maybe correlated with each other. Fixed Effects Model (FEM) and Random Effect Model (REM) are common methods to be used to solve the limitations.

3.3.2 Fixed Effect Model (FEM)

Fixed Effect Model (FEM) is a method used to addressed time-invariant unobserved individual heterogeneity in panel data which control correlated omitted variables (DeHaan, 2020). It assumes that each individuals have their unique characteristics which constant over time. One of the core assumptions of FEM is individual specific effect are correlated with independent variables showing each individual are not randomly distributed.

Below shows the equation for FEM:

$$Y_{it} = \alpha_i + \beta_1 X_{1,it} + \beta_2 X_{2,it} + \cdots + \beta_k X_{k,it} + \mu_{it}$$

Where Y_{it} is the dependent variable for unit i at time t,

α_i represents the fixed effect for unit i.

$\beta_1, \beta_2, \ldots, \beta_k$ are the coefficients to be estimated,

$X_{1,it}, X_{2,it} \ldots, X_{k,it}$ are the independent variables for unit i at time t,

μ_{it} is the error term.

Limitation of FEM are time invariant variables cannot be estimated as it being captures by individual specific effects. In addition, it requires large sample to produce reliable estimates hence robustness checking using different proxies is important for the research to ensure a consistent estimate if using small panel data sample.

3.3.3 Random Effect Model (REM)

Random Effect Model (REM) is the last method for panel data analysation. In contrast with Fixed Effect Model (FEM) where the model focus on individual-specific effects, REM treats unobserved entity-specific effects as random and uncorrelated with independent variables whereby time invariant variables could be estimated.

Below shows the equation for REM:

$Y_{it} = \alpha_i + \beta_1 X_{1,it} + \beta_2 X_{2,it} + \cdots + \beta_k X_{k,it} + \mu_{it}$

Where Y_{it} is the dependent variable for unit i at time t,

α_i represents the ramdom effect for unit i.

$\beta_1, \beta_2, \ldots, \beta_k$ are the coefficients to be estimated,

$X_{1,it}, X_{2,it} \ldots, X_{k,it}$ are the independent variables for unit i at time t,

μ_{it} is the error term.

Limitation of REM is assuming unobserved entity-specific effects and uncorrelated with independent variables, it can cause biased and inconsistent estimated if the assumption is not fulfilled. In addition, FEM will be much more robust than REM due to its ability to omit variable bias. REM also require large sample to obtain reliable estimates due to its random elements (Gomes, 2022)

3.4 Model Selection

When deciding which model to use between Pooled OLS, FEM and REM, a statistical specification test will be conducted to determine which model is best preferred. The following of, Poolability F- test, Breusch-Pagan Lagrangian Multiplier Test (BPLM) and Hauman Specification Test will then be use for the purpose of this model selection.

3.4.1 Breusch-Pagan Lagrangian Multiplier Test (BPLM)

The existence of Breusch-Pagan Lagrangian Multiplier (LM) Test proposed by Breusch & Pagan (1980), consists of two types of BPLM. The first BPLM is used to test for heteroscedasticity by regressing the squared residuals on the explanatory factor while the second type of BPLM, also known as LM test, is used to test between pooled OLS and Random Effect Model (REM) to determine whether REM are significant in panel data model. To determine which model best fits into our research, we will be using the second type of BPLM by assuming the null hypothesis has no random effects, showcasing pooled OLS is more preferable while the alternative hypothesis assumes that there are random effects indicating REM is more preferable. A statistical significance shows that null hypothesis will be rejected and accepting the alternative hypothesis of REM model is a better fit but if it otherwise then pooled OLS will be much better fit.

3.4.2 Poolability F-test

Poolability F-test is then utilized in this panel data to determine between Pooled OLS and Fixed Effect Model (FEM). F-test is used to test significance of individual-specific effects in the paned data whereby to find the significant difference between the variances Kumar (2024) which able to determine the appropriateness of pooling the data. The test compares between pooled OLS and FEM by testing whether the individual coefficients are equal to zero. Null hypotheses assume that when there are no country-specific effects shows that Pooled OLS are much preferable, while the alternative hypothesis assume that when there is differences across countries shows FEM are more preferable. When the poolability F-test shows a statistically significant result, it indicates FEM model is more preferred as compared to pooled OLS. Pooled OLS is used otherwise when results yield the insignificancy.

3.4.3 Hausman Specification Test

Hausman Specification test is applied when testing among the Fixed Effect Model (FEM) and Random Effect Model (REM). This tests whether the unobserved traits are captured by dummy variables or as error terms. Frondel & Vance (2010), in addition, holds assumption by examining random effects of the correlation of each individual variable and regressor. The null hypothesis, on the other hand, assumes that random effects is consistent and efficient while the alternative assumption assumes its inconsistency and inefficiency. Rejecting null hypothesis shows evidence of accepting alternative hypothesis, indicating FEM is preferable while in contrast, an insignificant result showcases that accepting null hypothesis and REM is much preferable.

3.5 Diagnostic Checking

Diagnostic checking is a vital step in ensure the accuracy and reliability of the result. Several tests incorporated, will be conducted to check for autocorrelation, heteroscedasticity, cross sectional dependence and stationarity. These tests include panel unit root test, autocorrelation test, heteroscedasticity and cross-sectional dependence test and will be conducted using Stata.

3.5.1 Panel Unit Root Test

It is critical to determine whether the variables in the panel data are stationary or contains stochastic trend as such their statistical properties do not change over time. Non-stationary variables can lead to spurious regression. Hence the journal of Choi (2001), reports the null hypothesis containing unit root, indicates the nonstationary of data while alternative hypothesis containing no unit root indicates a stationary data.

Goal: To ensure variables are either:

- I(0): Stationary in levels.
- I(1): Stationary after first differencing.

3.5.1.1 Im, Pesaran, and Shin (IPS) W-Stat

The Im, Pesaran, and Shin (IPS) W-Stat, proposed by Im et al (2003), allows for heterogeneous unit roots across the panel units. One of its advantages on the IPS W-stat test, is that it allows for testing on the cross-sectional dependency, where common shocks affect all units, such as global recessions. Unlike the Levin-Lin-Chu (LLC) test, the IPS W-stat test accounts for flexibility when it comes across an unbalanced panel data.

3.5.1.2 Augmented Dickey-Fuller (ADF-Fisher Chi-Square) Test

The ADF-Fisher Chi-Square Test were proposed by Maddala & Wu (1999). It combines Augmented Dickey-Fuller (ADF) test with Fisher's test, using chi-square statistic to make statistical inference in addition to consider for unbalanced and balanced panel data, supported by Greene (2018). ADF-Fisher Chi-Square Test also takes in account of the heterogenous unit roots across panel units that are independent, and cross-sectional units that are independent of one another. Nonetheless, when this fails to meet the assumption, it may cause the test statistics to be biased. Though, by adding lags, it enables the model to capture serial correlation.

3.5.1.3 Phillips-Peron (PP-Fisher Chi-Square) Test

The PP-Fisher Chi-Square Test proposed by Choi (2001) is an extended version from Maddala & Wu (1999) that uses Phillips-Peron (PP) test instead of ADF test. One of its key strengths that lies within this test, is that it is able to handle unbalanced panel data, taking account the heterogenous unit roots across panel units, heteroscedasticity while handling serial correlation problems. PP-Fisher Chi-Square Test are technically more robust as compared to ADF-Fisher Chi-Square Test. Due to Phillips-Perron (PP) corrections that are accounted for the usage of non-parametric adjustments, it handles for autocorrelation and heteroscedasticity that requires lag lengths to be adjusted and added for fitting.

3.5.2 Wooldridge Test for Autocorrelation

Wooldridge testing is inquired to detect autocorrelation, on whether the errors term in the regression model is correlated over the panel time. Null hypothesis assumes that there is no first order serial autocorrelation whereas the alternative hypothesis assumes that first order serial autocorrelation exists. The result favouring alternative hypothesis, indicates the existence of first serial order correlation in the panel data, hence adjustments are needed. By using robust standard error such as Driscoll-Kraay Standard Error Estimation, it mitigates the possibility of the problem.

3.5.3 Breusch-Pagan/Cook-Weisberg Test for Heteroscedasticity

Breusch-Pagan/Cook-Weisberg, tests for heteroskedasticity in the model to check whether the variance of residuals is constant throughout the observation which is one of OLS assumptions. For this test, the null hypothesis assumes variance of residual is constant (homoscedasticity) while the alternative assumptions assume that the variance of residual is not constant throughout the observation. If the result of the test appears to be significant, null hypothesis need to be rejected and heteroscedasticity exists in the model. A heteroscedasticity robust standard requires to solve the problem to ensure accuracy of the data.

3.5.4 Modified Wald Test for Groupwise Heteroscedasticity

Modified Wald Test is to test for Groupwise Heteroskedasticity which is specifically for fixed effects panel data. It occurs when the residual of variance is different across the countries. Null hypothesis assumes homoscedasticity which shows the panel have same residual variance while alternative hypothesis assumes that there is groupwise heteroscedasticity which the residual variance is different across the countries. The significance of the result shows a rejection towards null hypothesis indicating the existence of groupwise heteroscedasticity. To ensure the regression results remain accurate and reliable, adjustments can be done by using the robust standards errors.

3.5.5 Pesaran's Test of Cross-Sectional Dependence

Pesaran CD Test is a specific type of cross-sectional dependency (CSD) test, developed by Pesaran (2004) to take into account cross sectional dependence. This data collection phase does not involve statistical tests but rather focuses on gathering reliable and relevant datasets to detect errors across countries that are correlated. Null hypothesis assumes that there is no cross-sectional dependence while alternative hypothesis assumes that there is cross-sectional dependence. A significant result shows rejection of null hypothesis indicating that there is cross-sectional dependence. This may be a result from external shocks such as unexpected policy shifts in one country, or the global oil crisis spill-over to others.

