The connectivity of international trade to Malaysia's carbon emissions

NG YI HONG

BACHELOR OF ECONOMICS (HONOURS)
GLOBAL ECONOMICS

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF ACCOUNTANCY AND MANAGEMENT
DEPARTMENT OF ECONOMICS

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NG YI HONG

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DECLARATION

We hereby declare that:
(1) This undergraduate research project is the end result of our own work and that due acknowledgement has been given in the references to ALL sources of information be they printed, electronic, or personal.

(2) No portion of this research project has been submitted in support of any application for any other degree or qualification of this or any other university, or other institutes of learning.

(3) Equal contribution has been made by each group member in completing the research project.

(4) The word count of this research report is __12266_______________________.

Name of Student:	Student ID:	Signature:
1. Ng Yi Hong_______________	2101689__________	__________________

Date: ____3/5/2024__________

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DEDICATION

I would like to dedicate this research paper to Universiti TunkuAbdul Rahman (UTAR) for providing me with the opportunity to apply the knowledge I gained to this study. Moreover, I extend my gratitude to Dr. Yogambigai a/p Rajamoorthy, who served as my Final Year Project (FYP) supervisor, for generously sharing her expertise and answering my questions promptly, even beyond office hours. Without her guidance, support, and patience, completing this research would not have been possible. Additionally, I would like to dedicate this paper to Dr. Ngoo Yee Ting, who acted as the second examiner of my FYP, and whose suggestions significantly contributed to the enhancement of this research.

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TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF ABBREVIATIONS

CO2	Carbon Dioxide
EX	Exports
IM	Imports
FDI	Foreign Direct Investment
RE	Renewable Energy
EIA	Energy Information Administration
GDP	Gross Domestic Product
MGTC	Malaysian Green Technology and Climate Change Corporation
WTO	World Trade Organizations
GATT	General Agreement on Trade and Tariffs
ASEAN	Association of Southeast Asian Nations
ITA	International Trade Administration
FTA	Free Trade Agreements
CCPI	Climate Change Performance Index
EKC	Environmental Kuznets Curve
VECM	Vector Error Correction Model

PREFACE

As the global community is struggling with the multifaceted challenges of climate change and sustainable development, the interplay between international trade and carbon emissions has emerged as a critical area of inquiry. Malaysia, with its robust presence in international trade and burgeoning economy, stands as a pertinent case study in understanding this intricate relationship.

This research looks into the connectivity between Malaysia's international trade activities and its carbon emissions. Specifically, it aims to investigate the relationship between exports, imports, foreign direct investment (FDI) inflow, and renewable energy consumption against Malaysia's carbon emissions. This study aims to shed light on the intricate dynamics influencing Malaysia's carbon footprint to its participation in international commerce by examining these key variables.

The significance of this research lies in its potential to inform policymakers, stakeholders, and the wider academic community about the environmental implications of Malaysia's trade activities. By identifying the factors influencing carbon emissions in the context of international trade, this study strives to contribute to the discourse on sustainable development strategies and climate mitigation efforts in Malaysia and beyond.

ABSTRACT

This study examine the relationship between (trade) imports and exports of goods and services, (investment) net inflow of foreign direct investment and (consumption) renewable energy consumption against carbon emission in Malaysia over the period 1990 to 2020. Utilizing Vector Error Correction Model (VECM) and cointegration analysis, the research aims to elucidate the dynamics shaping Malaysia's carbon emissions in the context of its trade activities, investment inflows, and energy consumption patterns.

The findings reveal that while exports and imports of goods and services exhibit an insignificant relationship with Malaysia's carbon emissions, FDI inflow exerts a significant positive effect on carbon emissions. This suggests that the influx of foreign investment contributes to the rise in carbon emissions within the Malaysian economy. Conversely, renewable energy consumption demonstrates a significant negative effect on carbon emissions, indicating the potential of sustainable energy sources in mitigating environmental impact. These findings have implications for policymakers and stakeholders seeking to formulate strategies for sustainable development and climate mitigation. This study contributes to a deeper understanding of the complex nexus between trade, investment, energy consumption, and carbon emissions in Malaysia. It highlights the need for integrated policies that promote both economic growth and environmental sustainability in the context of globalization and economic development.

Keywords: Malaysia, Exports of goods and services, Imports of goods and services, FDI inflow, Renewable energy consumption

CHAPTER 1: RESEARCH OVERVIEW

1.0 Introduction

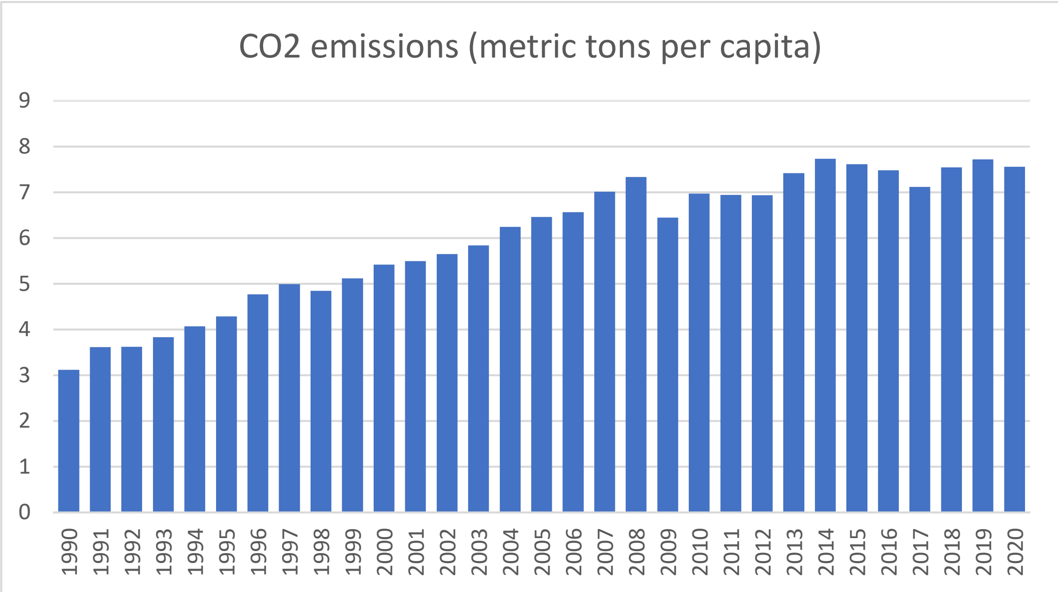
The first chapter of this study will develop the initial framework regarding this study of the connectivity of international trade to Malaysia's carbon emissions. This chapter will discuss the background of study, problem statement, research questions and objectives, hypotheses of the study, and the significance of study.

1.1 Background of study

Back thousand years ago, human emerged behaviour of exchanging goods and services to satisfy their basic need, until now international trade to satisfy countries' needs and achieve world goals. The Industrial Revolution continued to create demand for the country and expanded its territory and trade with other countries to develop resources. Under the fourth Industrial Revolution, people integrate digitalization, automation, and robotization with multiple sectors, such as manufacturing, production, transportation, and other services. The world increasingly depends on these sectors to strengthen capital and eliminate poverty, leading to sustainable growth. However, these sectors are always inseparable from fossil fuels, their operation has driven greenhouse gases. Fossil fuels have contributed to 70 percent to 80 percent of the emissions from human activity over nearly 20 years (National Geographic Society, 2023). Therefore, the association between environmental quality and human activities always received high attention in the Anthropocene era.

The environment is severely harmed by the increasing amount of manmade greenhouse gas emissions in the atmosphere. Greenhouse gases are mainly categorized as Carbon dioxide, Methane, Nitrous oxide, and Industrial gases. The release of carbon dioxide has the highest concentration of all greenhouse gases (EIA, 2022). The emission of carbon dioxide can trap the heat in the atmosphere and cause a warming temperature inside the Earth. Malaysia amounted to 7.72 metric tons of carbon emissions in 2019, which has increased by 8.43% compared to 2017 (World Bank, n.d.). From 1990 to 2020, the highest mean temperature of Malaysia can be reached 26.92 Celcius in 2016. Higher temperatures will increase the sea level, causing floods, food and water shortages, and poor air quality in Malaysia. In 2020, natural gas had the greatest capacity in the total energy supply of Malaysia, which amounted to 39 percent. The second greatest energy capacity is oil energy, which is also fossil fuel and occupies 34 percent (IRENA, 2023). These energies are mainly consumed by transport, manufacturing, and construction, and the industry sector which have contributed highly to Malaysia's carbon emissions. International trade is closely associated with the capacity of 20 percent to 30 percent based on total carbon emissions. (Peters et al., 2011). Environmental quality is closely associated with production, transport, and consumption along supply chains in and between countries.

Figure 1.1.1: Carbon emissions in Malaysia



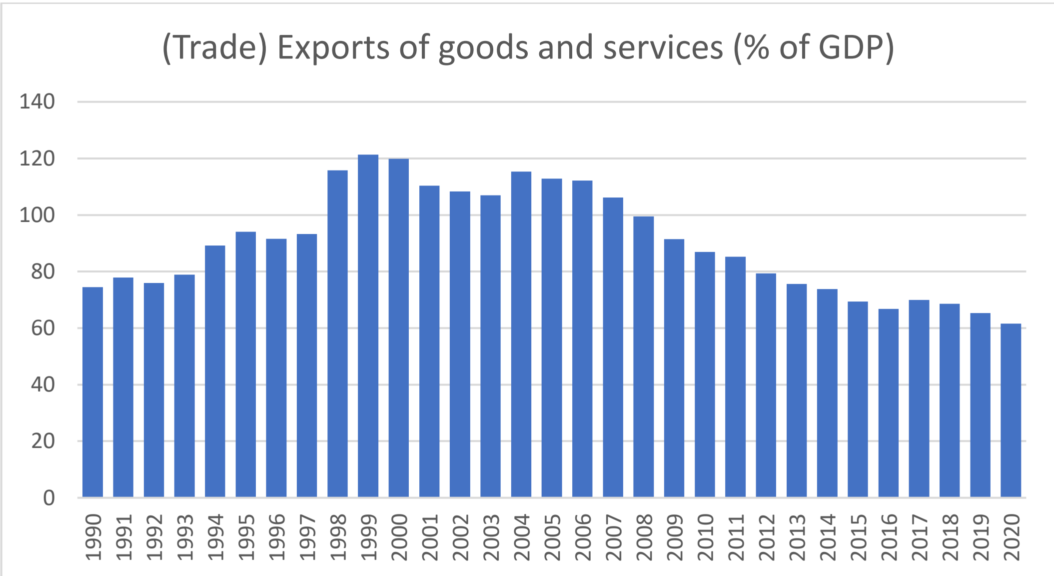
Adapted from: Macrotrends (2020)

As mentioned, international trade has a vital role in exacerbating carbon emissions, leading to environmental degradation and climate change (Mehmood & Tariq, 2020). Therefore, the extent of concern regarding the connectivity of international trade to carbon emission has been increasing nowadays. According to the study of Essandoh, Islam and Kakinaka (2020), they discovered that international trade has both positive and negative effect on carbon emission in developing countries and developed countries. Malaysia is well aware of this fact, thus Malaysia is committed to finding a balance between the country's economy and environmental quality. Malaysia planned to reduce its carbon emissions per unit of GDP by 45 percent by 2030 in compared to 2015 levels. In 2011, Malaysian government launched the Malaysian Green Technology and Climate Change Corporation (MGTC), aiming to contribute efforts toward leading cities developing and supporting Malaysia's comprehensive sustainable development. Besides monitoring carbon emission, MGTC also planned to generate 230,000 new green jobs and a GDP growth rate of RM100 billion from green technologies. It is the responsibility of MGTC to monitor the development in the climate change mitigation, green growth, and green lifestyle (MGTC, n.d.). According to the annual report 2021, MGTC is succeeded in reduce 1,270,004 kg of carbon emission and planting 29,753 trees to sequester carbon. There are over 403 chargEV stations installed at over 200 private and public locations. The chargEV stations provide electricity charging services for those electric cars which consume electricity power instead of fossil fuels. In 2021, Malaysia’s charge network delivered 997 mwh of electricity which contributed to environmental quality improvement (MGTC, 2021).

Malaysia has always been an open economy, it has a great reliance on international trade. Regional and bilateral free trade agreements are highly valued by Malaysia, which has liberalised its trade policies. Malaysia was one of the founding members in the World Trade Organisation (WTO) and a member in the General Agreement on Trade and Tariffs (GATT) since 1957. Currently, the ASEAN in which Malaysia participates has established the free trade area agreement. It is committed to improving ASEAN's competitive advantage as a production foundation in the global market and bring in more foreign direct investment to ASEAN. Besides that, the establishment of a bilateral free trade agreement has been made between Malaysia, India, Pakistan, Chile, Japan, New Zealand, Turkey and Australia (ITA, n.d.). These initiatives helped Malaysia to have greater access to the market and increased external demand. The net inflow of foreign direct investment, exports, imports, and other sectors related to international trade has been affected significantly. In 2020, trade with Free Trade Agreement (FTA) countries amounted to RM1.185 trillion, constituting 66.7% of Malaysia's overall trade. The value of Malaysia's exports to FTA partners contributed to RM667.46 billion, or 68% of the country's overall exports (MATRADE, 2020).

Exports of goods and services is a dispensable element of gross domestic product (GDP) in Malaysia. Figure 1.1.2 shows the trend of exports in Malaysia. In the 1990s, exports increased significantly based on Malaysia's GDP due to the rising demand for raw materials. Due to its abundance of natural resources for mining and agriculture, Malaysia is well-positioned to profit from the rising demand for raw materials worldwide, especially from the rapidly expanding economies of Asia (BNM, 2011). However, as time goes on, there is declining in exports due to weak external demand, political uncertainty and a high inflation rate.

