THE IMPACT OF TRADE, FOREIGN DIRECT INVESTMENT (FDI), AND ECONOMIC GROWTH ON CARBON DIOXIDE (CO2) EMISSIONS IN SELECTED ASIAN COUNTRIES

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Abstract

This study examines the impact of trade, foreign direct investment (FDI), and economic growth on carbon dioxide (CO2) emissions in Selected Asian countries for the period 1990 to 2019. The objectives of this study are (1) to investigate the relationship between trade and CO2 emission, (2) to investigate the relationship between FDI and CO2 emission, and (3) to investigate the relationship between economic growth and CO2 emission. This study uses ordinary least squares (OLS) method to analyze the data. Multicollinearity test, heteroskedasticity test, and serial correlation test were also used to check the stability of the model. In addition, Granger causality test was applied to this study. The results show that there is a significant positive correlation between economic growth and CO2 emissions. If GDP increases by 1%, the average CO2 emission will increase by 0.186%, holding other variables constant. The explanation of trade and FDI on CO2 emissions is insignificant. Multicollinearity, heteroskedasticity and serial correlation are not present in the model of this study. Finally, the results of Granger causality test show that there is no Granger causality between independent variables and dependent variable. The government establishes better environmental regulations and strengthens the regulation of chemical and heavy industry sectors. Promoting technological advancement and investment in new energy technologies, government focus on energy efficiency and environmental initiatives in the corporate sector can effectively curb the growth of CO2 emissions.

Keywords: Carbon Emission, Trade, Foreign Direct Investment, Economic Growth

INTRODUCTION

The growing threat of global warming and climate change has been a major concern since the 1990s. The rapid growth of carbon emissions has serious implications for global climate change, and the rapid increase in atmospheric carbon dioxide (CO2) emissions is one of the main causes of global warming (Zubair et al., 2020). In recent years, the discussions of regulations and academia surrounding climate change and sustainability have grown. The probability of catastrophic catastrophes like floods and droughts has risen due to climate change's increased surface water dispersion and changing rainfall. Melting down of northern icebergs and glaciers brought on by rising temperatures has led to significant sea level rise (Steffen et al., 2022). These effects of global warming have the possibility to cause irreparable ecosystem harm, thereby jeopardizing economic sustainability. By altering crop production's sensitivity to climatic fluctuation, global warming lowers agricultural output. It is because capital resources are susceptible to physical harm from warming-related calamities, global warming might result in huge financial damage.

Additionally, the effects of global warming negatively impact median wealth, labor supply, factory output, and labor productivity (Ameur et al., 2022). The fifth assessment of the Intergovernmental Panel on Climate Change predicts that localized social and economic growth would be significantly impacted by global warming. The research also concluded that CO2 from the burning of fossil fuels is the primary factor contributing to climate change and global warming (Chen et al., 2019). According to Lin et al. (2019), the world's total fossil energy-related CO2 emissions were 11.19 billion tons in 1965 and increased to 33.444 billion tons in 2017, with an average annual increase of 3.75%. According to Chen et al. (2019), per capita CO2 emissions have increased from 1.5 metric tons in 1980 to 7.5 metric tons in 2014, mainly due to the significant increase in fossil energy use.

Climate change will pose potential risks to human activities and livelihoods. Atmospheric pollution and extreme weather conditions are frequent and pose a serious threat to human health and property security. Governments all over the world are considering reducing greenhouse gas emissions to mitigate global warming because of the emergence of various environmental problems, particularly global warming (Li and Wei, 2021).

As the largest developing country, China's rapid economic growth since industrialization has consumed a large amount of fossil energy, causing serious environmental problems, and China is currently the largest energy consumer and carbon emitter (Lin and Zhu, 2019). Since China's reform and opening in 1978, the country's industries and economy have risen fast. In 2010, China even overcame Japan to become the second-largest economy in the world. However, the rapid economic growth has consumed a large amount of fossil energy and caused serious environmental problems. The high consumption of fossil fuel energy has caused a substantial rise in CO2 emissions (Chen et al., 2019).