Chapter 4: Data Analysis

4.1 Descriptive Statistics

In this study, the research examines 159 observations of data gathered across 7 countries over a 23-year period, from the year 2000 to 2022. The main objective of our descriptive statistical analysis is to examine the key features of the chosen variables for the investigation. By computing measurements like the mean, median, maximum, minimum, and standard deviation, we want to present an extensive overview of the distribution, dispersion, and core tendencies of the data. Our focus is on the dependent variable, carbon emissions, represented by carbon dioxide (CO_2) emissions (total) excluding LULCF (Mt CO_2e). Additionally, we focus on two independent variables: green finance, measured by renewable energy sources of public energy RD&D expenditures in million USD, and governance, measured by government effectiveness: estimate. By examining these factors, we aim to gain a deeper understanding of how these affect carbon emissions globally throughout time.

Table 4.1 *Descriptive Statistics*

Variables	$lnCO_2$	lnGF	GOV	lnGDP	lnEI	lnRENE
Mean	6.67	5.37	1.40	28.82	1.38	2.21
Median	6.35	5.35	1.52	28.63	1.34	2.17
Std.Dev.	0.88	0.95	0.42	0.75	0.35	0.75
Min	5.66	2.39	0.19	27.78	0.71	0.08
Max	8.69	7.99	1.92	30.70	2.11	3.43

Notes. Some variables are taken in the form of ln. CO_2 is the total carbon dioxide emitted in million metric tons, GF (Green Finance) measured as Renewable Energy Sources (Public Energy of RD&D in Million USD), GOV is Government Effectiveness

Estimator, GDP is constant US$, EI (Energy Intensity) is the level of primary energy (MJ/$), RENE (Renewables) is RENE consumption (% equivalent primary energy)

The descriptive statistics of the variables, namely CO_2, GF, GOV, GDP, EI and RENE tabulated in **Table 4.1**, highlights on the significant disparities across the nations of G7 examined. The total observations gathered resulted in an unbalanced panel data due to the absence of green finance data in Italy from 2021 to 2022. This observation does not signify a flaw in the data but rather a reflection of the reality, that is common in real-world research.

CO_2 (million metric tons) showcases the mean of 6.67 that is slightly higher than the median of 6.35, positing a right-skewed distribution. The carbon emissions ranges from the minimum value of 5.66, recorded by France in 2020 and the maximum value 8.69, recorded by the United States in 2000. The standard deviation of 0.88 further stresses on the high consistency among the CO_2 variables, reducing any outliers that is crucial for testing it accurately. This therefore suggests the uniformity of common global factors that creates a convergent pattern in per output of emissions.

Green finance (RD&D in Million USD), exhibits a moderate variability of 5.57 mean and 5.35 median in value, indicating a strong right skewness. The standard deviation of 0.95 shows the highest amongst all other variables, confirming that green finance investment is the most volatile and dispersed variable in the dataset. United Kingdom posits a value of 2.39 in 2000 that likely reflects on the early-stage investment of renewable energy sources while United States upshot a maximum value of 7.99 in 2009, suggesting an increasing alignment towards a greener technology. This vast gap somehow underscores the extreme inequality in green finance commitments across the samples.

GOV (governance indicated by government effectiveness) has a mean value of 1.40 and a median value of 1.52. The standard deviation posits a low value of 0.42, suggesting the level of government effectiveness across the sample does not vary much as other variables. The low score of 0.19's minimum value in Italy, 2007, captures its significance in the government turnover and political fragility while the maximum value of 1.92 in Canada, 2003 aligns with the period of strong economic performance and governing.

On the other hand, controlled variables account for GDP, EI, and RENE across the examined nations. Firstly, GDP (measured in constant US$) has a mean of 28.82 that is slightly higher than the median of 28.63. The standard deviation noted as 0.75, represents a cohort of advanced, high-income economies with very similar levels of economic output. Minimum value of 27.78 in Canada, 2000, reflects the economic conditions at the start of the millennium, thus serving this as a high baseline from which the nations in the sample grew. Maximum value of 30.70 is shown by the United States in 2022, showcasing a persistent economic growth in technological advancement and economic policy, solidifying its position at the top of the income distribution within this sample. Secondly, EI (energy intensity measured in MJ/$) has a mean of 1.38 and median of 1.34, indicating a symmetrical distribution. The standard deviation of 0.35 has a moderate variability that is relatively consistent. Minimum value of 0.71 MJ/$ in the United Kingdom, hallmarks the highly energy-efficient economy in 2022, driven by policy improvements while the maximum value of 2.11 MJ/$ in Canada, represents a period of lower energy efficiency in 2000 due to greater reliance on energy-intensive industries, less stringent efficiency standards for buildings and vehicles.

Lastly, RENE (renewable consumption measured in %), has a mean value of 2.21 and a median of 2.17, indicating a highly symmetrical distribution. The standard deviation of 0.75 indicates a moderate degree of variability, where this level of dispersion is crucial for analysis, as it provides the necessary variation to statistically test what factors are contributing or driving the countries to adopt renewables faster than others. The minimum value of 0.08% in 2001, captures the absolute starting point of the modern renewable energy journey for United Kingdom while the maximum value of 3.43% in Canada, represents a significant progress in 2020 which may be due to their long-standing and massive investment in hydropower, providing bulk of its renewable output.

Overall, the descriptive statistics reveal a dual significance of homogeneity and heterogeneity among developed nations. This divergence is evident in the wide range of green finance and renewable energy adoption that highlights the different national policy trajectories and transition speeds despite a shared economic foundation. The variability in this testing provides an analytical leverage, confirming the need for tailored models to effectively interpret the isolation on the impact of green financing and governance on environmental outcomes within this advanced economic cohort.

4.2 Panel Unit Root Testing

In ensuring the reliability and accuracy of the result in the long run, it is important to create a robust regression model that accurately captures it. One important assumption that needs to be fulfilled in regression analysis is the data stationarity. When data is stationarity, it implies that statical properties do not change over time which have constant mean, variance and covariance. Non-stationary data can lead to spurious regression results, whereby the hypothesis testing considered unworthy and not reliable in addition, leads to misleading result. To address the concern, we examined a panel unit root test of our sample consisting of 7 countries from the period of 2000 to 2022. The objective of this test is to detect the presence of unit root whether differencing is required to ensure the data is in the state of stationarity.

There will be a total of 3 panel unit root test that will be conducted which include Im, Pesaran and Shin (IPS) W-stat test, ADF - Fisher Chi-Square Test, and PP - Fisher Chi-Square Test whereby three of the tests are suitable to be used for unbalanced panel data. However, the test has its own assumption and limitation. IPS W-stat test allow individual effects by having heterogeneity across the panel data which means the alternative hypothesis allows stationarity and non-stationarity, but it does not work well in small panel data due to lag of power as it unable to capture full effect of data stationarity patterns. ADF - Fisher Chi-Square Test assume that the variable acts independently which are sensitive towards structural breaks while PP - Fisher Chi-Square Test also assume independence of variable across the panels data and are more robust compared to ADF Chi Square Test. Hence, there the tests have different assumption and limitation which why is essential to conduct multiple unit root test to ensure a more robust result and concrete evidence of data stationarity.

Table 4.2 *Panel Unit Root Test for Level*

Variables	Im, Pesaran and Shin W-stat		ADF- Fisher Chi Square		PP- Fisher Chi Square	
	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept &Trend
lnGF	-1.4894*	1.1579	20.1750	4.7496	35.2734***	29.2644***
GOV	0.9395	-1.2533	15.9295	18.4546	29.3876***	30.8653***
lnGDP	0.7471	-1.6042*	6.7858	20.8538	30.0721***	30.2917***
lnEI	6.1653	-0.4663	0.2781	15.8923	29.6231***	29.6275***
lnRENE	2.2916	-0.1090	7.3099	12.2645	30.8809***	41.1161***
lnGF*GOV	-0.9255	0.8860	16.7595	6.2181	29.3051***	39.6816***

*Notes * Indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level.*

Table 4.3 Panel *Unit Root Test for First Differences*

Variables	Im, Pesaran and Shin W-stat		ADF- Fisher Chi Square		PP- Fisher Chi Square	
	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept &Trend
lnGF	-5.8821***	-4.6158***	76.5769***	62.3123***	161.1423***	147.6761***
GOV	-4.4871***	-3.6348***	53.7737***	43.5415***	186.5785***	159.5024***
lnGDP	-4.3362***	-2.8072***	49.6321***	31.6754***	177.4347***	136.5283***
lnEI	-3.7474***	-2.9581***	44.3794***	37.3317***	198.9133***	190.2713***
lnRENE	-3.1465***	-2.8958***	37.7451***	34.2563***	225.5739***	222.1921***
lnGF*GOV	-2.6595***	-2.5399***	63.9521***	31.1327***	160.3619***	182.7141***

*Notes. * Indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level.*

Table 4.2 presents the result of panel unit roots test in level form which include logged form variables including lnGF, GOV, lnGDP, lnEI, lnRENE, lnGF*GOV. These variables are important in our analysis, focusing on green finance, governance, gross domestic product, energy intensity, renewable energy consumption, and the interactive term of green finance and governance. IPS W stat test, ADF Chi Square test and PP Chi Square test were tested in intercept form and intercept and trend form. The IPS W stat ADF Chi Square test yields a mixed result showing the lnGF in IPS W stat without trend and ln GDP in IPS W stat with trend does not contain unit root while the other variable shows insignificant and contain unit root. However, for the PP Chi Square test it shows the variables are significant at 1% which strongly rejects null hypothesis where the variables do not contain unit root and stationary. Previous researchers by Maddala and Wu (1999) stated that IPS W stat and ADF fisher test have low statistical power which makes the result to be inconclusive. PP chi square has higher power which can detect stationarity more reliable making the test more robust (Mravak, 2023)

The first difference is required to ensure all the data are in stationary form before proceeding to the next methods which are displayed in **Table 4.3** showing the result of first differences of the logged variables. The result from the first difference indicating all the variables is stationary and is confirmed by three tests which include Im, Pesaran and Shin (IPS) W-stat test, ADF - Fisher Chi-Square Test, and PP - Fisher Chi-Square Test and showing the significance level at 0.01.