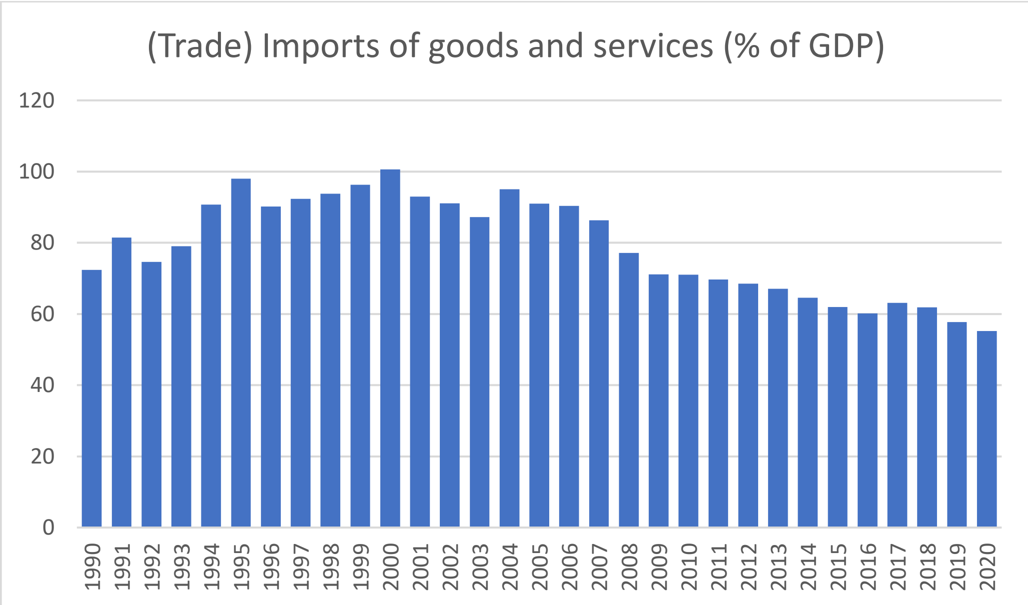
Figure 1.1.2: Exports of goods and services (Trade) in Malaysia



Adapted from: Trading Economics (2020)

Similarly, the high volume of imports was mainly in the 1990s. Consumer confidence and active manufacturing sector activity have stimulated the volume of imports. Under trade liberalization and the government's multiple incentive policies, people can travel abroad, thus stimulating domestic demand. After a few years, the declining trend of imports is associated with exports, the import sector has to struggle with changing consumer preferences, external and political uncertainties.

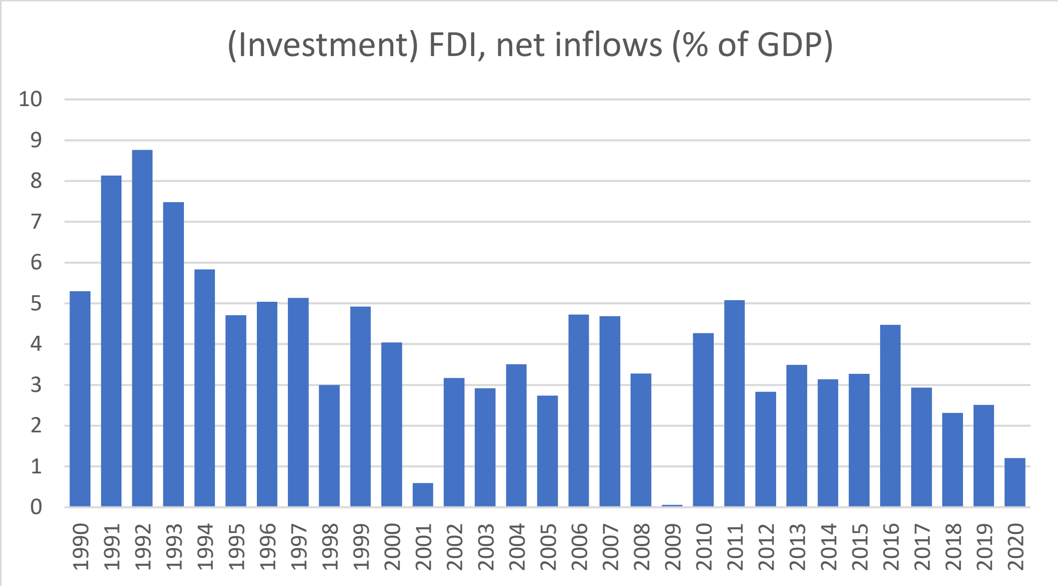
Figure 1.1.3: Imports of goods and services (Trade) in Malaysia



Adapted from: Trading Economics (2020)

Figure 1.1.3 shows the trends of the net inflow of FDI, net inflow in Malaysia. In 2009, Malaysia's FDI net inflow dropped dramatically associated with the global financial crisis and the collapse of the technology bubble. Moreover, during the period between 2000 and 2009, the investment has been shifted to the financial services and shared services operations sectors which is less capital intensive, leading to the lower amounts (BNM, 2009).

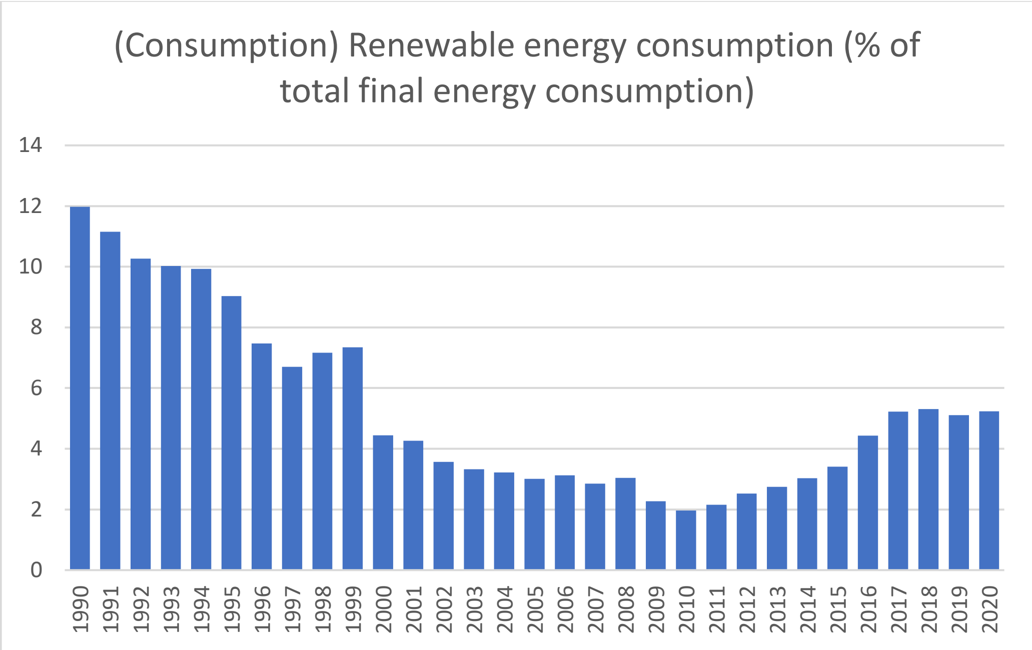
Figure 1.1.4: Foreign direct investment, net inflow (investment) in Malaysia



Adapted from: Trading Economics (2020)

To mitigate the damage of carbon emissions, Malaysia continuously promotes renewable energy utilization and also makes enormous investments in related industries. In 1990, renewable energy consumption reached its peak at 8.42 percent of total final energy consumption. The government has implemented the Electricity Supply Act by launching sensible energy prices and promoting electricity installations to encourage the rational use of electricity (Khairudin et al., 2020).

Figure 1.1.5: Renewable energy consumption (Consumption) in Malaysia



Adapted from: Trading Economics (2020)

1.2 Problem statement

Carbon emissions are an environmental problem that has plagued Malaysia for many years. According to CCPI report 2020, Malaysia was ranked 43th out of a total 61 countries for climate performance. Malaysia's national climate policy performance and international climate policy performance are rated as low and very low respectively (Burck et al., 2019). Even though the Malaysian government has released multiple policies to promote renewable energy utilization, Malaysia still failed to make any significant improvements. Despite having lackluster performance in international trade, Malaysia still doesn't have the roadmap to reach the previously announced emissions reduction goal. According to MGTC (2019), Malaysia's carbon emissions per capita are disproportionately high at 7.27 tonnes with 32 million population which is more than twice as much as 3.64 tonnes in

Thailand and even more than 6.59 tonnes in China. While the air quality of Thailand may be worse than Malaysia's and China may be one of the most polluted cities, 69 million population in Thailand and 1.38 billion population of China are far greater than Malaysia’s population and have significantly more industrial activity than Malaysia. In short, the reason why Malaysia’s carbon emissions have never been effectively reduced is Malaysia has over-reliance on private vehicles, rising energy consumption, and population.

Exports and imports from Malaysia continuously have declined trend after experiencing the financial crisis in 2009. Although the exports and imports have rebounded over several years, it is still not significant enough. Besides that, the pandemic has hit both exports and imports hard, exports and imports activities are still in a sluggish state till now. Under the pandemic, many countries have increased the boundaries and lockdowns, thus the volume of international trade has been greatly reduced. The fluctuation of exports and imports will affect the trend of carbon emissions (Boamah et al., 2017). However, the export and import could bring different effects on carbon emissions based on countries. According to Haug and Ucal (2019), the effect of export and import on environmental quality is reliant on the changes in scale, composition, and technique.

Besides that, FDI, net inflow also struggled with the financial crisis in 2009 and the pandemic global recession in 2020. In 2020, 31.7 billion ringgit has decreased to 13.9 billion ringgit in net FDI compared with the previous year, which marked as worst performance since Asian Financial Crisis in the year of 1998 (Sipalan, 2021). If the net inflow of foreign direct investment is not increased, it will limit the expansion of the green technology sector capacity and may also lose the opportunities to access foreign technology that helps to improve environmental quality. The government has to control the investment allocation reasonably between green and ordinary industries to monitor carbon emissions. Some Malaysians point out the concern of not being able to afford the expensive price of green technology. For example, Malaysia can introduce more reasonably priced electricity vehicles or channel investment to the related industries, increasing electricity vehicle utilization.

The Malaysian government implemented renewable energy policies all the time, but the capacity of renewable energy only contracted 4 percent of the total energy supply in 2020 (IRENA, 2023). According to the report of CCPI (2020), it stated that Malaysia failed to achieve any significant improvements in the renewable energy sector. Following the decrease in FDI and economic depression, large-scale renewable energy projects may have a lack of investments. In addition, the government doesn't have robust renewable energy policies to make renewable energy more attractive than fossil fuels. Therefore, the government has to address the renewable energy consumption issues of consumer preference and over-reliance on the natural gas and oil sectors.

1.3 Research questions

Research questions:

i. What kind of relationships between (trade) exports of goods and services, (trade) imports of goods and services, (investment) net inflow of foreign direct investment and (consumption) renewable energy consumption against carbon emission in Malaysia?
ii. What are the factors affecting the carbon emissions in Malaysia?
iii. Is international trade beneficial for carbon emissions in Malaysia?
iv. What are the ways to control carbon emissions in Malaysia?

1.4 Research Objectives

1.4.1 General Objective

To examine the relationship between (trade) imports and exports of goods and services, (investment) net inflow of foreign direct investment and (consumption) renewable energy consumption against carbon emission in Malaysia

1.4.2 Specific Objective

1. To identify the factors affecting the carbon emissions in Malaysia
2. To investigate the net impact of international trade on carbon emissions in Malaysia.
3. To find out the ways to control carbon emissions in Malaysia.

1.5 Hypotheses of the study

Hypothesis 1

H_{01}: Exports of goods and services has no significant relationship with carbon emissions.

H_{A1}: Exports of goods and services has significant relationship with carbon emissions.

Hypothesis 2

H_{02}: Imports of goods and services has no significant relationship with carbon emissions.

H_{A2}: Imports of goods and services has significant relationship with carbon emissions.

Hypothesis 3

H_{03}: FDI, net inflow has no significant relationship with carbon emissions.

H_{A3}: FDI, net inflow has significant relationship with carbon emissions.

Hypothesis 4

H_{04}: Renewable energy consumption has no significant relationship with carbon emissions.

H_{A4}: Renewable energy consumption has significant relationship with carbon emissions.

1.6 Significance of study

The significance of the study is to provide insight into examining the relationship between international trade, investment, and renewable energy consumption against carbon emission in Malaysia. International trade has a crucial role in the operation of the global economy, with trillions of dollars worth of goods and services traded across borders each year. However, international trade can also have negative impacts on the environment by increasing carbon emissions from transportation and manufacturing processes. The inflow of FDI can provide the developing economies with additional financial resources to promote the development of green technologies. Meanwhile, it also has the potential to contribute to carbon emissions by increasing industrial pollutants. It is a popular fact that renewable energy helps to improve the environmental standard by replacing fossil fuels, but sometimes it won't affect the carbon emissions significantly without robust energy policies.

By understanding the effects of these factors on carbon emissions, policymakers may take this study as a reference to identify which factors would affect carbon emissions significantly and take it as the trade and environmental policy direction. Besides that, the study also presents possible policy implications to balance international trade and carbon emissions. Understanding the long-term impacts of international trade on environmental quality is crucial for policymakers and stakeholders seeking to balance economic growth with sustainability. Furthermore, this study also contributes to allowing more people to understand the importance of renewable energy and the adoption of green technologies in international trade. Malaysia has over-reliance on fossil fuel sources, but there are still many improvements for Malaysia to conduct international trade in an environmentally friendly manner. Malaysia would have great environmental standards and trade performance by popularizing renewable energy consumption. Overall, this study will provide more research information for Malaysia and other countries with similar backgrounds for the policy decisions related to international trade and environmental sustainability, ultimately contributing to a more sustainable future for all.