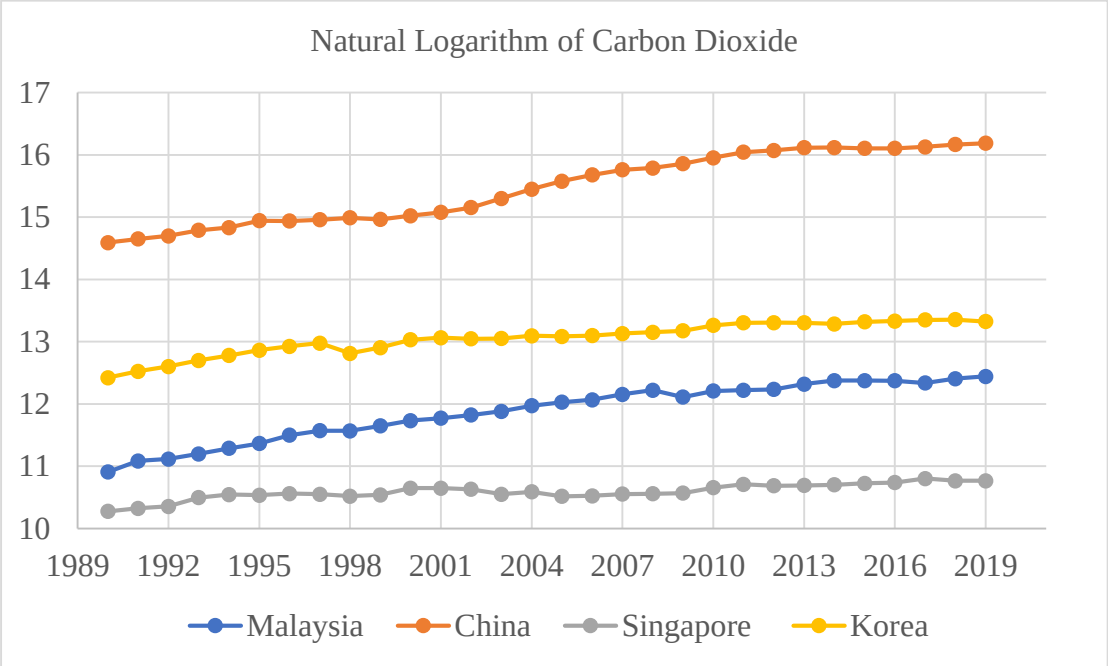
Also a developing country, Malaysia as a typical Southeast Asian country, has a moderate population size and land area, and its economy is relatively more developed than that of its neighboring countries. Malaysia, as a developing country and as one of the central countries of economic growth in Southeast Asia, is dynamically participating in the global energy system and is expected to emit more CO2 in the future (Chong et al., 2019). Meanwhile, recent study also revealed that environmental issue shall negatively affect the stock market of Malaysia

(Kelvin et al., 2022).

Singapore is one of the most developed countries and the most prosperous country in Southeast Asia. As having a developed free market economic system, Singapore's GDP per capita in 2019 is US$61,180, which is located at the third level in the world (World Bank, 2021). As a developed country with a high level of the economy, Singapore's rapid development cannot be achieved without the use of energy, a high level of urbanization and industrialization, and the growth of tourism. Singapore has had to increase its use of fossil fuels in order to meet its growing energy demand, and this has led to increasing CO2 emissions in Singapore (Raihan and Tuspekova, 2022).

Korea, which is also a developed country. Since the 1960s, the Korean government has pursued an export-led economic strategy, and Korea's economy has grown rapidly and was officially defined as a developed country in the United Nations Conference on Trade and Development in July 2021. As an export-oriented liberal economy, Korea's trade accounts for a large proportion of the overall economy (Kim et al., 2021). Korea's CO2 emissions increased significantly from 130 million tons to 640 million tons from the 1980s to the 22nd century (World Bank, 2021). As a result, Korea's total CO2 emissions in 2016 were among the top ten in the world and it is located in the eighth place in the world.

Figure 1: Carbon Dioxide Emission in China



As shown in Figure 1, From 1990 to 2019, China's CO2 emissions are at the highest, followed by South Korea, Malaysia, and Singapore. China's CO2 emissions have been increasing and the slope of CO2 emissions is very clear, Malaysia's CO2 emissions slope is very similar to China's. Singapore and South Korea have the most significant increase in CO2 emissions from 1990 to 1997. After 2000, the slope of CO2 emissions in South Korea and Singapore tends to level off.