In summary, the mixed result indicating IPS W stat and ADF - Fisher Chi-Square Test test have low power whereby PP - Fisher Chi-Square Test have high power and take into account serial correlation and heteroscedasticity without the needs of specific lag lengths. Variables that are non-stationary data could cause a serious which will lead to spurious regression problem in the long run and misleading result which makes regression analysis not reliable. By first differencing the variable shows all the data are stationary which could be categorized as I (1). The stationary of data enhances the reliability of our next methods and strengthen the ability to draw meaningful conclusion.

4.3 Pooled OLS, Random Effect Model (REM) and Fixed Effect Model (FEM)

Table 4.4 *The result of Pooled OLS, Fixed Effect Model (FEM), Random Effect Model (REM), and Diagnostic Tests*

	POLS	REM	FEM	FEM (Robust)
lnGF	-0.493*** (0.124)	-0.493*** (0.124)	-0.091*** (0.027)	-0.091*** (0.027)
GOV	-1.684*** (0.371)	-1.684*** (0.371)	-0.187** (0.093)	-0.187** (0.053)
lnGDP	1.048*** (0.040)	1.048*** (0.040)	0.695*** (0.072)	0.651** (0.194)
lnEI	0.984*** (0.059)	0.984*** (0.059)	0.695*** (0.083)	0.695** (0.207)
lnRENE	-0.028 (0.027)	-0.028 (0.027)	-0.088*** (0.016)	-0.088** (0.037)
lnGF*GOV	0.304*** (0.075)	0.304*** (0.075)	0.065*** (0.016)	0.065*** (0.009)
Constant	-22.109*** (1.122)	-22.109*** (1.122)	-12.599*** (2.214)	-12.599*** (5.849)
Observations	159	159	159	159
R^2	0.9536	-	-	-
Adjusted R^2	0.9518	-	-	-
R^2-Within	-	0.622	0.8985	0.8985
R^2-Between	-	0.9603	0.9186	0.9186
R^2-Overall	-	0.9536	0.9178	0.9178
Wald-Chi^2	-	-	3125.82	-
<u>Specification Tests</u>				
BPLM Test	0.00	-	-	-
Poolability F- Test	-	-	639.99***	-
Hausman Test	-	-	146.43***	-
<u>Diagnostic Tests</u>				
Wooldridge Auto-correlation test	-	-	27.444***	-
Heteroskedasticity test	-	-	44.99***	-
Groupwise Heteroskedasticity test	-	-	316.24***	-
Cross-sectional dependency test	-	-	0.851	-

*Notes. The standard error values are shown in parentheses. The test statistic values are shown without parentheses. * Indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level.*

Table 4.4 summarizes the use of pooled OLS as an initial baseline to estimate the average relationships across all countries and years in the panel and its implementation of fixed effects models (FEM) and random effect model (REM) included to further observe the long-run regression model.

Besides, we also carried out specification tests to further indicate which regression panel is best suited for our model in estimating the carbon emissions. Using Breusch-Pagan Lagrangian Multiplier Test (BPLM) are tested between Pooled OLS and REM which to further investigate whether the models exhibit random heterogeneity. Since we do not reject in BPLM, making pooled OLS a valid model to be used. Further investigation through poolability F-test, Baltagi et al. (1996) acknowledges for model uncertainty, indicating non-normality in data by choosing it as a nonparametric test. Unlike a standard parametric F-test, it does not assume a specific functional form such as a linear or quadratic relationship, making it robust to functional form misspecifications suited for our data. The test reliably identifies for structural instability, hence validating the null hypothesis of pooled OLS in our data is rejected, indicating the fixed effect model (FEM) is better suited among the two.

Finalizing and comparing the suitability of regressions, Hausman test was used to test on both FEM and REM. Its decision is based on a fundamental econometric principle in the trade-off between consistency and efficiency. The test directly tests the presence of unobserved individual-specific effects that are correlated with independent variables. This correlation is the source of endogeneity that would render many estimators biased (Jongadsayakul, 2022). Consequently, the test further suggests using fixed effect model (FEM) that is more preferable to estimate our panel data. Collectively, the results of these tests affirm the superiority and robustness of the fixed effects model (FEM).

Moreover, diagnostic tests are essential after specification tests to ensure the chosen model's results are not only well-specified but also statistically robust and reliable. Diagnostic tests evaluate whether the regression errors violate classical assumptions. If left unaddressed, these violations can lead to biased standard errors, inefficient coefficients, and misleading inferences, undermining the validity of hypothesis tests and confidence intervals. In the case of serial correlation tests, the null hypothesis of the autocorrelation test is rejected, with the F-statistics (27.444) in this test being significant at the 1% level, indicating the presence of first-order autocorrelation in our data set. As for heteroscedasticity and group-wise heteroscedasticity test, the chi2 statistics of 44.99 and 316.24 respectively rejects the null hypothesis at 1% level, indicating the presence of heteroscedasticity in the data set. Lastly, diagnostic testing for cross-sectional dependence yields a statistically insignificant result of 0.851, failing to reject the null hypothesis. This provides robust evidence that the error terms across national units are not simultaneously correlated, implying that country-level CO_2 emissions are not driven by latent common factors nor demonstrating economic spillovers in their year-to-year fluctuations.

Although standard specification test, namely the Poolability F-test and Hausman tests, validate the Fixed Effects Model (FEM) as the consistent estimator for our data, subsequent diagnostic analysis revealed violations of the classical regression assumptions on the presence of both autocorrelation and heteroskedasticity that renders the conventional FEM's standard errors biased and inefficient, thereby potentially leading to incorrect statistical inferences. To address this, we employ the FEM robust that corrects for both heteroskedasticity as well as serial correlation in our data, by calculating standard errors that are consistent even in the presence of such problems. This ensures the conclusiveness and validity of our hypothesis tests based on the FEM coefficients.

The results in **table 4.4** confirms that the CO_2 emissions increase when gross domestic production (GDP), energy intensity and along with the interactive term of green finance and governance increase, while the decrease in CO_2 emissions decreases along with green finance, governance and renewable consumptions, while keeping all other factors constant.

With the results obtained from FEM robust model, the coefficient suggests an increase in 1% of green finance will decrease the CO_2 emissions by 0.091% at a 1% level of significance, ceteris paribus. When the governance increases by 1%, the CO_2 emissions decreases 0.187% at 5% level of significance, ceteris paribus. Whereas the increase in the gross domestic production (GDP) at 1% will increase the CO_2 emissions by 65.1% at 5% level of significance, ceteris paribus. Besides, the increase in 1% energy intensity will increase carbon emissions by 0.695% at 5% level of significance, ceteris paribus. Next, a 1% increase in renewable consumption will decrease the CO_2 emissions by 0.088% at 5% level of significance, ceteris paribus.

Finally, an increase of 1% in the interactive term between green finance and governance will increase the CO_2 emissions by 0.065%, at 5% level of significance, ceteris paribus. The green finance and governance as the interactive terms show a positive coefficient which means that combination of both variables will increase CO_2 emissions. This result is supported by Hunjra et al. (2024) and Yadav et al. (2024), evidently validates on the positive interactive term by marginal return effects.

The individual of the variables green finance and governance shows the direct effect of the variables towards CO_2 emissions. This shows that the direct effect of both individual variables showing a decrease in CO_2 emissions. However, the interactive term (indirect effect) said otherwise which shows an increase in CO_2 emissions. The combination of interactive term and direct effect of green finance showing a total effect of -0.026 whereas the combination of interactive term and direct effect of governance showing a total effect of -0.122. Although the total effect remains negative but existing policies and frameworks may become a barrier towards the effectiveness of green finance and governance in reducing CO_2 emissions.

4.4 Robustness Checking with different proxy for Green Finance

Table 4.5 *The results of robustness checking*

	FEM (robust)
lnGF (X8)	-0.114*** (0.027)
GOV	-0.416** (0.133)

	FEM (robust)
lnGF (X1)	-0.083*** (0.021)
GOV	-0.155*** (0.041)

lnGDP	0.683**		lnGDP	0.671**
	(0.192)			(0.173)
lnEI	0.682**		lnEI	0.648**
	(0.197)			(0.217)
lnRENE	-0.098**		lnRENE	-0.105*
	(0.037)			(0.0493)
lnGF*GOV	0.076***		lnGF*GOV	0.053***
	(0.017)			(0.009)
Constant	-13.11*		Constant	-13.049**
	(5.687)			(5.340)
Observation	159		Observation	154
R^2	-		R^2	-
Adjusted R^2	-		Adjusted R^2	-
R^2-Within	0.8988		R^2-Within	0.8878
R^2-Between	0.9279		R^2-Between	0.9298
R^2-Overall	0.9266		R^2-Overall	0.9288
Wald-Chi²	-		Wald-Chi²	-

*Notes. The standard error values are shown in the parentheses. The test statistic values are shown without parentheses. * Indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level.*

To ensure the reliability of our findings, we have conducted a robust check-up using different proxies for the variables of green finance as shown in **table 4.5.** Moving ahead, we have also progressed our research of the main proxy of green finance, (X3) renewable energy sources, by comparing it with, (X8) of Total Budget, and (X1) energy efficiency, as employed by (Gu et al., 2023). These direct comparisons of green finance proxies significantly increase confidence in proceeding with the regression result affected by small panel data.