1.7 Chapter layout

This research has included total five chapters. The first chapter of research questions and objective set the course of study. The second chapter present literature review to provide a clearer understanding of all variables that are supported by previous researchers' studies. After that, third chapter will introduce the sample size, analysis methodology, and tests that are decided to be employed in this study. In the fourth chapter, we will interpret the result of data tests. Finally, we will conclude and discuss the result and findings in chapter 5.

1.8 Conclusion

Chapter 1 has sorted out the research problems and initial statement of the relationship between variables. The background has been introduced as the foundation and direction of the study. There is still need further research on the effects of the variables of international trade on carbon emissions. In Chapter 1, the report has established the hypotheses of the study for the research direction as well. In Chapter 2, there will be literature reviews supporting the statement of the relationship between exports, imports, FDI net inflow, renewable energy consumption, and carbon emissions. Besides that, there will also be a conceptual framework to clarify the connectivity of international trade to Malaysia's carbon emissions.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

This chapter aims to introduce the literature review which supports the statement of research topic and objectives. Besides that, chapter 2 also included the theoretical framework, conceptual framework and hypothesis development to identify and postulate the connectivity of independent variables to dependent variables.

2.1 Literature review

There have been many studies analyzed the relationship between international trade and environmental quality. Several literature have studied carbon emissions from different perspectives of international trade. The EKC concept offers an analytical framework to investigate the link between income and environmental quality. The EKC hypothesis has attracted a lot of empirical studies to analyze the relationship between environmental quality and the economic development in the country. Moreover, there are also many theories derived from EKC hypothesis, even though the comprehensive theories may don't consistent with EKC hypothesis due to the various countries' conditions, research time periods and econometric methodologies.

2.1.1 Carbon emissions

Fodha & Zaghdoud (2010) employed a cointegration analysis to explore the effect of economic growth on pollutant emissions. They used carbon emissions as the environmental indicator and indicated that carbon emissions are considered one of the main drivers of the current global warming and cause issues on a worldwide scale.

Shahbaz et al. (2013) conducted the study of long term relationship between energy use, economic growth and carbon emission for the period of 1980 to 2010. They indicated that the fluctuations of carbon emissions could be affected by the change in economic scale and harmonization of environmental regulations.

Behera & Dash (2017) investigate the relationship between FDI, energy consumption, and urban population against carbon emissions. They argued that the carbon emissions are mainly caused by urbanized clusters, inefficient industrial expansion, rising middle-class incomes, and spiraling automotive demand.

Zhu et al. (2016) study the carbon emissions' status in the developing economy by assessing the role of FDI and energy use. They discussed that artificial activities could affect the climate system significantly, carbon emissions has the highest capacity of anthropogenic emissions among greenhouse gases. Economic growth and energy use are the most important factors which contribute to environmental degradation.

Etokakpan et al. (2020) discovered the determinants of carbon emission in Malaysia by capturing variables of economic growth and globalization. The carbon emissions are generated by consistent global demand for energy, such as electricity, natural gas, and oil. The environment is under pressure due to the ongoing and persistent demand for more energy sources. They indicated that carbon dioxide emissions are well known to be created from non-renewable energy sources which is capable of worsening the environment. The health and environmental risks associated with fossil fuels have sparked international discussion and concern. Therefore, there must be a trade-off between productivity and environmental sustainability in economies that rely heavily on energy, especially Malaysia.

2.1.2 Trade (Exports of goods and services) and carbon emissions

Research conducted by Majekodunmi et al., (2023) ascertained that exports have positive effect on Malaysia’s carbon emissions. They employed ARDL model to analysis the data which spanned from 1978 to 2016. Exports contributed to the high level of production and consumption, thus generating carbon emissions and degrading Malaysia’s environment. However, the environmental impact of exports is negligible in the short term (Majekodunmi et al., 2023).

Aldakhil et al. (2019) studied the effect of high technology export in affecting carbon emissions using time series data between 1975 and 2016. They also aim to examine the dynamism of ICT in the context of South Asia's environmental sustainability goal, taking into account growth-specific characteristics and the principles of high-technology exports. From the analysis result, they revealed that the increase in exports could accelerate carbon emissions, and the exports of high technologies stimulate the development of the economy at the cost of environmental deterioration.

Haug and Ucal (2019) employed non-linear ADRL approach to investigate the effect of trade on carbon emissions and reported that exports are capable of affecting carbon emissions in long run, increased exports lead to decreased carbon emissions.

Lau et al. (2014) implied that the impact of export on environmental quality can be categorized as scale, composition and technique. First, according to the scale effect, an increase in the size of the economy's outputs will raise pollution. Therefore, it can be argued that environmental quality is negatively impacted by economic growth. Secondly, the composition effect is also reliant on changes in the economic landscape. As the economy shifts from an industrialized economy to a knowledge and service intensive economy, environmental quality tends to get better. Finally, the technique effect postulates that since a developed country has sufficient financial resources to spend more on research and development, economic expansion results in technical advancement that replaces old and filthy technologies with new and greener ones, resulting to enhance environmental quality.

Hasanov et al. (2018) researched the effect of trade on the carbon emissions of oil-exporting country. They employed the error correction model and cointegration test to explore the long-term effect of exports and imports. The exports and imports have statistically insignificant effects on carbon emissions based on territorial.

Liddle (2017) study the nexus of trade with national emissions. The author discuss that trade has significantly affect carbon emissions, imports raise consumption-based emissions whereas exports decrease them due to the mutually reinforcing nature of exports and imports.

2.1.3 Trade (Imports of goods and services) and carbon emissions

Salman et al. (2019) investigate the role of technology innovation in carbon emission over 1990 until 2017, then compares the effects of exports and imports. The authors indicate that imports affect carbon emissions through three channels. Firstly, transport of imported goods have to consume fuel, thus lead to generate carbon emissions. Secondly,the energy intensive imported goods will generate carbon when functioning. Thirdly, a nation may boost its competitiveness and efficiency through free trade, which enables it to increase its import activities. In the majority of industrialized nations with high environmental contamination, imports have a role. On the other hand, imports improve environmental quality in industrialized nations that are least polluted.

Pié et al. (2018) studied the effects of imports and exports on carbon emissions, they reveal that increasing in imports would associated with rising carbon emissions. Emissions from a nation's domestic demand are also linked to its imports from other countries.

Friedl and Getzner (2003) conducted a research of the nexus between economic development and carbon emissions in a small open economy, Austria. They estimated that imports affect carbon emissions positively, which contribute to the development of the transportation sector that also emits carbon.

Lim et al. (2009) measured CO2 emissions and energy use in Korea's industrial sectors. Through input–output structural decomposition analysis, the origins of the changes in CO2 emissions over the years 1990–2003 are examined in terms of different factors: shifts in the economic growth rate, the emission coefficient, and structural modifications which included exports and imports. The authors discovered that the rise in imports has the effect of reducing carbon emissions.

Al-mulali & Sheau-Ting (2014) explored the long term relationship between primary energy use, trade and carbon emissions. The trade is estimated as the sum of exports and imports. Based on the analysis, they argue that imports of goods and services carbon emissions positively, it increase the consumption of energy which in turn converts to carbon emissions.

Hu et al. (2020) studied the nexus between the diversification of imports, renewable energy consumption and carbon emissions. Based on the result, the imports hhas positive relationship with carbon emissions in Malaysia, the imports can’t contribute to reducing the carbon emissions in developing economy, such as Malaysia.

Boamah et al. (2017) studied the role of international trade in reducing carbon emissions in China between 1970 and 2014. This research revealed that international trade helps to improve economic growth, leading to reducing the carbon emissions of country. The authors divided international trade factors into exports and imports. The empirical result indicated that both exports and imports are the main factors that have the significant impact on carbon emissions.

2.1.4 Investment (Foreign direct investment, net inflows) and carbon emissions

Mohsin, Naseem, Sarfaz & Azam employed Westerlund cointegration test to analyze the nexus between economic and sustainable environmental quality in the Central Asian and European countries over the period from 1971 to 2016. Regarding the issue, they discovered that although foreign direct investment has capability of improving the production level and stimulating the economic growth of developing countries, a rise in foreign direct investment, net inflows increased environmental concerns and reduced the need for environmental policy. From the study, they discovered that FDI are negatively contributing to carbon emissions in long run. A country's financial resources are increased by attracting foreign direct investment, which supports economic growth by taking sustainable environmental measures (Mohsin et al., 2022). Developing countries must be able to ignore environmental difficulties through inadequate enforcement of the law or other means to entice foreign direct investment.

However, if environmental friendly technology is introduced to lower the level of carbon emission by FDI, the effects of FDI could be reversed. The researchers indicate that foreign businesses may employ cutting-edge technology and effective management techniques to improve the environment in their host countries. Some countries can't improve environmental standard due to a lack of abundant internal resources, they can seek help from abroad or introduce foreign resources through foreign direct investment for the purpose of improving the environment (Mohsin et al., 2022). Therefore, foreign direct investment has the function of improving the environmental quality of the country in the long run.

Lau, Choong & Eng take Malaysia as a research object to explore the role of economic growth on carbon emissions by utilizing the Granger causality methodology. They also aim to empirically investigate the EKC hypothesis for Malaysia in the context of foreign direct investment from 1970 to 2008 (Lau et al., 2014). From the result, they revealed that FDI has the effect of affecting carbon emissions positively. FDI can enhance the national output of a country meanwhile also contributing positively to carbon emissions. FDI can boost economic growth, but it can also bring negative impacts to the environment by increasing industrial pollutants. Moreover, polluting industries and enterprises frequently relocate to underdeveloped areas with poor environmental regulations in an effort to decrease costs associated with environmental controls, turning these areas into slums of pollution. (Lau et al., 2014).

Zhu et al. (2016) researched the relationship between economic growth, FDI, and energy consumption on carbon emissions. They measured the variable of FDI as the net inflow of foreign direct investment in the share of GDP. From the estimation, they discovered that FDI affects carbon emissions negatively.

Tang & Tan (2014) utilized Granger causality test and cointegration analysis to examine the effect of energy consumption, FDI, economic growth on carbon emissions. They discovered that FDI has bidirectional relationship with carbon emissions, so FDI is one of the main determinants of carbon emissions. FDI helps to decrease carbon emissions, defining that FDI is beneficial for the environment and reduces pollution by transferring green technology from developed countries to developing countries. Following the findings, they also suggest that the FDI net inflow has a suitable position to improve environmental standards.

Merican et al. (2007) studied the effect of FDI on carbon emissions in Malaysia. They included FDI inflow in the model, as it represents the scale effect of economic output. They revealed that FDI inflow has a significant and positive relationship with carbon emission in Malaysia which means that FDI inflow is a major determinant of pollution.

Lee (2009) examined the long term impact of economic growth on carbon emissions of Malaysia from 1970 until 2000. There is evidence emphasizing FDI net inflow plays crucial role of driving the growth of economic. This research implied that the role of FDI inflows has a significant and positive effect on environmental degradation, greater capital investments generate more pollution flows.

Jijian et al. (2021) conducted a study of the effect of international trade and FDI net inflow on different economies, including Malaysia on the period of 1993 to 2018. Based on the empirical result, they explored that FDI net inflow has not significant relationship with carbon emissions.

2.1.5 Consumption (Renewable energy consumption) and carbon emissions

Wang studies the role of renewable energy consumption on carbon emissions in China using Granger causality test, he collects data in the time period from 2007 to 2019. From the study, he confirmed that renewable energy consumption has a significant negative effect on carbon emissions in the long run. However, he demonstrates that renewable energy consumption has no significant relationship with carbon emission in the short run. Wang quote EKC research to support the study. Renewable energy tend to reduce carbon intensity of the high-income countries (Wang, 2022).

From the study, Raihan & Tuspekova provide an empirical analysis of the role of economy growth, forested area, renewable energy consumption on carbon emissions of Malaysia, employing carbon emissions as dependent variable. They captured data from 1990 to 2019 and employed DOLS approach. Based on the results, they indicate that renewable energy consumption has significant effect in reducing Malaysia's carbon emissions, thus renewable energy consumption affects the carbon emissions negatively and significantly. However, Malaysia's low extent consumption of renewable energy consumption can't significantly enhance the reduction of carbon emissions and develop the economic growth of Malaysia. Besides that, the authors revealed the utilization of renewable energy sources may be hampered by worries about infrastructure, institutional frameworks, and administrative processes. Due to technological and financial limitations, monopsony power, and knowledge asymmetries, the renewable energy market in Malaysia is also inefficient. The authors suggest that it is required to clear these obstacles to develop a renewable energy market in Malaysia (Raihan & Tuspekova, 2022).

Khan et al. (2020) utilize unit root test and cointegration test to analysis the connectivity between financial development, renewable energy consumption and carbon emissions. They indicated that renewable energy consumption could help to reduce carbon emissions. Besides that, they suggested that the fossil fuel consumption should be reduced and shifted to renewable energy sources can significantly improve environmental standards.