Since China's accession to the WTO in 2001, China's imports and exports have continued to see rapid expansion, making it one of the top countries in international commerce.

Specifically, the international change in goods and services increased from $6.208 billion in 2002 to $43.602 billion in 2013, has a 19.4% yearly growth rate on average. Along with boosting the economy, the expansion of overseas commerce has also led to a rise in energy consumption in China. (Zheng et al., 2019). According to Chen et al. (2019), Products consumed on the global market accounted for 34% of the total CO2 emissions of goods produced in China in 2004. In other words, the production and habitation demand of developed nations account for more than one-third of China's CO2 emissions, which may be the major cause of the country's CO2 emissions rising so quickly. At the same time, in the last few decades. Malaysia has also experienced rapid growth in industrialization and urbanization, which has led to a rapid leap in the Malaysian economy. The growth in various economic indicators has also led to an increase in energy consumption and thus the associated rapid increase in CO2 emissions. From 1980 to 2015, Malaysia's CO2 emissions increased from 18690 kilotons to 196209 kilotons with an average annual growth rate of 6.75% (Chong et al., 2019).

Moreover, since China's reform and opening up, more and more foreign companies have chosen to build their enterprises or factories in China. According to Yu and Xu (2019), developed countries tend to shift their energy-intensive production to developing countries where wages and energy costs are low, thus leading to an increase in local CO2 emissions. FDI on the other hand can promote technological progress and improve energy efficiency in developing countries through its own technological spillover, which results in a reduction in regional CO2 emissions. China is the only country in the world that is a leader in coal production and consumption. This means that China's CO2 emissions come mainly from coal power generation and coal mining. in 2014, China's CO 2 emissions exceeded 12 Gigatons, accounting for 30% of the world's total emissions. The Chinese energy sector has been the largest contributor to GHG emissions over the last decade (Zaman et al., 2021).

China is the world's top producer of CO2 emissions, representing 29.1% of global CO2 emissions (Cui et al., 2019). Over the past decades, China has experienced rapid economic growth and became the second-largest economy in the world in 2010. However, this crude development model of high input, energy consumption, pollution, and emissions in China has also led to significant greenhouse gas emissions in China. As a major global emitter of greenhouse gases and air pollutants, many major environmental problems have emerged. For example, very severe haze weather problems persist in eastern and northeastern China (Zaman et al., 2021). China's total energy consumption reached 43,581 million metric tons of standard coal in 2016 from 23.0281 metric tons of standard coal in 2004, and CO2 emissions increased from 4267.34 metric tons in 2004 to 8821.65 metric tons in 2016, which caused serious environmental pollution in China (Wang et al., 2021).

Due to slow economic growth, China's CO2 emissions have tripled. China is rerouting emissions that are inherent in traded items in international supply and production networks. Through commerce, this system intensifies CO2 emissions, putting an unfair burden on exporting and importing nations to reduce CO2 emissions, which can lead to disputes. According to Yang et al. (2020), the study refers to issues related to the carbon curse, and they analyze four reasons why fuel-rich countries appear to be associated with high carbon intensity. These fossil resource-rich countries prefer to follow a high carbon-intensive development path, and fossil fuel-rich countries are faced with the problem of how to effectively reduce emissions,

as is the case with China.

In addition, data show that global temperatures are currently 1.1 degrees Celsius higher than they were in 1800 and could rise by 4.4 degrees Celsius by the end of the century based on the current trend of increasing CO2 emissions. The Earth's temperature is becoming warmer and warmer as a result of increasing CO2 emissions, which is causing significant changes in the global climate. Climate change will not only affect the environment but also human health and daily life and economic activities. According to Demirhan. (2020), agricultural activities will also be affected by climate change, as some crops and plants will be unable to adapt to the temperature change or farmland will be damaged by natural disasters as a result of the climate change caused by the increase in temperature, resulting in a decrease in crop yield. Forest fires, droughts, and floods are typical natural disasters related with climate change. Climate change also threatens the existence of species and biodiversity. In addition to the ability of climate change to cause air and water pollution due to increased CO2 emissions, High CO2 emissions directly affect people's health and have a range of detrimental effects on human health, including cardiovascular disease, stroke, lung cancer, and respiratory disease.