The result from this robustness checking indicates the findings result to be similar compared to our main FEM result using proxy (X8) where CO_2 emissions increase when gross domestic production (GDP) per capita, energy intensity and along with the interactive term of green finance and governance increase, while the decrease in CO_2 emissions decreases along with green finance, governance and renewable consumptions, keeping all other factors constant. The consistency suggests that the findings are not sensitive to any changes of the proxies, therefore reinforcing the robustness to be more concrete and reliable.

4.5 Marginal Effects

Based on the chapter 4.3, the results conditioned on the direct impact of green finance and governance respectively and an indirect impact on the interactive term. This has led us to further study on computing the calculation of marginal effects to observe the overall effect of green finance and governance affecting the carbon emissions. This is an important aspect to further understand the measurement in the change of the outcome variable caused by a change in the explanatory variable, while holding all other variables constant.

The interactive term based on the econometric model showcases that the effect of one independent variable (governance, GOV), on the dependent variable ($\ln CO_2$) depends on the value of another independent variable (green finance, lnGF), vice versa. This interdependent relationship creates a conditional effect, suggesting that changes occur within the relationship at different levels.

The econometric model denoted from the coefficients of FEM (robust) is shown as:

$$\ln CO_{2it} = \beta_0 + \beta_1 \ln GF_{it} + \beta_2 GOV_{it} + \beta_3 \ln RENE_{it} + \beta_4 \ln EI_{it} + \beta_5 \ln GDP_{it} + \beta_6 (\ln GF_{it} * GOV_{it}) + \mu_{it} \quad (1)$$

$$\ln CO_2 = -12.599 + (-0.091)\ln GF + (-0.187)GOV + (-0.088)\ln RENE + (0.695)\ln EI + (0.651)\ln GDP + (0.065)\ln GF * GOV + \mu_{it} \quad (2)$$

Based on the article of Brambor et al. (2006), results of marginal effect can be interpreted as:

Marginal effect of lnGF on $\ln CO_2$:

$$\frac{dy}{dx} = \frac{dCO_2}{d\ln GF} = -0.091 + (0.065)\ GOV \quad (3)$$

Marginal effect of GOV on $\ln CO_2$:

$\frac{dy}{dx} = \frac{dCO_2}{dGOV}$ = -0.187 + (0.065) lnGF (4)

The following equations are computed at different levels to observe both the efficacy of green finance and governance at its most effective and weak state;

Based on Eq. (3), the effect of green finance (lnGF) at governance (GOV) are computed at different levels of WGI score (-2.5 to +2.5):

For country with weak governance (GOV= -2.5):

-0.091 + (0.065) GOV = -0.091 + (0.065) (-2.5) = -0.091 + (-0.163) **= -0.254**

For country with average governance (GOV= 0):

-0.091 + (0.065) GOV = -0.091 + (0.065) (0) = -0.091 + (0) **= -0.091**

For country with effective governance (GOV= +2.5):

-0.091 + (0.065) GOV = -0.091 + (0.065) (+2.5) = -0.091 + (0.163) **= 0.072**

From the results above, 0.254, indicating a negative sign in weak governing, suggests that an increase in green finance is associated with a decrease in CO_2 emissions. In essence, an increase in one unit of green finance will approximately decrease a 25.40% of CO_2 emissions for a country at low governance. This suggests that even small green finance investments matters more when institutions are fragile.

For a country with average governance, it results in a negative sign of 0.091, indicating an increase in green finance is associated with a decrease in CO_2 emissions. The increase in one unit of green finance will approximately decrease 9.10% of CO_2 emissions. At average levels of governance, it suggests that the effect is weaker that may be due to what governance structures partly substitute what green finance could achieve.

For a country with strong governance, the positive sign of 0.072 indicates that an increase in green finance is associated with a strong increase in CO_2 emissions. This large effect signifies that an increase in one unit of green finance poses an increase of approximately 7.20% in CO_2 emissions. This result highlights the critical role on governance, whereby strong institutions prompt green finance to increase in emissions after a certain point. This somehow indicates that green finance may be redirected to less impactful areas, such as “greenwashing” projects. Hence, as strong governance have their policies in place, green finance no longer adds value; and can even crowd out more efficient investments.

Consequently, the effectiveness of green finance is entirely dependent on the quality of governance. Gren finance is most impactful at weak-to-average governance contexts. While in strong governance environments, policymakers need to ensure green finance is well-targeted to avoid redundancy.

Based on Eq. (4), the effect of governance (GOV) at green finance (lnGF) are computed at different levels of min, mean and max:

For country with low level of green finance inputting the minimum value of (lnGF=2.39):

-0.187 + (0.065) lnGF = -0.187 + (0.065) (2.39) = -0.187 + (0.155) **= -0.032**

For country with average level of green finance inputting the mean value of (lnGF=5.37):

-0.187 + (0.065) lnGF = -0.187 + (0.065) (5.37) = -0.187 + (0.349) **= 0.162**

For country with high level of green finance inputting the maximum value of (lnGF=7.99):

-0.187 + (0.065) lnGF = -0.187 + (0.065) (7.99) = -0.187 + (0.519) **= 0.332**

Based on the effect of governance at green finance levels, the country with low green finance posits a negative sign of 0.032, associating a decrease in carbon emissions. With one unit improvement in the WGI score constitutes to a decrease of approximately, 3.2% in CO_2 emissions, even with low green finance. This suggests that better governance has little to no effect on reducing emissions.

Governance alone cannot push carbon reduction strongly without sufficient green financing.

With an average level of green finance, the result of 0.162, confirms that at average governance, it increases emissions, nonetheless. One unit of improvement in governance results in an increase of 16.20% in CO_2 emissions. While, for a country with high green finance, the negative sign still indicates that better governance reduces CO_2 emissions. One unit of improvement in governance is associated with an increase of 33.20% in CO_2 emissions.

The increment of values from 16.20% to 33.20%, showcases the effect being strong when green finance rises. This critical point delivers that while governance amplifies the influence of green finance, the allocation of such finance (RD&D investments), may be misdirected or even slow in delivering emission reductions, while strong governance may accelerate activities that raise emissions in the short run. Though governance has a reinforcing role, it must be coupled with effective allocation of green finance towards emission-reduction technologies, otherwise the interaction may lead to higher emissions.

Overall, both green finance and governance are complementary factors that directly interpret the marginal effects of the results. Interestingly, the marginal effects indicate that governance exerts a stronger influence than green finance in high-emissions contexts. While green finance initially reduces emissions, its impact diminishes as the levels increase. In contrast, governance's marginal contribution becomes positive and increasingly dominant at higher green finance levels. This suggests that without targeted allocation and complementary policy design, strong governance may amplify the scale of financed activities, thereby offsetting the emission reduction gains. Hence, governance quality itself is not significant but also potentially more decisive than green finance in shaping the emission trajectories.

Chapter 5: CONCLUSION AND IMPLICATION

5.1 Summary of Statistical Analysis

The analytical methods that were used in this study are the Fixed Effects Model (FEM), the Random Effects Model (REM), and Pooled Ordinary Least Squares (OLS) model. We employed Hausman test and F-test in determining the best model to use in our data analysis (Jongadsayakul, 2022). Based on the results that we tested, we found out that Fixed Effect Model (FEM) was the most appropriate model to be used.

We fully examined, compared, and tested the Pooled OLS, FEM and REM to ensure that our results were accurate and robustness. This was done through cross-sectional dependence (CSD) test, heteroskedasticity test as well as the Wooldridge test. This is because we indicated that these models were affected by econometric problems such as autocorrelation, heteroskedasticity and cross-sectional dependency (Hoechle, 2007).

Therefore, green finance and governance as a combination were aimed at reducing the carbon emissions in the main research objective. But our findings suggest that an interaction of the two factors may not help to mitigate these effects but to increase them. This result has shown that the hypothesis that there might be a possibility of increase in carbon emission because of interaction term.

The study also includes other variables that significantly influence carbon emissions as the control variables. Effective variables that can achieve lower carbon emissions include energy intensity, renewable energy consumption (% of total final energy consumption), and gross domestic product (GDP). These predicted outcomes are justified by the findings of the study that advance our understanding of the way these factors affect the dynamics of carbon emissions.

5.2 Implications of the study

The findings of the research which show that more green financing and governance will reduce carbon emissions, make it imperative to offer pertinent recommendations. These suggestions ought to concentrate on boosting green finance and governance to achieve our goals of reducing carbon emissions. As a result, two important recommendations emerge which are expand green finance initiatives to enhance environmental quality and strengthen governance frameworks to optimize the impact of green finance.

5.2.1 Expand Green Finance Initiatives

Studies indicate that green finance highly reduces the carbon dioxide emissions. It is important that countries maximize these advantages by increasing green finance and ensuring that the funs is directed to the right place, low carbon sectors. The investments in important sectors such as renewable energy and energy efficiency infrastructure can be covered by tax initiatives or subsidies on green bonds, but they can also be stimulated to invest in the new technologies (Zhang, 2024).

Positive outcomes can be achieved by the development of green finance. Countries continuing to use fossil fuels may experience economic issues in the short term if green investments increase at a faster rate than industries moving away from the use of fossil fuel. In countries where the financial system is well developed such as US, large-scale green finance has the potential to sustainably maintain the flow of ventures to minimise the fluctuation in funding sizes and decrease the prices of transitioning to sustainable economies (Ma & Jiang, 2025). Nevertheless, the over-reliance on a single green finance instrument, such as green bonds may be not enough. It would be possible to accumulate more money in particular areas and undermine broader sustainability objectives.