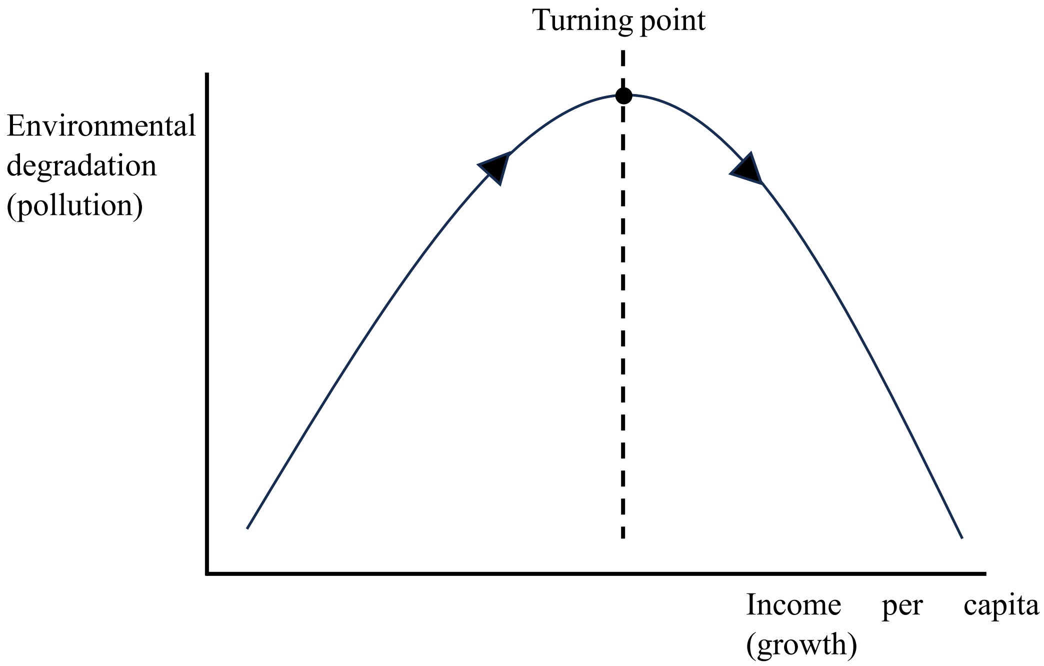
Shafiei & Salim (2014) utilize unit root test, Granger causality and cointegration analysis to analyze the determinants of carbon emissions in multiple countries, including Malaysia. Renewable energy consumption has been captured as the independent variable to examine the effect on carbon emissions. Based on the test results, renewable energy consumption has a significant and negative relationship with carbon emissions. They concluded that the countries with huge investments in renewable energy technologies have greater reductions in carbon emissions.

Hanif (2018) examines the relationship between urbanization, economic growth, non-renewable energy, renewable energy with carbon emissions. They discovered that renewable energy consumption has a significant and negative relationship with carbon emissions. Besides that, they emphasize the importance of utilizing renewable energy sources to reduce carbon emissions in addressing biological and environmental problems.

Zoundi (2017) utilizes cointegration analysis to assess the long-term relationship of renewable energy and carbon emissions. The study indicated that the alleged common global agenda of nations is to force developed nations to enact more environmental improvement policies and assist developing nations in lowering their carbon dioxide emissions without damaging their economic development. Among these policies, renewable energy has been included, it can help developing nations to handle environmental challenges. Based on the result, the author implied that renewable energy consumption can reduce carbon emissions and even have an increasing impact in the long term.

2.2 Review of Relevant Theoretical Model

Figure 2.2.1: Environmental Kuznets Curve Hypothesis Model



Adapted from: Yurttagüler and Kutlu (2017)

2.2.1 EKC hypothesis

According to the EKC hypothesis, environmental quality and economic growth have an inverted U-shaped relationship as determined by several environmental indicators. The primary tenet of the EKC concept is that environmental degradation rises as income levels rise up to a certain degree, at which point the environment starts to improve and an inverted U-shaped curve is produced (Halicioglu & Ketenci, 2016). This theory states that environmental degradation increases in the early stages of economic growth. This phenomenon is caused by the low extent of environmental awareness, failure to implement environmental policy and regulation, and scarce of advanced technologies to stop environmental pollution during the early stages of economic expansion (Mahmoodi & Dahmardeh, 2022). However, environmental quality enhancement and environmental degradation start to decline concurrently with economic growth associated with a variety of factors when reaching after certain level of income per capita and GDP (Kijima et al., 2010; Pata, 2018). For example, raising environmental consciousness, developing more ecologically friendly production methods, establishing and upholding environmental protection policies and regulations, raising financial support for environmental advancements, etc (Mahmoodi & Dahmardeh, 2022).

2.2.2 Heckscher-Ohlin trade theory

The theory of Heckscher-Ohlin trade advocates that developing countries would focus on the production of commodities backed by available labour and abundant natural resources. The developed countries would focus on activities requiring intensive manufacturing and human capital. The trade transports the goods produced in one country to another for either consumption or additional processing. This implies that pollution is caused by the manufacturing of these products and their connection to consumption in other nations (Halicioglu & Ketenci, 2016). Besides that, in Heckscher-Ohlin trade theory, the amount of capital per worker is more important relative to the absolute amount of capital in the trade, for example, Luxembourg, a small country has a greater amount of capital per worker compared to India, but having lesser amount of overall capital. Therefore, according to the Heckscher-Ohlin theory, Luxembourg chose to export capital-intensive goods to India and import labor-intensive goods in trade (Britannica, 2021). This has supported that international trade able to generate carbon emissions.

Export and import activities have been a core discussion point for carbon emissions since there is greater involvement of developing countries in international trade over time.

2.2.3 Pollution halo hypothesis

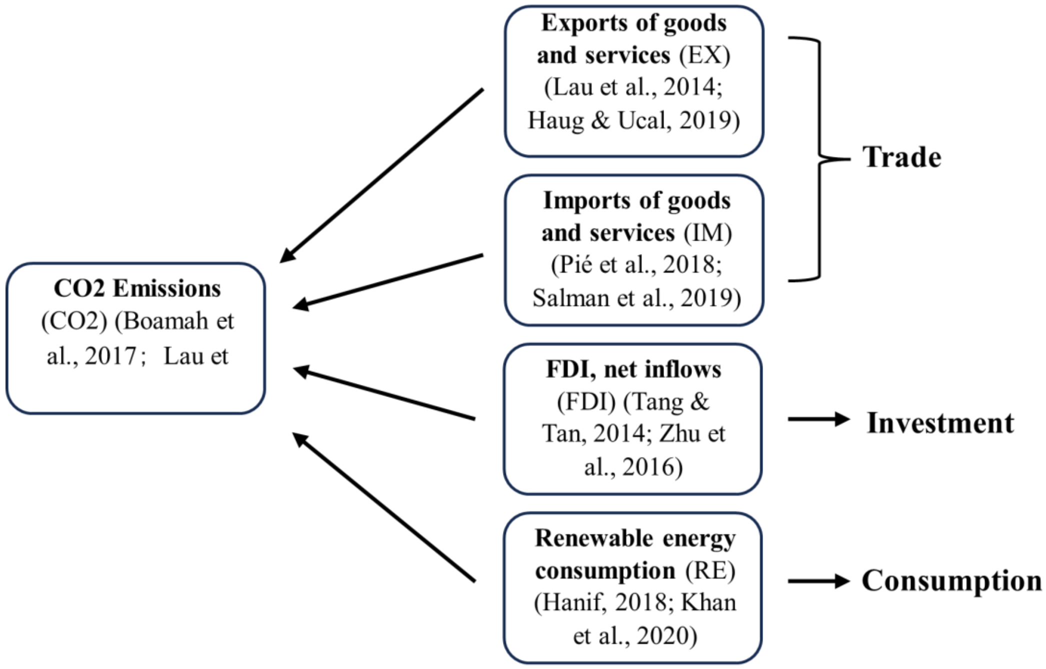
The theory discusses that multinational firms transfer environmentally friendly production and technology to the host country through foreign direct investment or technology spillover. The host countries can reduce the overall carbon emissions and protect environment with greener technology (IGI Global, n.d.). This theory has correspond to which foreign direct investment has the potential to improve the environmental quality of host countries, it might reduce host countries' demand for conventional energy by introducing environmentally friendly technologies.

2.2.4 Energy transition theory

The transition from fossil fuel energy to renewable energy sources on production and consumption systems. Technology improvements and a cultural encouragement towards sustainability environment goals make it possible to switch from non-renewable energy sources like coal, oil, and natural gas to renewable energy sources, seeking to minimize greenhouse gas emissions associated with energy consumption through various decarbonization methods (S&P Global, n.d.). According to researchers, energy transition is a process that calls for adjustments in economics, politics, institutions, and socioculture in addition to technology development (Berkhout et al., 2012). The consumption and transition of renewable energy can be implied as closely associated with economy.

2.3 Conceptual framework

Figure 2.3: Conceptual framework of the Carbon Emission in Malaysia



Adapted from: Developed for the research

Figure 2.2 presents the conceptual framework of the carbon emission in Malaysia with other four independent variables. The dependent variable is the carbon emission (CO2), whereas the independent variables are exports of goods and services (EX), imports of goods and services (IM), FDI net inflow (FDI) and renewable energy consumption (RE).

The model of Malaysia's carbon emissions

$$CO2_t = \alpha_1 + \beta_1 EX_t + \beta_2 IM_t + \beta_3 FDI_t + \beta_4 RE_t + \varepsilon_t$$

Where:

CO2 = Carbon emission (metric tons per capita)

EX = Exports of goods and services (%)

IM = Imports of goods and services (%)

FDI = Foreign direct investment, net inflows (%)

RE = Renewable energy consumption (%)

t = time period, 1990 to 2020

ε = error term

Firstly, the dependent variable, carbon emissions in metric tons per capita (CO2), is primarily leftovers from the production and consumption of energy, which has the major contribution of greenhouse gases linked to global warming. Burning fossil fuel energy and producing cement have occupied the primary capacity of anthropogenic carbon dioxide emissions. The first independent variable, exports of goods and services (EX), it reflects the value of a country supplies all commodities and other market services to other countries. Secondly, imports of goods and services (IM), it reflects the value of a country accepts all commodities and other market services from other countries. Thirdly, foreign direct investment, net inflows (FDI), is committed to conducting a long-term management stake in a business that operates in various economy than the investor's. Lastly, the renewable energy consumption (RE), it contributes to the share in the total final energy consumption (World Bank, n.d.).

2.4 Hypotheses development

Hypotheses were developed for this study:

Hypothesis 1

H_{01}: Exports have no positive relationship with carbon emissions.

H_{A1}: Exports have a positive relationship with carbon emissions.

Hypothesis 2

H_{02}: Imports have no positive relationship with carbon emissions.

H_{A2}: Imports have a positive relationship with carbon emissions.

Hypothesis 3

H_{03}: FDI, net inflows have no negative relationship with carbon emissions.

H_{A3}: FDI, net inflows have a negative relationship with carbon emissions.

Hypothesis 4

H_{04}: Renewable energy consumption has no negative relationship with carbon emissions.

H_{A4}: Renewable energy consumption has a negative relationship with carbon emissions.

2.5 Research gap

There are sufficient empirical and theoretical establishments in the literature regarding the connectivity of international trade to carbon emissions. However, there exists lack of research that provides empirical evidence to validate environmental degradation and international trade relationship in the single case of Malaysia. In addition, many studies have not focused on the period from 1990 to 2020. This period is the peak period of international trade due to global liberalization. There are very few studies conducted to utilize the time series approach. Major research investigates the connectivity between the environment, energy, and economic growth, trade is often referred to as trade openness and foreign trade. To fill the gap, this study separates the trade openness to exports and imports to capture its effect on carbon emissions.

2.6 Conclusion

Chapter 2 has introduced works of literature from different researchers which are related to our research topic. The researchers have discovered different outcomes, so the study has developed several hypotheses by observing the research problem and the supported previous studies from other researchers. To have a better understanding of the nexus between variables, Chapter 2 also included the conceptual framework. To prepare the data analysis of variables, chapter 3 will start to take steps into research methodology.

CHAPTER 3: METHODOLOGY

3.0 Introduction

Chapter 3 introduces the overview of the employed research methodology in this research. In chapter 2, we have introduced literature regarding the connectivity of international trade to carbon emissions. A mere literature review can't completely extrapolate the result of this research, thus we have to conduct tests and analyses as well. In this research, we will introduce the statistical tests that we have employed in this research. We employed quantitative and secondary data. The data source of all variables are obtained from the World Bank. Eviews 12 runs test and analyzes. Section 3.1 discusses the research design. Section 3.2 looks into the data collection method. Section 3.3 presents data analysis. Section 3.4 will conclude the chapter 3.

3.1 Research design

This research is based on quantitative data since we collected numerical data on the specified timeline. Following this research objective of determine how international trade affects the carbon emissions in Malaysia, this research looks into the connectivity of exports, imports, FDI net inflows, and renewable energy consumption to the carbon emission of Malaysia.

3.2 Data collection methods

We employ secondary and quantitative data to conduct this research, data are collected annually.

3.2.1 Secondary data

The secondary data are collected annually in the time period of 1990 to 2020. The data source of all variables is from World Bank. The data is conducted with time series analysis by examining a set of data which collected over a period of time for forecasting purpose. This research has included a dependent variable, carbon emission (CO2), and four independent variables, exports of goods and services (EX), imports of goods and services (IM), FDI net inflows (FDI) and renewable energy consumption (RE). The motive for applying this data period was mainly influenced by the great extent of data integrity and reliability at the chosen period. In 1990s, international trade in Malaysia has gradually matured, and the government implemented many sound development plans to encourage the shift from agriculture to manufacturing and exporting bases. Therefore, we choose 1990 as the starting point to capture the trend of carbon emissions associated with the development of international trade. While updated datasets are needed to capture the latest trends and developments, data availability beyond 2020 is limited, so we take 2020 as the end of the data period to employ the most recent and comprehensive data.

3.3 Research instrument

3.3.1 E-views

E-views is a cutting-edge application for conducting statistics estimations, forecasts, and econometrics that provides strong analytical capabilities and a user-friendly interface,. It provides financial institutions, enterprises, government organisations, and academics with access to strong statistical, time series, forecasting, and modeling tools. E-views is also suitable for running data analysis, such as time series data, panel data, and cross-section data. In EViews, we can organize the data effectively, generate forecasts or establish model simulations, conduct statistical and econometric research, and create tables and graphs for further presentations.