According to the preceding discussion, energy consumption, trade, Foreign Direct Investment, and economic growth, are significant determinants of CO2 emissions. In this situation, this study examines how CO2 emissions in Malaysia, China, Korea, and Singapore are impacted by trade, economic growth, foreign direct investment, and energy consumption.

This study is aimed at achieving the following objectives:

To investigate the impact of trade on CO2 emission in China, Malaysia, Singapore, and Korea.
To investigate the impact of foreign direct investment (FDI) on CO2 emission in China, Malaysia, Singapore, and Korea.
To investigate the impact of economic growth on CO2 emission in China, Malaysia, Singapore, and Korea.

Consequently, it is essential to carry out this study to look into the reasons behind CO2 emissions in China, Malaysia, Singapore, and Korea and to provide suggestions for creating solutions to preserve a sustainable and healthy environment. In order to help policy maker and the public understand how these factors impact CO2 emissions in these countries and take into consideration measures to lower CO2 emissions, the goal of the research is to explore the factors affecting CO2 emissions. The paper also makes policy suggestions to lower CO2 emissions in the framework of green and sustainable growth, since CO2 emissions in China and Malaysia have been rising annually and have drawn strong criticism and condemnation from the international community. Research is required to comprehend the reasons of CO2 emissions and how to safeguard a healthy and sustainable environment because China is now the world's greatest CO2 emitter. Accounting to (SCIO) www.scio.gov.cn, China also aims to reach its peak CO2 emissions by 2030 and become carbon neutral by 2060. As a result, the governments of these countries have to formulate and put into effect adequate laws for CO2 emissions.

LITERATURE REVIEW

This section reviews the previous studies about trade, foreign direct investment (FDI), and GDP affecting CO2 emissions in China, Malaysia, Singapore, and Korea. The discussion is an empirical literature review based on the type of factor.

Review of Empirical literature

Trade and CO2 emission

Balogh. (2022) analyzed the impact of economic growth, agriculture and trade on CO2 emissions for 152 non-EU countries from 2000 to 2018. The study tested the panel data with variables for serial correlation, cointegration and Granger causality. The results of the regression analysis indicate that agricultural exporters have a sink effect on CO2 emissions in other countries, which reflects the existence of an implicit effect of carbon emissions due to trade. China's economy is export-oriented, the opening of foreign trade has gradually increased China's trade, which has had a significant impact on the Chinese economy. According to Zhang et al. (2018), this study examined the effects of China's economic development, trade patterns, currency exchange, and foreign direct investment from 1982 to 2016, as well as the accuracy of the proposed Environmental Kuznets Curve (EKC) assumption for China. The EKC hypothesis is found to be true for China during the study period and the effect of trade in services on China's carbon emissions is negative. Wasti and Zaidi (2020) studied the effect of energy consumption, GDP and trade liberalization on CO2 emissions in Kuwait by using annual data from 1971 to 2017. The study tested the data by its smoothness and then applied autoregressive distributed lag models to the data set, and the findings supported the long-run and short-run relationships between the variables. In addition, Granger causality tests indicate a unidirectional causal relationship between trade liberalization and CO2 emissions.

Kim and Tromp (2021) examined CO2 emissions from Korea's trade from 2000 to 2014 in order to investigate whether Korea's growing international trade is a major obstacle to reducing carbon emissions. The results of the study show that CO2 emissions from Korea's international trade grew rapidly during the study period and accounted for 7% of the growth in global carbon emissions. The results of the analysis of bilateral trade show that as trade between Korea and China grew, the growth in CO2 emissions reflected in the growth in trade with China accounted for the largest share of the growth in CO2 emissions in Korea. According to Ding et al. (2018), China's bilateral commerce with other countries produces a significant amount of CO2 emissions that have an impact on both domestic and international carbon emissions, and the study by Ding et al. (2018) estimates the CO2 emissions embodied in China's bilateral trade with 219 regions over the period 2000 to 2014 and analyzes the effect of bilateral commerce between China and the world's CO2 emissions under non-trade assumptions. contribution of global carbon emissions under non-trade assumptions. The study used non-competitive import assumptions and is evaluated using data from a single regional input-output table. The results show that China's exports contribute more to CO2 emissions than imports over the entire period. This indicates that China generates a large amount of CO2 emissions for other countries through international trade. At the same time, with the rapid growth of imports, China has avoided a large amount of CO2 emissions. In addition, CO2 emissions associated with bilateral trade with

China have been falling since 2011.