Economic development developed together with green finance. It requires an additional green investment capacity to combat the environmental obstacles without sufficient funds (Desalegn & Tangl, 2022). By realizing and enhancing access to various instruments, such as green loans and funds specialized in sustainable investments policy makers can stimulate the development of low-carbon projects without destabilizing the economy (Braga & Ernst, 2023). Therefore, this moderate policy maintains the world healthy and relies on global financial integration.

5.2.2 Strengthen Governance Frameworks

Efficient governance routines will be essential in making the environment safer. This can be achieved through implementation of its policies that reduce carbon dioxide emissions. The countries must have a combination of strict rules and measures that assist the people in tackling the rules, especially in the major areas like energy and transportation. Policies such as differentiated emission standards and subsidized clean technology can enable domestic emission controls to continue and stimulate new thinking about sustainable activities (Lyu et al., 2024).

In short run, nations with ineffective institutions can find it difficult to implement complicated environmental laws and become inefficient, or make industries change their minds (Howes et al., 2017). Conversely, well-designed policies should help strong governments use these policies to enhance carbon emission reduction efforts, reduce the risks of non-compliance, and reduce the expense of monitoring and enforcement. Nevertheless, the excessive reliance on high-level regulations in the long term will constrain innovativeness when the policies fail to adapt to new environmental demands, which harms long-term sustainability objectives.

Environmental control by the government may cooperate alongside economic growth. Governments need to enhance their governance capacity to achieve sustainability objectives and operate with constrained resources. They can achieve it by making laws understandable, allowing affected groups to provide input, and revising regulations where necessary (Oberthür et al., 2025). In such a way by considering both the work of preserving the environment and preserving a healthy economy, the authorities promote long-term sustainability and employ international collaboration to prevent the risks of global warming.

5.3 Limitation of study

The study on how green finance and governance affect carbon emissions is also accompanied by limitations that undermine its power and its applicability elsewhere. First, it was difficult to obtain all the data to use in all variables. The sample size of 161 observations based on seven G7 countries between year 2000-2022 is based on such figures as green finance using (public energy RD&D spending) and governance (using the estimates of government effectiveness). However, the proxy of green finance (public RD&D spending) only measures part of green finance but not the whole. In addition, there are not much is provided on how the fund of green finance is utilized on the variances in local policies restricting the results in terms of accuracy and completeness.

Using Pooled OLS, Fixed Effects Model (FEM), and Random Effects Model (REM) to analyse how green finance and governance affect carbon emissions in this research has several limitations. First, pooled OLS assumes that all countries are similar but does not consider individual country-specific factors such as economic structures, which may bias the results when those determinants have an influence on emissions (Khosravi et al., 2025). Second, fixed effects model (FEM) adjusts those differences yet might fail to capture time-varying impacts, such as policy shifts in addition to having difficulty with variables that fluctuate gradually, which may undermine results (Hill et al., 2019). Third, random effects model (REM) assumes that country-specific effects are independent of the explanatory variables which is not necessarily true, thereby giving unreliable estimates in the event of violation (Ziller, 2024).

The research relies on two variables which are green finance and governance to measure whether it can or cannot reduce CO_2 emission. The measures are acceptable yet insufficient as they do not provide complete description of the numerous forces that reduce carbon emissions The statistics of green finance may lack information on the efficiency and sustainability of projects. Governance indices can bypass national politics or the competence of the law’s implementation. The study also includes only per-capita carbon dioxide emissions and does not include carbon dioxide associated with land use, land-use change and forestry (LULCF), which may result in underreporting the actual situation.

In addition, the research examined only few variables and included only the information of the G7 countries, therefore its results may not be effective to all countries. Therefore, the positive interaction term effect which are the combination between green finance and governance, may implies possible buffering effect which should be investigated further but that may reflect the limitation of the model specification.

5.4 Recommendation for Future Studies

Future research on the impact of green finance and governance on carbon emissions can take what has been studied in this study to another level by examining the weaknesses, and by looking at other new areas that can enable an effective understanding at reducing the effects of carbon emission. Among the recommendations, a broader coverage of the data and countries will be employed. Although limited to seven G7 countries, incorporating developing countries or regions whose economies and environment are different may be more comprehensive. As an example, investigations of countries with developing economies or a high dependence on fossil fuel might demonstrate how green finance and governance can be applied to it. It would also be useful to include more countries to ensure that the research can be more applicable to other countries of the world too.

The second suggestion is to use more definite and various data sources. This study incorporates the use of public energy RD&D spending as a measurement of the proxy for green finance that could thus be incomplete in presenting the whole picture. Therefore, the measurement of government effectiveness of governance can also be incomplete in displaying the overall impact. It is also possible to develop research into a particular governance condition including green investments in the private sector such as green bond or sustainable loans and resolved into factors of further particular governance such as the intensity of environmental policy or corruption levels (Schmittmann & Gao, 2022; Tawiah et al., 2023). Furthermore, the results would be more reliable with better data quality, especially to avoid such gaps for example green finance data in Italy in year 2021 and 2022. This can be enhanced with the utilization of superior data collection or real-time tracking.

Lastly, policy frameworks aimed at increasing the effectiveness of green finance and governance are needed in the reduction of carbon emissions. One of the suggestions is the need to study focused policies such as carbon pricing, green subsidies or regulations incentives in a range of economies (Sterner et al., 2023). Examination of how policy enforcement differs in terms of quality of governance and is reflected in green finance allocation might lead to optimal strategies. As an example, one could examine how clear environmental regulations or anti-corruption policies can raise the effectiveness of green investments (Wu et al., 2021). This would assist policy makers in coming up with customized and evidence-based plans to meet global sustainability objectives in a cost-effective manner. In summary, these steps would better formulate policies to reduce carbon emissions and facilitate achievement of global sustainability objectives.

5.5 Conclusions

This study demonstrates that the efficacy of green finance as a potent tool to combat climate change is critically contingent upon the quality if a nation's governance. Hence, based on our overall findings, the complementary relationship unravels when governance acts as an essential catalyst that unlocks the potential of green finance. In essence, governance is the moderating force in the study that determines whether green finance becomes a solution or a contributor to the problem of climate change. Without the foundational framework of strong institutions, and effective regulation, substantial investments in green finance may be misallocated, leading to inefficiencies in carbon emissions. Conversely, good governance alone has a potent effect on reducing emissions, but its impact may be magnified exponentially when it channels and manages robust financial flows.

In summary, this research shifts the policy debate from narrow focus on mobilizing capital to a more holistic strategy that recognizes governance as the fundamental engine and green finance as the high-octane fuel. With the complementary integration of both components, only can nations effectively steer their economies towards a sustainable, low-carbon future.

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Appendices

Appendix 4.1: Descriptive Statistics

Summary Statistics

stats	ly	lnGF	GOV	lnGDP	lnEI	lnRENE
mean	6.673786	5.368837	1.403043	28.82254	1.375505	2.206633
median	6.353609	5.346936	1.521322	28.63404	1.342865	2.173899
std dev	.882467	.9495663	.4162243	.7535587	.3470026	.7541059
min	5.660612	2.385363	.1916483	27.7822	.7129498	.0813866
max	8.687606	7.99073	1.92468	30.69644	2.112635	3.425963

Appendix 4.2 IPS W-stat with Intercept

```
Im-Pesaran-Shin unit-root test for lnGF
---------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: Some panels are stationary              Avg. number of periods =  22.71

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                      sequentially
Time trend:   Not included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -1.4894        0.0682
------------------------------------------------------------------------------

Im-Pesaran-Shin unit-root test for GOV
---------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                      sequentially
Time trend:   Not included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar              0.9395        0.8263
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for lnGDP
---------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Not included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar              0.7471        0.7725
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for lnEI
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Not included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar              6.1653        1.0000
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for lnRENE
---------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Not included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar              2.2916        0.9890
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for lnGF*GOV
----------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: Some panels are stationary              Avg. number of periods =  22.71

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Not included

ADF regressions: 5 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -0.9255        0.1774
------------------------------------------------------------------------------
```

Appendix 4.2 ADF Chi-Squared Test with Intercept

```
Fisher-type unit-root test for lnGF
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots          Number of panels       =      7
Ha: At least one panel is stationary       Avg. number of periods =  22.71

AR parameter: Panel-specific               Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                 ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        20.1750       0.1247
 Inverse normal            Z        -1.3953       0.0815
 Inverse logit t(39)       L*       -1.4191       0.0819
 Modified inv. chi-squared Pm        1.1670       0.1216
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for GOV
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots          Number of panels  =      7
Ha: At least one panel is stationary       Number of periods =     23

AR parameter: Panel-specific               Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                 ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        15.9295       0.3177
 Inverse normal            Z         1.1328       0.8714
 Inverse logit t(39)       L*        1.2427       0.8893
 Modified inv. chi-squared Pm        0.3646       0.3577
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnGDP
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P         6.7858       0.9427
 Inverse normal            Z         1.2230       0.8893
 Inverse logit t(39)       L*        1.1735       0.8762
 Modified inv. chi-squared Pm       -1.3634       0.9136
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnEI
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P         0.2781       1.0000
 Inverse normal            Z         6.1190       1.0000
 Inverse logit t(39)       L*        6.8890       1.0000
 Modified inv. chi-squared Pm       -2.5932       0.9952
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnRENE
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P         7.3099       0.9221
 Inverse normal            Z         2.6365       0.9958
 Inverse logit t(39)       L*        2.7916       0.9960
 Modified inv. chi-squared Pm       -1.2643       0.8969
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnGF*GOV
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: At least one panel is stationary        Avg. number of periods =  22.71

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 5 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        16.7595       0.2692
 Inverse normal            Z        -0.5127       0.3041
 Inverse logit t(39)       L*       -0.5660       0.2873
 Modified inv. chi-squared Pm        0.5215       0.3010
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

Appendix 4.2 PP-Fisher Chi-Square Test with Intercept