In this research, we will run time series data analysis with E-views, such as Descriptive Analysis, Correlation Analysis, Unit Root test, Vector Error Correction Model (VECM), and Residual Diagnostic test.

3.4 Scale measurement

This research has included total of five variables, the dependent variable is carbon emissions (CO2), and the other independent variables are exports of goods and services (EX), imports of goods and services (IM), FDI net inflows (FDI) and renewable energy consumption (RE).

The scale measurement of all variables is shown as below:

Table 3.4: Data descriptions

Variables	Measurement of Data	Source
CO2 emissions (CO2)	Metric tons per capita	World Development Indicators
Exports of goods and services (EX)	Percentage of GDP	World Development Indicators
Imports of goods and services (IM)	Percentage of GDP	World Development Indicators
Foreign direct investment, net inflows (FDI)	Percentage of GDP	World Development Indicators
Renewable energy consumption (RE)	Percentage of total final energy consumption	World Development Indicators

Source: Developed for the research

3.5 Data analysis

3.5.1 Descriptive analysis

Descriptive analysis summarizes the attributes of data, it involves the process of identifying relationships and trends by employing both historical and current data. Descriptive analysis has the advanced function of providing statistically sound, statistically analyzable and objective data, building a scientific foundation for sensory evaluation (Kemp, 2018).

In this study, we use E-views to conduct descriptive analysis. It presents mean, median, maximum, minimum, standard deviation, skewness, Jarque Bera value, Kurtosis value, and probability of each variable. We will only display the values of mean, median, maximum and minimum of all variables.

3.5.2 Correlation Analysis

Correlation analysis is a statistical method for determining and characterizing the relationship between multiple variables. It evaluates the extent to which changes in a variable are related to changes in another variable. Correlation analysis measures the extent and direction of the correlation between variables by computing correlation coefficients, such as Pearson's r or Spearman's rank correlation coefficient (Schober et al., 2018).

Strong positive correlations, where one variable tends to increase along with the other, its correlation coefficients close to +1. Besides that, strong negative correlations, where one variable tends to drop as the other increases, the value of correlation coefficient is close to -1. There may be little to no linear relationship between the variables if the value of correlation coefficient is near to zero.

According to Senthilnathan (2019), correlation is committed to exploring the relationship degree between two variables in consideration. The measurement of quantifying such relationship degree between variables is known as correlation coefficients.

Table 3.5.2: Strength of correlations

Value of Correlation Coefficient	Relationship Interpretation
0.000 – 0.199	Very Weak
0.2 – 0.399	Weak
0.400 – 0.599	Moderate
0.600 – 0.799	Strong
0.800 – 1.000	Very Strong

Adapted from: Care et al. (2018)

3.5.3 Unit Root Test

Unit root test is designed to determine whether a time series variable is non-stationary, it demonstrates a distinctive pattern of behaviour over time as opposed to random variations around a constant mean. According to Studenmund (2013), if the time series variable has unit root, means that it is non-stationary and follows a random walk, with non-constant mean and variance over time as well, which makes it challenging to infer useful information or make precise predictions from the data. On the other hand, if the data exists unit root, the data leads to spurious regression results.

Besides that, the unit root could be divided into Augmented Dickey Fuller (ADF) test and Phillip Perron (PP) test. The difference of these two tests is the way they manage serial correlation in the test regressions. ADF test corrects for serial correlation by adding lag differences of the variable in the regression whereas the PP test uses a different method to handle serial correlation and is resilient to heteroskedasticity. To determine whether the data is non-stationary and has unit root, for example:

H_0: The time series data has unit root and is non-stationary.

H_A: The time series data has not unit root and is stationary.

If the unit root t-statistic value of ADF and PP test exceeds the critical value at 0.01, 0.05, and 0.1 significance level, we should reject the null hypothesis and conclude that the variable doesn't have unit root and is stationary.

3.5.4 Johansen Co-integration Rank Test

Co-integration rank test is a statistical method to estimate the number of cointegrating relationships among a set of time series variables. The variables are said to be cointegrated if there is long-term relationship arises among them. If the individual variable was found stationary in the unit root test, the nonstationary variables' linear combinations can be stationary, or cointegrated. The spurious regressions still can be prevented if the variables are cointegrated and even the dependent variable and one or more independent variables are nonstationary. There is a way to test whether the variables have long-run relationship exists among them, shown below:

H_0: The variables do not have a long-run relationship.

H_A: The variables have a long-run relationship.

The co-integration rank test also includes Johansen test and the Engle-Granger test. Johansen test can manage multiple cointegrated variables in a system. After estimating the Vector Error Correction Model (VECM), we can look at the rank of the cointegration matrix to determine the number of cointegrating relationships among the variables. In the Johansen test, if the p-value exceeds 0.05 significance level, we should accept the null hypothesis, which means that the variables are not cointegrated and don't have long run relationship. In contrast, Engle-Granger test only can manage single cointegration relationship. To test whether cointegration arises, it conducts the estimation of a simple regression model and evaluates the significance of the residuals.

3.5.5 Vector Error Correction Model (VECM)

Vector Error Correction Model (VECM) is a statistical method to analyze the relationship between multiple variables that are non-stationary in levels but stationary in the first difference. VECM model is distributed as VECM equations and cointegration equations. VECM equations required all endogenous variables to adjust the dynamism of the short term. The cointegration equation is incorporated into the specification in a way that limits the endogenous variables' long-term behavior and forces it to converge to their cointegrating connection. Since a series of local short-term adjustments has successfully and gradually correct deviations from the long-term equilibrium, the cointegration equation is also called an error correction model (Engle and Granger, 1991).

VECM equation:

$$\Delta^2 LnCO2 = \alpha + \beta\, \Delta^2\, LnEX_{t-1} + \beta\, \Delta^2\, LnIM_{t-1} - \beta\, \Delta^2\, LnFDI_{t-1} - \beta\, \Delta^2\, LnRE_{t-1} + \varepsilon_{t-1}$$

3.5.6 Granger Causality

Granger Causality is designed to analysis the causal relationship among the variables. The Engle-Granger test has capability to analyze the cointegration relationship between two variables. By determining whether time series variables "Granger causes" another time series variable, we can know whether the historical values of X offer more predictive information than the historical values of Y alone regarding the current or future values of Y (Granger, 1969). The null and alternative hypothesis of Granger Causality test are shown below:

H_0: Independent variables no "Granger-causes" dependent variable.

H_A: Independent variables "Granger-causes" dependent variable.

The occurrence of causal direction among these two variables is known as bi-direction whereas only one variable is significant in the test known as unidirection. If the F test's p-value is less than significance level of 0.05, we should reject null hypothesis, means that the variables has causal relationship with another variable, the two variables have co-integrated and long-run relationship. However, if variable y is significant with another variable x but variable x is not significant with variable y, we can conclude that the variables don't have a co-integrated and long-run relationship (Studenmund, 2013).

3.5.7 Residual Diagnosis

3.5.7.1 Normality Test

Studenmund (2013) introduced the normality test in classical assumption VII, it indicate that the error term should be normally distributed. It tests whether the observations of the error term are normally distributed. The bell-shaped, symmetric curve that represents the normal distribution has equal values for the mean, median, and mode. Jarque – Bera test used the skewness and kurtosis to analyze the normality of data. The distribution's asymmetry is measured by skewness, while its peakedness or tails are measured by kurtosis. Both skewness and kurtosis are anticipated to be zero in a normal distribution. The way to test whether the residual has normality, is shown below

H_0: The residuals are normally distributed.

H_A: The residuals are not normally distributed.

If the p-value is less than significance level of 0.05 or the Jarque – Bera critical value is less than the statistic value, we should reject the null hypothesis and accept the alternative hypothesis of residuals are not normally distributed.

3.5.7.2 Breush-Godfrey Serial Correlation Lagrange Multiplier (LM) Test

In Classical Assumption IV, serial correlation test is introduced, in which observations of the error term are uncorrelated with each other (Studenmund, 2013). It determines the degree of correlation between the residuals over various lagged time intervals. If the F statistic p-value is less than the significance level of 0.05, we should reject the null hypothesis, which means that the residuals have a serial correlation. To test the serial correlation of residuals, the hypotheses are shown as below:

H_0: The residuals have no serial correlation.

H_A: The residuals have serial correlation.

3.5.7.3 Heteroskedasticity White Test

Studenmund (2014) suggested heteroskedasticity in Classical Assumption V, the variance of error terms must be constant. The Heteroskedasticity White Test is designed to calculate the squared residuals from the regression model. Following that, the independent variables and their cross-products are regressed using these squared residuals. The goodness-of-fit of this auxiliary regression model is gauged by the test statistic. If homoscedasticity exists among the variables, the variance of the error term across all levels of the independent variable is constant. In contrast, If heteroskedasticity exists among the variables, the variance of error term across all levels of the independent variable is not constant.

If F statistic p-value exceeds 0.05 significance level, the alternative hypothesis of heteroskedasticity should be rejected. We can know there is no evidence of heteroskedasticity in the residuals, which means that the error terms' variance is constant over all levels of the independent variables.

H_0: The residuals have no heteroskedasticity.

H_A: The residuals have heteroskedasticity.

3.5.7.4 Multicollinearity Test

Multicollinearity has introduced in Classical Assumption VI which there is no perfect collinearity between independent variables (Studenmund, 2014). When two independent variables exhibit perfect collinearity, it suggests that one or more of the variables are actually the same, that one is a multiple of the other, or that one of the variables has added with constant. Examining the correlation matrix between the independent variables is one way to find multicollinearity. Strong correlations (almost 1 or -1) suggest the possibility of multicollinearity.

The variance inflation factor (VIF) estimates the extent to which multicollinearity increases the variance of the estimated regression coefficients. Multicollinearity inflates the variance of the related coefficient estimate if a high VIF has been captured. In practical terms, multicollinearity is typically indicated when the value of VIF is greater than 5, the null hypothesis of no multicollinearity have to be rejected, means that the residuals have multicollinearity. To measure VIF, the formula is one divided by one minus R-squared.

H_0: The residuals have no multicollinearity.

H_A: The residuals have multicollinearity.

3.6 Conclusion

In short, Chapter 3 has presented the research methodology that has been applied to proceed with this research. This research employed secondary and time series data over the period of 1990 to 2020. The main data source of all variables are obtained from World Bank. The model of research has included a dependent variable and four independent variables. This research utilized E-view as the measurement tool to conduct the tests and analyses. The tests to analyze times series data are Descriptive Analysis, Correlation Analysis, Unit Root test, Johansen Co-integration rank test, Vector Error Correction Model (VECM), and Granger Causality. On the other hand, the residual diagnoses to detect issues in the model are the Normality test, Serial Correlation test, Heteroskedasticity White test, and Multicollinearity test. Chapter 4 will further interpret the result of the tests.

CHAPTER 4: DATA ANALYSIS

4.0 Introduction

Chapter 4 discusses and interprets the results of tests introduced in Chapter 3. Based on the unit root test result, the data has been run as second difference data. The descriptive analyses of all variables which are the log second difference data carbon emission (LNCO2_2), log second difference exports of goods and services (LNEX_2), log second difference imports of goods and services (LNIM_2), log second difference foreign direct investment, net inflow (LNFDI_2) and log second difference renewable energy consumption (LNRE_2) have been completed. After that, this research analyzes the correlation between log second difference carbon emissions with other independent variables. This study has employed Vector error correction model (VECM) to measure the stationary of the variables. Furthermore, the long-term equilibrium and cointegrated relationship of variables has been estimated by Granger Causality and Co-integration rank test. To ensure the data don't violate 7 Classical Assumptions, the residual diagnosis has been employed as well, such as normality test, heteroscedasticity white test, serial correlation test, and others. The results and interpretation of the tests will be shown in the following part.

4.1 Descriptive analysis

We use Eviews to run the test, the used data are the original data of the study. The table 4.1 presents descriptive analysis of the variables.

Table 4.1: Descriptive Analysis of Dependent Variable and Independent Variables

	LNCO2_2	LNEX_2	LNIM_2	LNFDI_2	LNRE_2
Mean	-0.0025	-0.0015	-0.0024	-0.0174	0.0014
Median	-0.0036	-0.0039	-0.0009	-0.1006	0.0059
Maximum	0.0899	0.0856	0.063	3.6392	0.2005
Minimum	-0.0756	-0.0733	-0.0894	-1.8017	-0.229
Std. Dev.	0.0322	0.0317	0.0359	0.9216	0.0783
Skewness	0.3807	0.3516	-0.4144	1.9662	-0.4947
Kurtosis	4.4172	3.6611	3.0158	10.3649	5.1593
Jarque-Bera	3.1274	1.1255	0.8304	84.2274	6.8165
Probability	0.2094	0.5696	0.6602	0	0.0331
Sum	-0.0731	-0.0444	-0.0706	-0.5051	0.0412
Sum Sq. Dev.	0.029	0.0282	0.03615	23.7812	0.1717
Observations	29	29	29	29	29

Sources: Developed for the research

Based on the result of descriptive analysis, the mean value of log second difference carbon emissions (LNCO2_2) is -0.0025, with a maximum value of 0.0899, minimum value of -0.0756, and standard deviation of 0.0322. Meanwhile, the mean value of log second difference exports of goods and services (LNEX_2) is -0.0015, maximum value 0.0856, minimum value -0.0733, and standard deviation 0.0317. The variable log second difference for imports of goods and services

(LNIM_2) presents a mean value of -0.0024 with a maximum value of 0.063, minimum value of -0.0894, and standard deviation of 0.0359 while the mean value of log second difference of FDI, net inflow (LNFDI_2) is -0.0174 with maximum value 3.6392, minimum value -1.8017 and standard deviation 0.9216. The variable log second difference for renewable energy consumption (LNRE_2) shows the mean value of 0.0014, maximum value 0.2005, minimum value -0.229 and standard deviation 0.0783.