```
Fisher-type unit-root test for lnGF
Based on Phillips-Perron tests
----------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: At least one panel is stationary        Avg. number of periods =  22.71

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Not included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        35.2734       0.0013
 Inverse normal            Z        -2.9020       0.0019
 Inverse logit t(39)       L*       -3.2193       0.0013
 Modified inv. chi-squared Pm        4.0203       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for GOV
Based on Phillips-Perron tests
----------------------------------
Ho: All panels contain unit roots          Number of panels  =      7
Ha: At least one panel is stationary       Number of periods =     23

AR parameter:    Panel-specific            Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Not included
Newey-West lags: 208 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        29.3876       0.0093
 Inverse normal            Z        -0.3720       0.3549
 Inverse logit t(29)       L*       -0.7444       0.2313
 Modified inv. chi-squared Pm        2.9080       0.0018
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnGDP
Based on Phillips-Perron tests
----------------------------------
Ho: All panels contain unit roots          Number of panels  =      7
Ha: At least one panel is stationary       Number of periods =     23

AR parameter:    Panel-specific            Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Not included
Newey-West lags: 350 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        30.0721       0.0075
 Inverse normal            Z        -2.0372       0.0208
 Inverse logit t(34)       L*       -1.9588       0.0292
 Modified inv. chi-squared Pm        3.0373       0.0012
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnEI
Based on Phillips-Perron tests
----------------------------------
Ho: All panels contain unit roots          Number of panels  =      7
Ha: At least one panel is stationary       Number of periods =     23

AR parameter:    Panel-specific            Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Not included
Newey-West lags: 620 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        29.6231       0.0086
 Inverse normal            Z        -4.9509       0.0000
 Inverse logit t(9)        L*       -8.7298       0.0000
 Modified inv. chi-squared Pm        2.9525       0.0016
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnRENE
Based on Phillips-Perron tests
-----------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     23

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Not included
Newey-West lags: 25 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        30.8809       0.0058
 Inverse normal            Z         2.0295       0.9788
 Inverse logit t(39)       L*        1.5845       0.9394
 Modified inv. chi-squared Pm        3.1902       0.0007
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnGF*GOV
Based on Phillips-Perron tests
-------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: At least one panel is stationary        Avg. number of periods =  22.71

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Not included
Newey-West lags: 23 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        29.3051       0.0095
 Inverse normal            Z        -1.3725       0.0849
 Inverse logit t(39)       L*       -1.8722       0.0343
 Modified inv. chi-squared Pm        2.8924       0.0019
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

Appendix 4.3 IPS W-stat with Intercept and Trend

```
Ips trend
Im-Pesaran-Shin unit-root test for lxGF
--------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: Some panels are stationary              Avg. number of periods =  22.71

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                    sequentially
Time trend:   Included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar               1.1579       0.8766
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for GOV
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -1.2533       0.1051
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for lnGDP
----------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -1.6042       0.0543
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for lnEI
---------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -0.4663       0.3205
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for lnRENE
-----------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -0.1090       0.4566
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for lnGF*GOV
-----------------------------------------
Ho: All panels contain unit roots          Number of panels       =      7
Ha: Some panels are stationary             Avg. number of periods =  22.71

AR parameter: Panel-specific               Asymptotics: T,N -> Infinity
Panel means:  Included                                      sequentially
Time trend:   Included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar              0.8860        0.8122
------------------------------------------------------------------------------
```

Appendix 4.3 ADF Chi-Square Test with Intercept and Trend

```
Fisher-type unit-root test for lnGF
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: At least one panel is stationary        Avg. number of periods =  22.71

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P         4.7496       0.9890
 Inverse normal            Z         1.9056       0.9716
 Inverse logit t(39)       L*        1.7960       0.9599
 Modified inv. chi-squared Pm       -1.7482       0.9598
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for GOV
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        18.4546       0.1869
 Inverse normal            Z        -1.1059       0.1344
 Inverse logit t(39)       L*       -1.1087       0.1372
 Modified inv. chi-squared Pm        0.8418       0.1999
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnGDP
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared (14)   P        20.8538       0.1054
 Inverse normal             Z        -1.5460       0.0611
 Inverse logit t(39)        L*       -1.5383       0.0660
 Modified inv. chi-squared Pm         1.2953       0.0976
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnEI
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)    P        15.8923       0.3200
 Inverse normal             Z        -0.1186       0.4528
 Inverse logit t(39)        L*       -0.2047       0.4194
 Modified inv. chi-squared Pm         0.3576       0.3603
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnRENE
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     23

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included
Drift term:   Not included                  ADF regressions: 5 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)    P        12.2645       0.5851
 Inverse normal             Z         0.3334       0.6306
 Inverse logit t(39)        L*        0.3604       0.6398
 Modified inv. chi-squared Pm        -0.3280       0.6285
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnGF*GOV
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: At least one panel is stationary        Avg. number of periods =  22.71

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P         6.2181       0.9607
 Inverse normal            Z         1.5381       0.9380
 Inverse logit t(39)       L*        1.4912       0.9280
 Modified inv. chi-squared Pm       -1.4706       0.9293
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

Appendix 4.3 PP-Fisher Chi-Square Test with Intercept and Trend

```
Fisher-type unit-root test for lnGF
Based on Phillips-Perron tests
----------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: At least one panel is stationary        Avg. number of periods =  22.71

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included
Newey-West lags: 30 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        29.2644       0.0096
 Inverse normal            Z        -0.0164       0.4934
 Inverse logit t(39)       L*       -0.3787       0.3535
 Modified inv. chi-squared Pm        2.8847       0.0020
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for GOV
Based on Phillips-Perron tests
----------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     23

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included
Newey-West lags: 35 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        30.8653       0.0058
 Inverse normal            Z        -1.1527       0.1245
 Inverse logit t(39)       L*       -1.6512       0.0534
 Modified inv. chi-squared Pm        3.1872       0.0007
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnGDP
Based on Phillips-Perron tests
----------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     23

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        30.2917       0.0070
 Inverse normal            Z        -2.8866       0.0019
 Inverse logit t(39)       L*       -2.8624       0.0034
 Modified inv. chi-squared Pm        3.0788       0.0010
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnEI
Based on Phillips-Perron tests
----------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     23

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        29.6275       0.0086
 Inverse normal            Z        -1.9630       0.0248
 Inverse logit t(39)       L*       -2.2251       0.0160
 Modified inv. chi-squared Pm        2.9533       0.0016
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnRENE
Based on Phillips-Perron tests
-----------------------------------
Ho: All panels contain unit roots          Number of panels  =      7
Ha: At least one panel is stationary       Number of periods =     23

AR parameter:    Panel-specific            Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        41.1161       0.0002
 Inverse normal            Z        -1.7868       0.0370
 Inverse logit t(39)       L*       -2.7581       0.0044
 Modified inv. chi-squared Pm        5.1245       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for lnGF*GOV
Based on Phillips-Perron tests
-------------------------------------
Ho: All panels contain unit roots          Number of panels       =      7
Ha: At least one panel is stationary       Avg. number of periods =  22.71

AR parameter:    Panel-specific            Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included
Newey-West lags: 40 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        29.6816       0.0084
 Inverse normal            Z         1.4146       0.9214
 Inverse logit t(39)       L*        0.8265       0.7932
 Modified inv. chi-squared Pm        2.9635       0.0015
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

Appendix 4.4 First Difference IPS W-stat with Intercept

```
Im-Pesaran-Shin unit-root test for D.lnGF
-----------------------------------------
Ho: All panels contain unit roots          Number of panels       =      7
Ha: Some panels are stationary             Avg. number of periods =  21.71

AR parameter: Panel-specific               Asymptotics: T,N -> Infinity
Panel means:  Included                                     sequentially
Time trend:   Not included

ADF regressions: 1 lag
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -5.8821        0.0000
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for D.GOV
----------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Not included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -4.4871       0.0000
------------------------------------------------------------------------------


Im-Pesaran-Shin unit-root test for D.lnGDP
------------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Not included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -4.3362       0.0000
------------------------------------------------------------------------------

Im-Pesaran-Shin unit-root test for D.lnEI
-----------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Not included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -3.7474       0.0001
------------------------------------------------------------------------------


Im-Pesaran-Shin unit-root test for D.lnRENE
-------------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Not included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -3.1465       0.0008
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for D.lnGF*GOV
-------------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: Some panels are stationary              Avg. number of periods =  21.71

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                       sequentially
Time trend:   Not included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar              -2.3595       0.0091
------------------------------------------------------------------------------
```

Appendix 4.4 First Difference ADF Chi-Square Test with Intercept

```
Fisher-type unit-root test for D.lnGF
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: At least one panel is stationary        Avg. number of periods =  21.71

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        76.5469       0.0000
 Inverse normal            Z        -6.6986       0.0000
 Inverse logit t(39)       L*       -8.0462       0.0000
 Modified inv. chi-squared Pm       11.8202       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.GOV
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        53.7737       0.0000
 Inverse normal            Z        -5.0089       0.0000
 Inverse logit t(39)       L*       -5.5448       0.0000
 Modified inv. chi-squared Pm        7.5165       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnGDP
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        49.6321       0.0000
 Inverse normal            Z        -4.8579       0.0000
 Inverse logit t(39)       L*       -5.1616       0.0000
 Modified inv. chi-squared Pm        6.7338       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnEI
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        44.3794       0.0001
 Inverse normal            Z        -4.1290       0.0000
 Inverse logit t(39)       L*       -4.4577       0.0000
 Modified inv. chi-squared Pm        5.7412       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnRENE
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        37.7451       0.0006
 Inverse normal            Z        -3.4025       0.0003
 Inverse logit t(39)       L*       -3.6601       0.0004
 Modified inv. chi-squared Pm        4.4874       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnGF*GOV
Based on augmented Dickey-Fuller tests
---------------------------------------
Ho: All panels contain unit roots          Number of panels       =      7
Ha: At least one panel is stationary       Avg. number of periods =  21.71

AR parameter: Panel-specific               Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                 ADF regressions: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        63.9521       0.0000
 Inverse normal            Z        -5.9550       0.0000
 Inverse logit t(39)       L*       -6.7133       0.0000
 Modified inv. chi-squared Pm        9.4401       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

Appendix 4.4 First Difference PP-Fisher Chi-Square Test with Intercept

```
Fisher-type unit-root test for D.lnGF
Based on Phillips-Perron tests
-----------------------------------
Ho: All panels contain unit roots          Number of panels       =      7
Ha: At least one panel is stationary       Avg. number of periods =  21.71

AR parameter:    Panel-specific            Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Not included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P       161.1423       0.0000
 Inverse normal            Z       -11.1386       0.0000
 Inverse logit t(39)       L*      -17.0148       0.0000
 Modified inv. chi-squared Pm       27.8073       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.GOV
Based on Phillips-Perron tests
-------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter:   Panel-specific              Asymptotics: T -> Infinity
Panel means:    Included
Time trend:     Not included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P       186.5785       0.0000
 Inverse normal            Z       -11.8212       0.0000
 Inverse logit t(39)       L*      -19.6925       0.0000
 Modified inv. chi-squared Pm       32.6143       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnGDP
Based on Phillips-Perron tests
-------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter:   Panel-specific              Asymptotics: T -> Infinity
Panel means:    Included
Time trend:     Not included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P       177.4347       0.0000
 Inverse normal            Z       -11.8551       0.0000
 Inverse logit t(39)       L*      -18.7353       0.0000
 Modified inv. chi-squared Pm       30.8863       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnEI
Based on Phillips-Perron tests
-------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter:   Panel-specific              Asymptotics: T -> Infinity
Panel means:    Included
Time trend:     Not included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P       198.9133       0.0000
 Inverse normal            Z       -12.4402       0.0000
 Inverse logit t(39)       L*      -21.0030       0.0000
 Modified inv. chi-squared Pm       34.9453       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnRENE
Based on Phillips-Perron tests
-------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Not included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P       225.5739       0.0000
 Inverse normal            Z       -13.0835       0.0000
 Inverse logit t(39)       L*      -23.8153       0.0000
 Modified inv. chi-squared Pm       39.9837       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------

Fisher-type unit-root test for D.lnGF*GOV
Based on Phillips-Perron tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: At least one panel is stationary        Avg. number of periods =  21.71

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Not included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P       160.3619       0.0000
 Inverse normal            Z       -10.8367       0.0000
 Inverse logit t(39)       L*      -16.9247       0.0000
 Modified inv. chi-squared Pm       27.6598       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

Appendix 4.5 First Difference IPS W-stat with Intercept and Trend

```
Im-Pesaran-Shin unit-root test for D.lnGF
----------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: Some panels are stationary              Avg. number of periods =  21.71

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                      sequentially
Time trend:   Included

ADF regressions: 1 lag
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -4.6158        0.0000
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for D.GOV
----------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                      sequentially
Time trend:   Included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -3.6348        0.0001
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for D.lnGDP
------------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                      sequentially
Time trend:   Included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -2.8072        0.0025
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for D.lnEI
-----------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                      sequentially
Time trend:   Included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -2.9581        0.0015
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for D.lnRENE
-----------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: Some panels are stationary              Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                        sequentially
Time trend:   Included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -2.8958        0.0019
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for D.lnGF*GOV
-------------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: Some panels are stationary              Avg. number of periods =  21.71

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                        sequentially
Time trend:   Included

ADF regressions: 2 lags
------------------------------------------------------------------------------
                    Statistic      p-value
------------------------------------------------------------------------------
 W-t-bar             -2.5399        0.0055
------------------------------------------------------------------------------
```

Appendix 4.5 First Difference ADF Chi-Square Test with Intercept and Trend

```
Fisher-type unit-root test for D.lnGF
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: At least one panel is stationary        Avg. number of periods =  21.71

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included
Drift term:   Not included                  ADF regressions: 1 lag
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        62.3123       0.0000
 Inverse normal            Z        -5.3504       0.0000
 Inverse logit t(39)       L*       -6.4448       0.0000
 Modified inv. chi-squared Pm        9.1302       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.GOV
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        43.5415       0.0001
 Inverse normal            Z        -3.9713       0.0000
 Inverse logit t(39)       L*       -4.3028       0.0001
 Modified inv. chi-squared Pm        5.5828       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnGDP
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        31.6754       0.0045
 Inverse normal            Z        -3.0332       0.0012
 Inverse logit t(39)       L*       -3.0404       0.0021
 Modified inv. chi-squared Pm        3.3403       0.0004
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnEI
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        37.3317       0.0007
 Inverse normal            Z        -3.1464       0.0008
 Inverse logit t(39)       L*       -3.4703       0.0006
 Modified inv. chi-squared Pm        4.4093       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnRENE
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        34.2563       0.0019
 Inverse normal            Z        -3.1075       0.0009
 Inverse logit t(39)       L*       -3.2473       0.0012
 Modified inv. chi-squared Pm        3.8281       0.0001
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnGF*GOV
Based on augmented Dickey-Fuller tests
--------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: At least one panel is stationary        Avg. number of periods =  21.71

AR parameter: Panel-specific                Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Included
Drift term:   Not included                  ADF regressions: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P        31.1327       0.0053
 Inverse normal            Z        -2.6735       0.0038
 Inverse logit t(39)       L*       -2.8194       0.0038
 Modified inv. chi-squared Pm        3.2378       0.0006
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

Appendix 4.5 First Difference PP-Fisher Chi-Square Test with Intercept and Trend

```
Pp with trend
Fisher-type unit-root test for D.lnGF
Based on Phillips-Perron tests
------------------------------------
Ho: All panels contain unit roots          Number of panels       =      7
Ha: At least one panel is stationary       Avg. number of periods =  21.71

AR parameter:    Panel-specific            Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P       147.6761       0.0000
 Inverse normal            Z       -10.5097       0.0000
 Inverse logit t(39)       L*      -15.5921       0.0000
 Modified inv. chi-squared Pm       25.2624       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------

Fisher-type unit-root test for D.GOV
Based on Phillips-Perron tests
------------------------------------
Ho: All panels contain unit roots          Number of panels  =      7
Ha: At least one panel is stationary       Number of periods =     22

AR parameter:    Panel-specific            Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P       159.5024       0.0000
 Inverse normal            Z       -10.5809       0.0000
 Inverse logit t(39)       L*      -16.8105       0.0000
 Modified inv. chi-squared Pm       27.4974       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnGDP
Based on Phillips-Perron tests
-------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P       136.5283       0.0000
 Inverse normal            Z       -10.0712       0.0000
 Inverse logit t(39)       L*      -14.4156       0.0000
 Modified inv. chi-squared Pm       23.1557       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnEI
Based on Phillips-Perron tests
-------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P       190.2713       0.0000
 Inverse normal            Z       -11.9637       0.0000
 Inverse logit t(39)       L*      -20.0885       0.0000
 Modified inv. chi-squared Pm       33.3121       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnRENE
Based on Phillips-Perron tests
-------------------------------------
Ho: All panels contain unit roots           Number of panels  =      7
Ha: At least one panel is stationary        Number of periods =     22

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P       222.1921       0.0000
 Inverse normal            Z       -12.8931       0.0000
 Inverse logit t(39)       L*      -23.4434       0.0000
 Modified inv. chi-squared Pm       39.3446       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for D.lnGF*GOV
Based on Phillips-Perron tests
---------------------------------------
Ho: All panels contain unit roots           Number of panels       =      7
Ha: At least one panel is stationary        Avg. number of periods =  21.71

AR parameter:    Panel-specific             Asymptotics: T -> Infinity
Panel means:     Included
Time trend:      Included
Newey-West lags: 2 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(14)   P       182.7141       0.0000
 Inverse normal            Z       -11.3917       0.0000
 Inverse logit t(39)       L*      -19.2545       0.0000
 Modified inv. chi-squared Pm       31.8840       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
------------------------------------------------------------------------------
```

Appendix 4.6: Pooled Ordinary Least Squares

```
      Source |       SS           df       MS      Number of obs   =       159
-------------+----------------------------------   F(6, 152)       =    520.97
       Model |  117.379763         6  19.5632938   Prob > F        =    0.0000
    Residual |  5.70784608       152  .037551619   R-squared       =    0.9536
-------------+----------------------------------   Adj R-squared   =    0.9518
       Total |  123.087609       158  .779035499   Root MSE        =    .19378

------------------------------------------------------------------------------
          ly |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnGF |  -.4930087   .1241643    -3.97   0.000    -.7383193   -.2476981
         GOV |  -1.683531   .3712409    -4.53   0.000    -2.416989   -.9500726
       lnGDP |   1.048098   .0401566    26.10   0.000     .9687604    1.127435
        lnEI |   .9836886   .0592379    16.61   0.000     .8666526    1.100725
      lnRENE |  -.0284128   .0276356    -1.03   0.306    -.0830123    .0261867
    lnGF*GOV |   .3042919   .0751804     4.05   0.000     .1557586    .4528253
       _cons |  -22.10872   1.121582   -19.71   0.000    -24.32463   -19.89282
------------------------------------------------------------------------------
```

Appendix 4.7: Fixed Effect Model (FEM)