4.2 Correlation analysis

The correlation of the dependent variable (CO2) against other independent variables (EX, IM, FDI and RE) is displayed on table 4.2 as below:

Table 4.2: Correlation of Dependent Variable and Independent Variable

	LNCO2_2
LNCO2_2	1.0000
LNEX_2	-0.0857
LNIM_2	0.2339
LNFDI_2	0.7074
LNRE_2	0.0009

Sources: Developed for the research

Based on the result, we can see that there is a very weak negative linear correlation between Δ^2LNCO2 and Δ^2LNEX. Meanwhile, there is a weak linear positive correlation between Δ^2LNCO2 and Δ^2LNIM and Δ^2LNRE. A strong linear positive correlation is observed between Δ^2LNCO2 and Δ^2LNFDI.

4.3 Unit root test

Unit root test plays an important role in analyzing the stationary of time series variables. In this study, we used Augmented Dickey Fuller (ADF) and Phillips Perron (PP) test, the result is shown as below:

Table 4.3.1: Unit Root Test Result (Constant without Trend)

	Augmented Dickey Fuller (ADF) Test Statistic			**Phillips Perron (PP) Test Statistic**		
	Level	**1st**	**2nd**	**Level**	**1st**	**2nd**
LnCO2	**-3.1523****	**-6.4444*****	**- 7.9693*****	**-5.6483*****	**-6.4351*****	**-21.6267*****
LnEX	**-0.1308ns**	**-3.482****	**-5.6578*****	**-0.4898 ns**	**-3.5203****	**-10.9287*****
LnIM	**0.0451ns**	**-5.2709*****	**-6.0244*****	**0.0451 ns**	**-5.2699*****	**-20.3398*****
LnFDI	**-4.7384*****	**-6.4316*****	**-7.7662*****	**-4.7384*****	**-26.0434*****	**-43.6508*****
LnRE	**-1.8703ns**	**-3.9117*****	**-5.5942*****	**-1.8118 ns**	**-3.8936*****	**-18.6528*****

Sources: Developed for the research

Table 4.3.2: Unit Root Test Result (Constant with Trend)

	Augmented Dickey Fuller (ADF) Test Statistic			**Phillips Perron (PP) Test Statistic**		
	Level	**1st**	**2nd**	**Level**	**1st**	**2nd**
LnCO2	**-2.1333 ns**	**-5.8351*****	**-7.7952*****	**-2.1333 ns**	**-13.6689*****	**-20.834*****
LnEX	**-1.4848 ns**	**-4.1917****	**-3.7352****	**-1.8028 ns**	**-5.07*****	**-10.0572*****
LnIM	**-2.4965 ns**	**-5.7382*****	**-8.3301*****	**-4.6526*****	**-9.3301*****	**-19.2168*****
LnFDI	**-5.2659*****	**-6.3073*****	**-6.2791*****	**-5.2644*****	**-25.5041*****	**-42.7745*****
LnRE	**-0.1861 ns**	**-4.6317*****	**-7.8294*****	**-0.2767 ns**	**-4.5843*****	**-17.9397*****

Souces: Developed for the research

Table 4.3.1 shows all variables in the second difference form for ADF and PP tests are significant at 1%. Meanwhile, LnCO2, LnIM, LNFDI, and LNRE are significant at 1% in the form of the first difference in both ADF and PP tests, and only LnEX is significant at 5% in the first difference of both ADF and PP tests. At this case, the variables are stationary and don't have unit root. On the other hand, table 4.3.2 shows a similar result as in table 4.3.1, the differences are that LnEX is significant at 5% in the second difference form of ADF test and significant at 1% in the first difference form of PP test. Therefore, the model is conducted as the variables are stationary and don't have unit root.

4.4 Johansen Co-integration rank test

Table 4.4.1: Unrestricted Co-integration Rank Test Result (Trace)

Hypothesized No. of CE (s)	Eigenvalue	Trace Statistic	0.05 Critical value	Prob.**
None*	0.8641	174.0254	69.8189	0.0000
At most 1*	0.7989	120.1361	47.8561	0.0000
At most 2*	0.6883	76.8356	29.7971	0.0000
At most 3*	0.6614	45.3581	15.4947	0.0000
At most 4*	0.4496	16.1211	3.8415	0.0001

Sources: Developed for the research

Table 4.4.2: Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE (s)	Eigenvalue	Trace Statistic	0.05 Critical value	Prob.**
None*	0.8641	53.8893	33.8769	0.0001
At most 1*	0.7989	43.3006	27.5843	0.0002
At most 2*	0.6883	31.4775	21.1316	0.0012
At most 3*	0.6614	29.2369	14.2646	0.0001
At most 4*	0.4496	16.1211	3.8415	0.0001

Sources: Developed for the research

In Table 4.4.1 and 4.4.2, the result of both trace test and maximum eigenvalue test results indicated that 5 cointegrating equations were significant at 0.05 significance level, we can conclude that the long-term equilibrium between the variables was met.

4.5 Vector Error Correction Model (VECM)

VECM equation:

$$\Delta^2 LnCO2 = -1.3465 + 0.1869\ \Delta^2\ LnEXt_{-1} - 0.5386\ \Delta^2\ LnIMt_{-1} - 38.2215\ \Delta^2 FDI_{t-1}$$

$$t=[0.5073^{ns}] \qquad [-1.5772^{ns}] \qquad [-5.9268^{***}]$$

$$+\ 1.4351\ \Delta^2\ LnRE_{t-1} + 0.21596\ \varepsilon_{t-1}$$

$$[1.7059*]$$

R-squared = 0.803199 Adj. R-squared = 0.744159

Based on the VECM model of carbon emission, the explanatory variables accounted for about 80.3 percent of the variation in the log second difference carbon emission ($\Delta^2 LnCO2$) equation. Estimations reveal that the explanatory variables, namely the FDI net inflow ($\Delta^2\ FDI_{t-1}$) and renewable energy consumption ($\Delta^2\ RE_{t-1}$) were the important explanatory variables with statistical significance levels of both 0.01 and 0.1. Therefore, a 1 unit increase in FDI net inflow ($\Delta^2\ FDI_{t-1}$) on average, has a positive effect on increasing carbon emission (CO2) by 38.2215 units with a statistically significance level of 0.01, other variables held constant. On the other hand, 1 unit increase in renewable energy consumption ($\Delta^2 RE_{t-1}$) on average, has a negative effect on decreasing carbon emission (CO2) by 1.4351 units with statistical significance 0.1 level, other variables held constant.

4.6 Granger Causality

Table 4.6: Analyses of Granger Causality

Null Hypothesis	F-statistic	Probability	Decision
LNEX_2 does not Granger Cause LNCO2_2	1.6324	0.2183	No Granger Cause
LNCO2_2 does not Granger Cause LNEX_2	0.7341	0.4913	No Granger Cause
LNIM_2 does not Granger Cause LNCO2_2	2.2674	0.1273	No Granger Cause
LNCO2_2 does not Granger Cause LNIM_2	1.4949	0.2462	No Granger Cause
LNFDI_2 does not Granger Cause LNCO2_2	1.5329	0.2381	No Granger Cause
LNCO2_2 does not Granger Cause LNFDI_2	3.6683	0.0422**	Has Granger Cause
LNRE_2 does not Granger Cause LNCO2_2	1.8696	0.1779	No Granger Cause
LNCO2_2 does not Granger Cause LNRE_2	0.2152	0.8081	No Granger Cause

Sources: Developed for the research

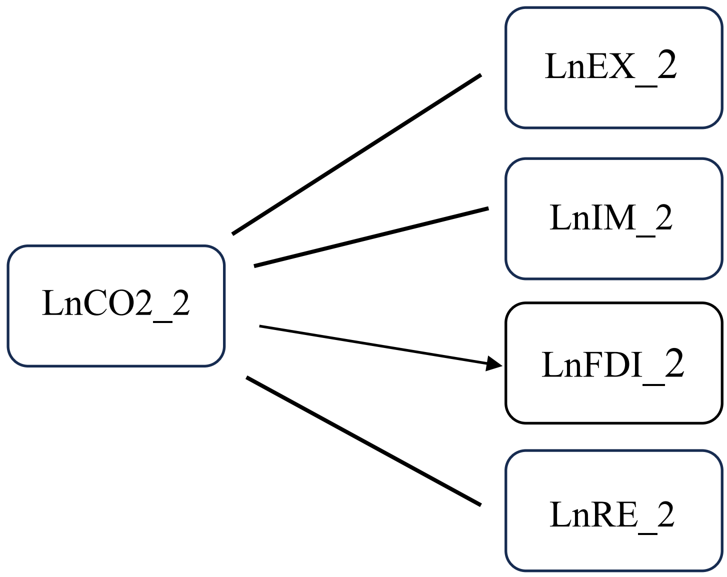
Based on the result of Eagle – Granger test, F statistics of two variables, LnEX_2 / LnCO2_2 and LnCO2_2 / LnEX_2 are not significant at 0.05 level. There is no variable LnEX_2 "Granger-causes" (or) "G-causes" variable LnCO2_2. Then, there is no cointegrated relationship variable LnCO2_2 and also no long-term equilibrium relationship.

Moreover, the F statistics of two variables, LnIM_2 / LnCO2_2 and LnCO2_2 / LnIM_2 are not significant at 0.05 level. There is no variable LnIM_2 "Granger-causes" (or) "G-causes" variable LnCO2_2. Then, there is no cointegrated relationship variable LnCO2_2 and also no long-term equilibrium relationship.

Besides that, the F statistics of two variables, LnFDI_2 / LnCO2_2 is not significant at 0.05 level, but LnCO2_2 / LnFDI_2 is significant at 0.05 level. There is a variable LnCO_2 "Granger-causes" (or) "G-causes" variable LnFDI_2. Then, there is a cointegrated relationship between variable LnCO2_2 and LnFDI_2 and also a long-term equilibrium relationship.

The F statistics of two variables, LnRE_2 / LnCO2_2 and LnCO2_2 / LnRE_2 are not significant at 0.05 level. There is no variable LnRE_2 "Granger-causes" (or) "G-causes" variable LnCO2_2. Then, there is no cointegrated relationship variable LnCO2_2 and also no long-term equilibrium relationship.

Figure 4.6: Granger Causality



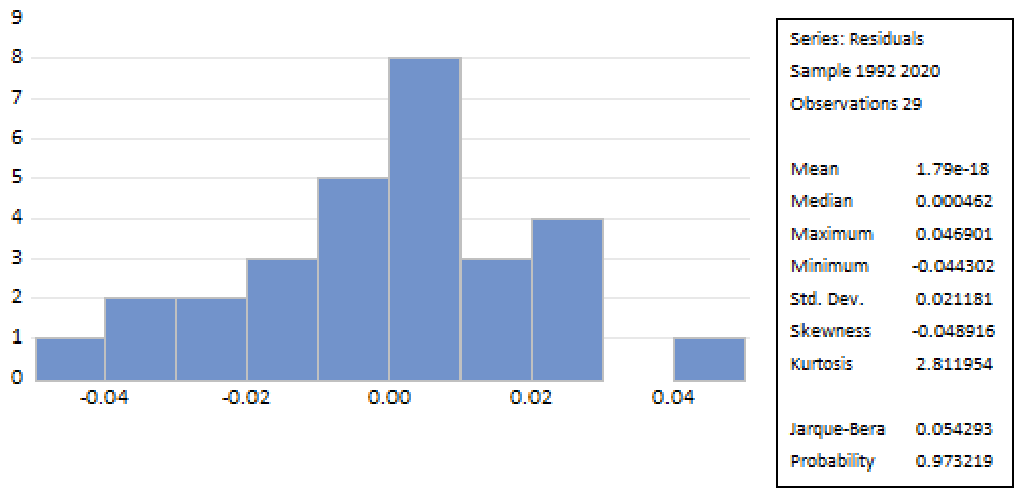
Adapted from: Developed for the research

4.7 Residual Diagnosis

The residual diagnosis of carbon emission has included normality test, serial correlation test, heteroscedasticity white test and multicollinearity test, the tests shown below:

4.7.1 Normality test

Figure 4.7.1: Normality Test Result



Adapted from: Developed for the research

H_0 (null hypothesis): The residuals are normally distributed.

H_A (alternative hypothesis): The residuals are not normally distributed.

Based on figure 4.7.1, the normality test result showed that the p value is 0.9732 which is greater than 0.05 significance level. Therefore, we should accept null hypothesis and conclude that the residual are normal distribution.

4.7.2 Heteroscedasticity White Test

Figure 4.7.2: Heteroskedasticity White Test Result

Heteroskedasticity Test: White

F-statistic	0.979904	Prob. F(14,14)	0.5149
Obs*R-squared	14.35282	Prob. Chi-Square(14)	0.4238
Scaled explained SS	8.905967	Prob. Chi-Square(14)	0.8370

Adapted from: Developed for the research

H_0 (null hypothesis): Residuals does not have heteroskedasticity.

H_A (alternative hypothesis): Residuals have heteroskedasticity.

The result of the white heteroskedasticity test (Figure 4.7.2) indicates that the p-value of 0.5149, is more than the 0.05 significance level. Hence, we should reject H_A and accept H_0 the residuals does not have heteroskedasticity.

4.7.3 Breush-Godfrey Serial Correlation LM Test

Figure 4.7.3: Breush-Godfrey Serial Correlation LM Test Result

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.385941	Prob. F(1,23)	0.2511
Obs*R-squared	1.648174	Prob. Chi-Square(1)	0.1992

Adapted from: Developed for the research

H_0 (null hypothesis): Residuals does not have serial correlation.

H_A (alternative hypothesis): Residuals have serial correlation.

Based on figure 4.7.3, the serial correlation test result shows that the p-value F(1,23) is 0.2511, which is more than the significance of 0.05 level. H_A should be rejected and H_0 is therefore accepted, which means that the residuals do not have serial correlation.

4.7.4 Multicollinearity Test

H_0 (null hypothesis): Residuals does not have multicollinearity

H_A (alternative hypothesis): Residuals have multicollinearity

$$VIF = \frac{1}{(1-R2)} = \frac{1}{(1-0.5668)} = 2.3084$$

VIF value is 2.3084 which is less than 5. We should accept H_0 and conclude that the residuals does not have multicollinearity.

4.8 Summary of hypothesis testing (VECM)

The inferential analyses have been conducted based on the Vector Error Correction Model (VECM) results for the second difference data model. The results are shown below:

Table 4.8: Summary of hypothesis testing (VECM result)

Hypotheses	Variables	Std. Error	t-Statistic	Conclusion
H1	LNEX_2	0.3684	0.5073^{ns}	Rejected
H2	LNIM_2	0.3415	-1.5772^{ns}	Rejected
H3	LNFDI_2	6.4489	-5.9268***	Supported
H4	LNRE_2	0.8412	1.70589*	Supported

Sources: Developed for the research

Based on Table 4.8, the t statistic of LNFDI_2 and LNRE_2 are statistically significant, we have to support the alternative hypothesis of having a significant relationship with carbon emissions. Therefore, LNFDI_2 and LNRE_2 have significant relationships with LNCO2_2. On the other hand, the t statistics of LNEX_2 and LNIM_2 are not significant, thus there is no significant relationship between LNCO2_2 with LNEX_2 and LNIM_2.

4.9 Conclusion

In conclusion, Chapter 4 has discussed the results of the Descriptive Analysis, Correlation analysis, Unit Root Test, Granger Causality, Johansen Cointegration Rank test, Vector Error Correction Model (VECM), and Residual diagnosis. Unit root test presents that the model is stationary and doesn't have a unit root. After that, the Johansen cointegration rank test shows that the result of both the trace test and maximum eigenvalue test indicates 5 cointegrating relationships at 0.05 level, thus there is long-term equilibrium among the variables. Based on the residual diagnosis result, there are no residual issues that occur in this model. Besides that, there is a significant and positive relationship between the variable of FDI and carbon emissions, meanwhile, there is a significant and negative relationship between the variable of RE and carbon emissions, whereas the variables of EX and IM have an insignificant relationship with carbon emissions in Malaysia. Chapter 5 will present a more complete statement regarding the findings, discussions, implications, limitations, and recommendations of the study.

CHAPTER 5: DISCUSSION, CONCLUSION AND IMPLICATIONS

5.0 Introduction

This chapter recap the main points of the previous chapters and have a conclusion on this research. This chapter also will discuss the findings around the relationship between carbon emissions and exports, imports, FDI net inflows, renewable energy consumption. Besides that, the implications and limitations of the research also will be presented. The recommendations of the research will be suggested to assist those researchers who want to conduct research that is related to this topic. Last but not least, this chapter will summarize this entire research.

5.1 Summary of Statistical Analyses

Based on the correlation analysis result, there is a very weak negative linear correlation between LNCO2_2 and LNEX_2. LNIM_2 and LNRE_2 have a weak linear positive correlation with LNCO2_2. LNFDI_2 has a strong linear positive correlation with LNCO2_2.

Regarding the VECM result, there is a significant and positive relationship between the FDI inflow (LNFDI_2) and carbon emissions (LNCO2_2), and there is a significant and negative relationship between renewable energy consumption (LNRE_2) and carbon emissions (LNCO2_2), whereas LNEX_2 and LNIM_2 don't have a significant relationship with LNCO2_2. A deeper discussion of results will be presented in section 5.2, discussions of major findings.

For residual analysis, the residuals are normally distributed on the Normality test. The Heteroskedasticity White test revealed that there is no heteroskedasticity on residuals. The residuals don't have serial correlation based on the result of Breush-Godfrey Serial Correlation LM Test. Furthermore, the residuals also don't have multicollinearity issues based on the Multicollinearity Test. For the unit root test, the model is stationary and doesn't have a unit root.

5.2 Discussions of Major Findings

In the literature review part, Hasanov et al. (2018) discovered that exports have an insignificant relationship with carbon emissions. Similarly, these are aligned with this study's results which have found that exports has an insignificant relationship with carbon emissions. Besides that, the studies of Pié et al. (2018) and Hu et al. (2020) revealed that there is a significant and positive relationship between imports and carbon emissions. In contrast, our study result shows that imports have an insignificant relationship with carbon emissions. This may be because Malaysia imports less carbon-intensive goods that don't contribute a significant portion of carbon emissions. According to the report of MATRADE (2020), the goods imported by Malaysia the most are electrical and electronic products which don't produce carbon significantly. Based on the test outcome, we discovered that FDI net inflow has a significant and positive relationship with carbon emissions which is aligned with the study of Lau et al. (2014). By destroying natural resources and exploiting the environment, FDI may encourage more production and consumption. The fierce rivalry between developing countries has raised FDI, this could lead to the loosening and failure of environmental policies for firms in foreign countries, which could encourage the firms in developed countries to shift their pollution-intensive goods production system to developing countries (Demena & Afesorgbor, 2020). The study of Shafiei & Salim (2014) and Hanif (2018) discovered that renewable energy consumption has a significant and negative relationship with carbon emissions. These were similar to our study results which has explored that renewable energy consumption affects carbon emissions negatively. Renewable energy sources, such as solar, hydropower, and wind won’t emit carbon dioxide, they can replace fuel sources by providing a greener pathway to reduce carbon emissions and prevent pollution.

5.3 Implications of the Study

From the generated model, it shows that FDI net inflow and renewable energy consumption are the main factors affecting carbon emission in Malaysia. The exports and imports of goods and services don’t affect carbon emissions of Malaysia significantly, but these variables would also help to mitigate environmental degradation if the policymakers adopt robust related strategies. Besides that, the carbon emissions in Malaysia have been on an upward trend over the years.

Malaysia should implement policies around the sectors of international trade to address environmental damage issues. Malaysia can develop viable export strategies by encouraging green export activities. Exports' negative environmental impact can be greatly decreased by promoting energy-efficient manufacturing techniques, such as the utilization of cutting-edge technologies and production system optimization. Furthermore, Malaysia should limit the environmental impact of export activities by implementing sustainable packaging. For instance, the manufacturing sectors could utilize eco-friendly materials to produce and package export goods. The sustainable transportation practices could also employed in both exports and imports activities. The sectors may increase the volume of autonomous electric vehicles to transport the goods which reduce the fuel consumptions and carbon emissions. The policymaker can implement tariff mechanisms to impose higher tariff on imported carbon intensive goods, lead to promoting importers and exporters to choose environmental friendly alternatives goods and shift to green production practices. Malaysia may successfully reduce the negative environmental effects of rising production and energy consumption by incorporating environmental considerations into export and import oriented sectors.

Besides that, Malaysia has to enact strict environmental regulations to guarantee that FDI inflow to Malaysia in an environmentally responsible manner. This could motivate the investors to pay attention on the environmental impact of their investment planning and fund sustainable projects. To facilitate beneficial spillovers and the transfer of knowledge and technology to the local economy, Malaysia policymakers should remove obstacles to investment in the environmental goods and services industry as well as less carbon intensive technologies. Through FDI, Malaysia can transfer efficient production technology from developed countries which could lead to the reduction in carbon emissions. Malaysia could also utilize the investment to invest in developing workforce, establish the training program regarding the sustainable environmental business practice and adopting clean technology. Furthermore, the policymaker should consider creating a standard for businesses to report their carbon emissions will yield important data that will allow Malaysia to comprehend the contribution of all businesses.

Renewable energy plays crucial role to mitigate the damage of environmental deterioration and reduce carbon emissions. As mentioned in previous chapters, Malaysia has over reliance on fuel consumption and failed to use renewable energy in effective level, cause the carbon emission can't be reduced significantly. To popularize the renewable energy consumption, the policymaker should prioritize the investment in the adoption of green technology across multiple economic sectors. One useful strategy is to encourage companies to integrate green technology into their manufacturing processes, particularly those in sectors of the economy that have a massive impact on the environment. This can entail pushing for sustainable habits, supporting the application of energy-efficient technology, and promoting renewable energy sources. Malaysia also can provide subsidies to those who actively use renewable energy sources and invest in eco-friendly operations. By significantly lowering carbon emissions and enhancing environmental performance, these actions can accelerate the shift to more environmentally friendly practices.

5.4 Limitations of the Study

There are some limitations have been faced when researching this study. When conducting this research, there is a limitation of data analysis constraints. Most of the previous researchers in the related study commonly use data of GDP per capita, urbanization, GNI per capita and others to represent the variables of international trade. However, those data in Malaysia can't generate successful test outcomes and would have residual issues in data analysis. It was difficult to find suitable variables and data to generate an appropriate model, and also challenging to find previous research with the same variables to support this study.

5.5 Recommendations for Future Research

The future researchers can analyze other factors or variables that affect carbon emissions in Malaysia. Future researchers can analysis the carbon emissions in Malaysia with manufacturing value and urban population by applying large size of samples to increase the accuracy and reliability of the study findings. Besides that, the future researchers also can employ appropriate variables to improve the model instead of insignificant variables, thus have more accurate findings.

5.6 Conclusion

In conclusion, this research aims to examine the relationship between exports of goods and services, imports of goods and services, FDI net inflows, and renewable energy consumption against carbon emission in Malaysia. The factor that significantly affects the carbon emissions of Malaysia are FDI net inflow and renewable energy consumption. A positive relationship exists between FDI net inflow and carbon emissions in Malaysia, meanwhile, a negative relationship exists between renewable energy consumption and carbon emissions in Malaysia, whereas exports of goods and services, imports of goods and services have an insignificant relationship with carbon emissions in Malaysia. Lastly, future researchers may use this study as a reference to provide better outcomes for policymakers to improve carbon emissions in Malaysia.

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APPENDIX

Appendix 1: Descriptive Statistic

	LNCO2_2	LNEX_2	LNIM_2	LNFDI_2	LNRE_2
Mean	-0.002522	-0.001529	-0.002434	-0.017418	0.001419
Median	-0.003608	-0.003916	-0.000861	-0.100559	0.005939
Maximum	0.089961	0.085615	0.063024	3.639222	0.200500
Minimum	-0.075612	-0.073261	-0.089395	-1.801671	-0.228942
Std. Dev.	0.032180	0.031720	0.035931	0.921590	0.078317
Skewness	0.380741	0.351572	-0.414425	1.966168	-0.494670
Kurtosis	4.417156	3.661094	3.015848	10.36493	5.159275
Jarque-Bera	3.127391	1.125511	0.830421	84.22735	6.816529
Probability	0.209361	0.569637	0.660201	0.000000	0.033099
Sum	-0.073132	-0.044353	-0.070599	-0.505131	0.041149
Sum Sq. Dev.	0.028996	0.028173	0.036149	23.78119	0.171741
Observations	29	29	29	29	29

Appendix 2: Correlation

	LNCO2_2	LNEX_2	LNIM_2	LNFDI_2	LNRE_2
LNCO2_2	1.000000	-0.085728	0.233949	0.707358	0.000906
LNEX_2	-0.085728	1.000000	0.587783	0.086776	0.242314
LNIM_2	0.233949	0.587783	1.000000	0.228247	-0.056918
LNFDI_2	0.707358	0.086776	0.228247	1.000000	0.027315
LNRE_2	0.000906	0.242314	-0.056918	0.027315	1.000000

Appendix 3: Johansen Cointegration Rank Test

Date: 03/23/24 Time: 01:54

Sample (adjusted): 1994 2020
Included observations: 27 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCO2_2 LNEX_2 LNIM_2 LNFDI_2 LNRE_2
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.864109	174.0254	69.81889	0.0000
At most 1 *	0.798854	120.1361	47.85613	0.0000
At most 2 *	0.688337	76.83557	29.79707	0.0000
At most 3 *	0.661371	45.35811	15.49471	0.0000
At most 4 *	0.449583	16.12114	3.841465	0.0001

Trace test indicates 5 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.864109	53.88931	33.87687	0.0001
At most 1 *	0.798854	43.30057	27.58434	0.0002
At most 2 *	0.688337	31.47746	21.13162	0.0012
At most 3 *	0.661371	29.23696	14.26460	0.0001
At most 4 *	0.449583	16.12114	3.841465	0.0001

Max-eigenvalue test indicates 5 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LNCO2_2	LNEX_2	LNIM_2	LNFDI_2	LNRE_2
41.73388	-12.87980	13.04529	0.994877	-2.001760
61.84363	12.32489	19.47716	-2.817131	-0.566570
-27.46955	-20.09397	19.65519	-0.109125	-20.20357
-39.03097	-2.017657	51.20338	1.119772	-4.165934
20.13700	94.21298	-63.25815	0.093334	-24.12456

Unrestricted Adjustment Coefficients (alpha):

D(LNCO2_2)	-0.032264	-0.006013	0.005522	0.013352	-0.002392
D(LNEX_2)	0.004478	-0.010853	0.017562	-0.020948	-0.011545
D(LNIM_2)	-0.012905	-0.018981	0.002977	-0.023278	0.003654
D(LNFDI_2)	-0.915838	0.256316	0.424013	-0.037339	-0.007449
D(LNRE_2)	0.034386	-0.016410	0.072205	-0.000538	0.003583

1 Cointegrating Equation(s): Log likelihood 185.8860

Normalized cointegrating coefficients (standard error in parentheses)

LNCO2_2	LNEX_2	LNIM_2	LNFDI_2	LNRE_2
1.000000	-0.308617	0.312583	0.023839	-0.047965
	(0.19799)	(0.17832)	(0.00547)	(0.06754)

Adjustment coefficients (standard error in parentheses)