```
Fixed-effects (within) regression               Number of obs      =       159
Group variable: code                            Number of groups   =         7

R-sq:                                           Obs per group:
     within  = 0.8985                                         min =         21
     between = 0.9186                                         avg =       22.7
     overall = 0.9178                                         max =         23

                                                F(6,146)           =    215.45
corr(u_i, Xb)  = 0.6793                         Prob > F           =    0.0000

------------------------------------------------------------------------------
          ly |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnGF |  -.0907972   .0271458    -3.34   0.001    -.1444467   -.0371476
         GOV |  -.1872239    .092929    -2.01   0.046    -.3708838    -.003564
       lnGDP |   .6511159   .0719454     9.05   0.000     .5089269     .793305
        lnEI |   .6951791   .0828706     8.39   0.000     .5313983      .85896
      lnRENE |  -.0879193   .0161245    -5.45   0.000     -.119787   -.0560517
    lnGF*GOV |   .0654991   .0164483     3.98   0.000     .0329916    .0980066
       _cons |  -12.59871   2.214489    -5.69   0.000    -16.97531   -8.222115
-------------+----------------------------------------------------------------
     sigma_u |   .3652738
     sigma_e |  .03784176
         rho |  .98938135   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(6, 146) = 639.99                    Prob > F = 0.0000
```

Appendix 4.8: Random Effect Model (REM)

```
Random-effects GLS regression                   Number of obs      =       159
Group variable: code                            Number of groups   =         7

R-sq:                                           Obs per group:
     within  = 0.6220                                         min =         21
     between = 0.9603                                         avg =       22.7
     overall = 0.9536                                         max =         23

                                                Wald chi2(6)       =   3125.82
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
          ly |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnGF |  -.4930087   .1241643    -3.97   0.000    -.7363662   -.2496512
         GOV |  -1.683531   .3712409    -4.53   0.000     -2.41115   -.9559122
       lnGDP |   1.048098   .0401566    26.10   0.000     .9693921    1.126803
        lnEI |   .9836886   .0592379    16.61   0.000     .8675844    1.099793
      lnRENE |  -.0284128   .0276356    -1.03   0.304    -.0825776     .025752
    lnGF*GOV |   .3042919   .0751804     4.05   0.000     .1569411    .4516427
       _cons |  -22.10872   1.121582   -19.71   0.000    -24.30698   -19.91046
-------------+----------------------------------------------------------------
     sigma_u |          0
     sigma_e |  .03784176
         rho |          0   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Appendix 4.9 BPLM Test

```
Breusch and Pagan Lagrangian multiplier test for random effects

        ly[code,t] = Xb + u[code] + e[code,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                   lnCO2 |    .7790355       .8826299
                       e |     .001432       .0378418
                       u |           0              0

        Test:   Var(u) = 0
                             chibar2(01) =     0.00
                          Prob > chibar2 =   1.0000
```

Appendix 4.10: Poolability F-Test

```
Fixed-effects (within) regression               Number of obs     =        159
Group variable: code                            Number of groups  =          7

R-sq:                                           Obs per group:
     within  = 0.8985                                         min =         21
     between = 0.9186                                         avg =       22.7
     overall = 0.9178                                         max =         23

                                                F(6,146)          =     215.45
corr(u_i, Xb)  = 0.6793                         Prob > F          =     0.0000

------------------------------------------------------------------------------
          ly |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnGF |  -.0907972   .0271458    -3.34   0.001    -.1444467   -.0371476
         GOV |  -.1872239    .092929    -2.01   0.046    -.3708838    -.003564
       lnGDP |   .6511159   .0719454     9.05   0.000     .5089269     .793305
        lnEI |   .6951791   .0828706     8.39   0.000     .5313983      .85896
      lnRENE |  -.0879193   .0161245    -5.45   0.000     -.119787   -.0560517
    lnGF*GOV |   .0654991   .0164483     3.98   0.000     .0329916    .0980066
       _cons |  -12.59871   2.214489    -5.69   0.000    -16.97531   -8.222115
-------------+----------------------------------------------------------------
     sigma_u |   .3652738
     sigma_e |  .03784176
         rho |  .98938135   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(6, 146) = 639.99                    Prob > F = 0.0000
```

Appendix 4.11: Hausman Test

```
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       fe           re         Difference          S.E.
-------------+----------------------------------------------------------------
        lnGF |   -.0907972    -.4930087        .4022115        .0625062
         GOV |   -.1872239    -1.683531        1.496307        .2977227
       lnGDP |    .6511159     1.048098       -.3969816        .3662275
        lnEI |    .6951791     .9836886       -.2885094        .4202137
      lnRENE |   -.0879193    -.0284128       -.0595065        .0778096
    lnGF*GOV |    .0654991     .3042919       -.2387928        .0379801
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =      146.43
                Prob>chi2 =      0.0000
```

Appendix 4.12: Cross Sectional Dependency

```
Pesaran's test of cross sectional independence =     0.851, Pr = 0.3947

Average absolute value of the off-diagonal elements =     0.283
```

Appendix 4.13: Wooldridge Test for Autocorrelation

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(   1,         6) =     27.444
           Prob > F =      0.0019
```

Appendix 4.14: Breusch-Pagan/Cook-Weisberg Test for Heteroskedasticity

```
  Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: lnGF GOV lnGDP lnEI lnRENE lnGF*GOV

         chi2(6)      =    44.99
         Prob > chi2  =   0.0000
```

Appendix 4.15: Modified Wald Test for Groupwise Heteroskedasticity

```
Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (7)   =          316.24
Prob > chi2 =          0.0000
```

Appendix 4.16: Fixed Effect Model (FE robust)

```
Fixed-effects (within) regression               Number of obs      =       159
Group variable: code                            Number of groups   =         7

R-sq:                                           Obs per group:
     within  = 0.8985                                         min =         21
     between = 0.9186                                         avg =       22.7
     overall = 0.9178                                         max =         23

                                                F(6,6)             =    294.04
corr(u_i, Xb)  = 0.6793                         Prob > F           =    0.0000

                                   (Std. Err. adjusted for 7 clusters in code)
------------------------------------------------------------------------------
             |               Robust
          ly |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnGF |  -.0907972   .0236856    -3.83   0.009    -.1487537   -.0328406
         GOV |  -.1872239   .0525566    -3.56   0.012    -.3158252   -.0586227
       lnGDP |   .6511159   .1936762     3.36   0.015     .1772072    1.125025
        lnEI |   .6951791   .2074242     3.35   0.015     .1876305    1.202728
      lnRENE |  -.0879193   .0366976    -2.40   0.054    -.1777151    .0018764
    lnGF*GOV |   .0654991   .0092326     7.09   0.000     .0429078    .0880904
       _cons |  -12.59871   5.849882    -2.15   0.075    -26.91286    1.715434
-------------+----------------------------------------------------------------
     sigma_u |   .3652738
     sigma_e |  .03784176
         rho |  .98938135   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Appendix 4.17: Fixed Effect Model using proxy X8

```
Fixed-effects (within) regression               Number of obs      =       159
Group variable: code                            Number of groups   =         7

R-sq:                                           Obs per group:
     within  = 0.8988                                         min =         21
     between = 0.9279                                         avg =       22.7
     overall = 0.9266                                         max =         23

                                                F(6,6)             =    934.72
corr(u_i, Xb)  = 0.6883                         Prob > F           =    0.0000

                                    (Std. Err. adjusted for 7 clusters in code)
------------------------------------------------------------------------------
             |               Robust
          ly |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnGF |  -.1143746   .0265415    -4.31   0.005    -.1793193   -.0494299
         GOV |  -.4160548   .1330587    -3.13   0.020    -.7416377   -.0904719
       lnGDP |   .6834984   .1917473     3.56   0.012     .2143097    1.152687
        lnEI |   .6821985   .1971637     3.46   0.013     .1997564    1.164641
      lnRENE |  -.0976019    .037119    -2.63   0.039    -.1884289    -.006775
    lnGF*GOV |   .0763786   .0172515     4.43   0.004     .0341656    .1185916
       _cons |  -13.11358   5.687434    -2.31   0.061    -27.03023    .8030724
-------------+----------------------------------------------------------------
     sigma_u |  .34860387
     sigma_e |  .03778242
         rho |   .9883897   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Appendix 4.17: Fixed Effect Model using proxy X1

```
Fixed-effects (within) regression               Number of obs      =       154
Group variable: code                            Number of groups   =         7

R-sq:                                           Obs per group:
     within  = 0.8878                                         min =         18
     between = 0.9298                                         avg =       22.0
     overall = 0.9288                                         max =         23

                                                F(6,6)             =    137.71
corr(u_i, Xb)  = 0.7140                         Prob > F           =    0.0000

                                    (Std. Err. adjusted for 7 clusters in code)
------------------------------------------------------------------------------
             |               Robust
          ly |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnGF |  -.0827518   .0205348    -4.03   0.007    -.1329987   -.0325049
         GOV |  -.1552177   .0411755    -3.77   0.009    -.2559706   -.0544648
       lnGDP |     .67079   .1731122     3.87   0.008     .2471996     1.09438
        lnEI |   .6478969   .2165059     2.99   0.024      .118126    1.177668
      lnRENE |  -.1046863   .0464392    -2.25   0.065    -.2183189    .0089463
    lnGF*GOV |   .0533769    .009616     5.55   0.001     .0298473    .0769065
       _cons |  -13.04874   5.340048    -2.44   0.050    -26.11536    .0178894
-------------+----------------------------------------------------------------
     sigma_u |  .35976106
     sigma_e |  .03794149
         rho |   .9889999   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```