D(LNCO2_2)	-1.346489
	(0.21596)
D(LNEX_2)	0.186904
	(0.36842)
D(LNIM_2)	-0.538585
	(0.34149)
D(LNFDI_2)	-38.22148
	(6.44898)
D(LNRE_2)	1.435050
	(0.84123)

2 Cointegrating Equation(s): Log likelihood 207.5363

Normalized cointegrating coefficients (standard error in parentheses)

LNCO2_2	LNEX_2	LNIM_2	LNFDI_2	LNRE_2
1.000000	0.000000	0.314016	-0.018325	-0.024387
		(0.07946)	(0.00355)	(0.03398)
0.000000	1.000000	0.004645	-0.136621	0.076399
		(0.31623)	(0.01413)	(0.13524)

Adjustment coefficients (standard error in parentheses)

D(LNCO2_2)	-1.718373	0.341437
	(0.37281)	(0.08908)
D(LNEX_2)	-0.484276	-0.191442
	(0.63325)	(0.15131)
D(LNIM_2)	-1.712464	-0.067727

	(0.52193)	(0.12471)
D(LNFDI_2)	-22.36998	14.95488
	(10.7066)	(2.55821)
D(LNRE_2)	0.420213	-0.645129
	(1.47875)	(0.35333)

3 Cointegrating Equation(s): Log likelihood 223.2750

Normalized cointegrating coefficients (standard error in parentheses)

LNCO2_2	LNEX_2	LNIM_2	LNFDI_2	LNRE_2
1.000000	0.000000	0.000000	0.018835	0.189628
			(0.00570)	(0.05379)
0.000000	1.000000	0.000000	-0.136072	0.079564
			(0.01390)	(0.13117)
0.000000	0.000000	1.000000	-0.118338	-0.681541
			(0.01714)	(0.16174)

Adjustment coefficients (standard error in parentheses)

D(LNCO2_2)	-1.870069	0.230471	-0.429469
	(0.38495)	(0.13006)	(0.14812)
D(LNEX_2)	-0.966694	-0.544330	0.192222
	(0.59825)	(0.20213)	(0.23019)
D(LNIM_2)	-1.794229	-0.127538	-0.479551
	(0.55366)	(0.18706)	(0.21304)
D(LNFDI_2)	-34.01744	6.434761	1.378991
	(8.56439)	(2.89362)	(3.29543)
D(LNRE_2)	-1.563225	-2.096014	1.548159
	(0.91401)	(0.30881)	(0.35170)

4 Cointegrating Equation(s): Log likelihood 237.8935

Normalized cointegrating coefficients (standard error in parentheses)

LNCO2_2	LNEX_2	LNIM_2	LNFDI_2	LNRE_2
1.000000	0.000000	0.000000	0.000000	0.095220
				(0.03599)
0.000000	1.000000	0.000000	0.000000	0.761610
				(0.16261)
0.000000	0.000000	1.000000	0.000000	-0.088383
				(0.06314)
0.000000	0.000000	0.000000	1.000000	5.012404
				(1.38789)

Adjustment coefficients (standard error in parentheses)

D(LNCO2_2)	-2.391202	0.203532	0.254187	-0.000810
	(0.33762)	(0.10268)	(0.22737)	(0.01217)
D(LNEX_2)	-0.149069	-0.502064	-0.880391	0.009656
	(0.52158)	(0.15863)	(0.35125)	(0.01880)
D(LNIM_2)	-0.885669	-0.080571	-1.671459	0.014243
	(0.40975)	(0.12462)	(0.27594)	(0.01477)
D(LNFDI_2)	-32.56005	6.510099	-0.532909	-1.721304
	(9.51209)	(2.89305)	(6.40589)	(0.34286)
D(LNRE_2)	-1.542223	-2.094928	1.520608	0.071956
	(1.01816)	(0.30967)	(0.68567)	(0.03670)

Appendix 4: Vector Error Correction Model (VECM)

Vector Error Correction Estimates
Date: 03/23/24 Time: 01:56
Sample (adjusted): 1994 2020
Included observations: 27 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LNCO2_2(-1)	1.000000
LNEX_2(-1)	-0.308617
	(0.19799)
	[-1.55873]
LNIM_2(-1)	0.312583
	(0.17832)
	[1.75296]
LNFDI_2(-1)	0.023839
	(0.00547)
	[4.35595]
LNRE_2(-1)	-0.047965
	(0.06754)
	[-0.71021]

C	-0.000508				

Error Correction:	D(LNCO2_2)	D(LNEX_2)	D(LNIM_2)	D(LNFDI_2)	D(LNRE_2)
CointEq1	-1.346489	0.186904	-0.538585	-38.22148	1.435050
	(0.21596)	(0.36842)	(0.34149)	(6.44898)	(0.84123)
	[-6.23495]	[0.50731]	[-1.57717]	[-5.92675]	[1.70589]
D(LNCO2_2(-1))	0.326808	-0.209386	0.364651	15.13332	-0.825192
	(0.20598)	(0.35139)	(0.32570)	(6.15089)	(0.80235)
	[1.58663]	[-0.59588]	[1.11958]	[2.46035]	[-1.02847]
D(LNEX_2(-1))	-0.149538	-0.672395	-0.183241	-8.946365	1.084200
	(0.13378)	(0.22822)	(0.21154)	(3.99488)	(0.52111)
	[-1.11781]	[-2.94624]	[-0.86623]	[-2.23946]	[2.08056]
D(LNIM_2(-1))	0.153046	0.335347	-0.296976	3.434117	-0.585039
	(0.11656)	(0.19885)	(0.18432)	(3.48081)	(0.45405)
	[1.31299]	[1.68640]	[-1.61123]	[0.98659]	[-1.28848]
D(LNFDI_2(-1))	0.008650	-0.000375	-0.001034	-0.142618	-0.008541
	(0.00555)	(0.00947)	(0.00878)	(0.16578)	(0.02163)
	[1.55817]	[-0.03955]	[-0.11773]	[-0.86028]	[-0.39495]
D(LNRE_2(-1))	-0.105738	0.106536	0.099223	-1.570965	-0.668843
	(0.04121)	(0.07030)	(0.06516)	(1.23048)	(0.16051)
	[-2.56611]	[1.51554]	[1.52283]	[-1.27670]	[-4.16699]
C	-0.002591	-0.001112	-0.001635	-0.038456	0.001892
	(0.00519)	(0.00886)	(0.00821)	(0.15501)	(0.02022)
	[-0.49904]	[-0.12552]	[-0.19919]	[-0.24808]	[0.09357]
R-squared	0.803199	0.347376	0.459352	0.830796	0.548921
Adj. R-squared	0.744159	0.151589	0.297157	0.780035	0.413597
Sum sq. resids	0.014460	0.042083	0.036155	12.89432	0.219406
S.E. equation	0.026888	0.045871	0.042518	0.802942	0.104739
F-statistic	13.60426	1.774252	2.832105	16.36679	4.056355
Log likelihood	63.37381	48.95200	51.00165	-28.33417	26.65967
Akaike AIC	-4.175838	-3.107556	-3.259382	2.617346	-1.456272
Schwarz SC	-3.839880	-2.771598	-2.923424	2.953303	-1.120314
Mean dependent	-0.001556	-0.001140	-0.001950	-0.009368	3.87E-05
S.D. dependent	0.053159	0.049801	0.050715	1.712015	0.136776

Determinant resid covariance (dof adj.)	3.23E-12
Determinant resid covariance	7.21E-13
Log likelihood	185.8860
Akaike information criterion	-10.80637
Schwarz criterion	-8.886614
Number of coefficients	40

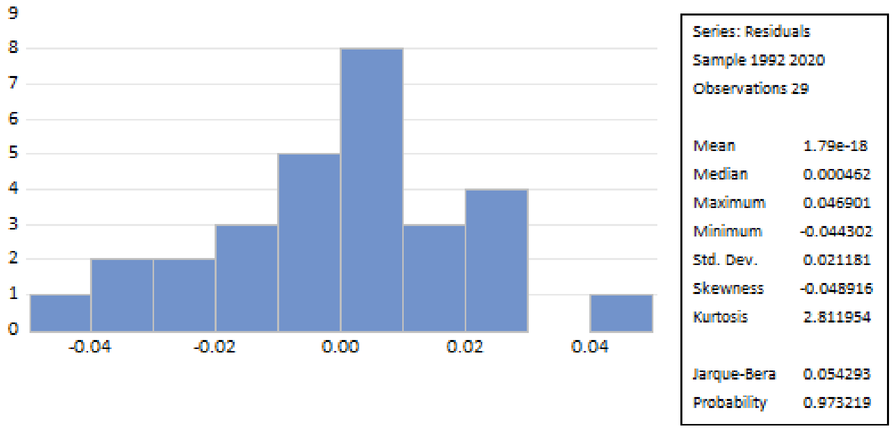
Appendix 5: Granger causality

Pairwise Granger Causality Tests
Date: 03/23/24 Time: 01:58
Sample: 1990 2020
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
LNEX_2 does not Granger Cause LNCO2_2	27	1.63239	0.2183
LNCO2_2 does not Granger Cause LNEX_2		0.73409	0.4913
LNIM_2 does not Granger Cause LNCO2_2	27	2.26742	0.1273
LNCO2_2 does not Granger Cause LNIM_2		1.49486	0.2462
LNFDI_2 does not Granger Cause LNCO2_2	27	1.53291	0.2381
LNCO2_2 does not Granger Cause LNFDI_2		3.66832	0.0422
LNRE_2 does not Granger Cause LNCO2_2	27	1.86957	0.1779
LNCO2_2 does not Granger Cause LNRE_2		0.21516	0.8081
LNIM_2 does not Granger Cause LNEX_2	27	1.86974	0.1778
LNEX_2 does not Granger Cause LNIM_2		1.55863	0.2328
LNFDI_2 does not Granger Cause LNEX_2	27	0.01539	0.9847
LNEX_2 does not Granger Cause LNFDI_2		0.24797	0.7825
LNRE_2 does not Granger Cause LNEX_2	27	1.33936	0.2826
LNEX_2 does not Granger Cause LNRE_2		3.72326	0.0405
LNFDI_2 does not Granger Cause LNIM_2	27	0.46982	0.6312
LNIM_2 does not Granger Cause LNFDI_2		0.04078	0.9601
LNRE_2 does not Granger Cause LNIM_2	27	1.76418	0.1947
LNIM_2 does not Granger Cause LNRE_2		0.36694	0.6970

LNRE_2 does not Granger Cause LNFDI_2	27	0.24354	0.7859
LNFDI_2 does not Granger Cause LNRE_2		1.24203	0.3083

Appendix 6: Normality Test



Appendix 7: Breush-Godfrey Serial Correlation Lagrange Multiplier (LM) Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.385941	Prob. F(1,23)	0.2511
Obs*R-squared	1.648174	Prob. Chi-Square(1)	0.1992

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 03/23/24 Time: 02:02
Sample: 1992 2020
Included observations: 29
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNEX_2	-0.025371	0.179679	-0.141202	0.8889
LNIM_2	-0.005185	0.156782	-0.033068	0.9739
LNFDI_2	-0.001128	0.004894	-0.230395	0.8198

LNRE_2	-0.004884	0.058637	-0.083301	0.9343
C	5.37E-05	0.004226	0.012707	0.9900
RESID(-1)	-0.251646	0.213756	-1.177260	0.2511

R-squared	0.056834	Mean dependent var	1.79E-18
Adjusted R-squared	-0.148203	S.D. dependent var	0.021181
S.E. of regression	0.022696	Akaike info criterion	-4.551264
Sum squared resid	0.011848	Schwarz criterion	-4.268375
Log likelihood	71.99333	Hannan-Quinn criter.	-4.462667
F-statistic	0.277188	Durbin-Watson stat	1.977122
Prob(F-statistic)	0.920888		

Appendix 8: Heteroscedasticity Test

Heteroskedasticity Test: White

F-statistic	0.979904	Prob. F(14,14)	0.5149
Obs*R-squared	14.35282	Prob. Chi-Square(14)	0.4238
Scaled explained SS	8.905967	Prob. Chi-Square(14)	0.8370

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/23/24 Time: 02:06
Sample: 1992 2020
Included observations: 29

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000334	0.000217	1.535910	0.1468
LNEX_2^2	0.177439	0.227324	0.780558	0.4481
LNEX_2*LNIM_2	-0.624606	0.416184	-1.500794	0.1556
LNEX_2*LNFDI_2	0.012004	0.018987	0.632202	0.5374
LNEX_2*LNRE_2	-0.332807	0.361720	-0.920067	0.3731
LNEX_2	0.006809	0.009345	0.728618	0.4782
LNIM_2^2	0.277762	0.154853	1.793717	0.0945
LNIM_2*LNFDI_2	0.003714	0.030828	0.120471	0.9058
LNIM_2*LNRE_2	0.363088	0.390202	0.930512	0.3679
LNIM_2	-0.007422	0.006468	-1.147549	0.2704
LNFDI_2^2	-1.92E-05	0.000214	-0.089657	0.9298
LNFDI_2*LNRE_2	-1.53E-05	0.002858	-0.005349	0.9958
LNFDI_2	-0.000385	0.000455	-0.846784	0.4114

LNRE_2^2	0.031191	0.051467	0.606026	0.5542
LNRE_2	-0.003659	0.003290	-1.112010	0.2849

R-squared	0.494925	Mean dependent var	0.000433
Adjusted R-squared	-0.010150	S.D. dependent var	0.000593
S.E. of regression	0.000596	Akaike info criterion	-11.70513
Sum squared resid	4.98E-06	Schwarz criterion	-10.99790
Log likelihood	184.7243	Hannan-Quinn criter.	-11.48363
F-statistic	0.979904	Durbin-Watson stat	2.583685
Prob(F-statistic)	0.514880		