China's interregional commerce is divided into four trade patterns by Xu et al. (2020). who consider China's industrial fragmentation. Afterword, based on the interregional input-output tables of China from 2002 to 2010, for various trade patterns, a decomposition model of interregional trade-related CO2 emissions and pollution known as the paradise hypothesis (PHH) was created. Finally, the study uses structural decomposition analysis to investigate the elements affecting the changes in environmental impacts. The results demonstrate that domestic trade activities are harmful to lowering local and national CO2 emissions in China's central, northwestern, and northern coastal areas, but the converse is true for the southern coastal and northeastern regions. However, this result is different from the findings of Sun et al. (2017). Sun et al. (2017), The paper uses yearly time series data from 1980 to 2012 to examine the validity of the pollution haven hypothesis (PHH) for China In order to determine how trade liberalization would affect CO2 emissions, the model also makes use of an ARDL (autoregressive distributed lagged cointegration) technique, runs a breakpoint unit root test, incorporates structural damage. The tests indicate robust, long-term links between each model's variables. According to the data, trade liberalization also increases carbon emissions. Dou et al. (2021) compared the influence of trade liberalization on CO2 emissions in major Asian countries between 1970 and 2019 and reached the same conclusions as Sun et al. The findings suggest that trade openness raises CO2 emissions in all three countries and that signing FTAs is highly beneficial for achieving long-term sustainable green growth.

Li and Wei (2021) used a panel ARDL to assess the interdependence of clean energy consumption, real GDP, trade openness, urbanization, and carbon emissions for G7 countries. The study uses panel autoregressive distributed lags (ARDL) to account for the long-term and short-term following testing, the relationship between CO2 emissions, clean energy use, trade openness, and urbanisation for wanslope heterogeneity, cross-sectional dependence, and long-term cointegration. The results show that increased trade openness stimulates CO2 emissions in the long term. The empirical findings further sustain the long-term availability of the environmental Kuznets curve (EKC). Wang et al. (2022) studied the implied CO2 emissions brought on by the export of goods from light industries in China, which calculated the input intensity and output intensity of the network as an indicator of the severity of ICE. Then, by calculating the carbon intensity of each sector, it is possible to determine the CO2 emissions that these trade flows imply. According to the study findings, manufacture of batteries, household appliances, lighting equipment, and furnishings. The industries that manufacture footwear, glass and ceramic items, building decoration, and industries that produce leather, fur, and feathers and their products have the most effects on China's carbon emissions from foreign commerce.

Thus, the hypothesis for this research is as follows:

H1: There is a positive relationship between trade and CO2 emissions

Foreign Direct Investment (FDI) and CO2 emission

As a result of reform and opening up, this has contributed to the opening up of China's financial environment thus attracting FDI. Zhang et al. (2018) evaluate the EKC assumption for China by analyzing the influence of FDI on carbon emissions in China from 1982 - 2016. The research

also tests the cointegration of variables by employing the ARDL technique. The results of the study found a positive relationship between FDI and carbon emissions, with an average increase of 0.0744% in carbon emissions for every 1% increase in FDI. Hanif et al. (2019) investigated FDI's long-term and short-term effects on CO2 emissions in 15 emerging major Asian countries from 1990 to 2013. In addition, the study employed an autoregressive distributed lag (ARDL) model, which revealed a positive correlation between foreign direct investment and CO2 emissions. The results show that foreign direct investment contributes to environmental deterioration and will increase domestic carbon emissions. Shahbaz et al. (2019) examined the relationship between foreign direct investment and carbon emissions in the Middle East and North Africa region from 1990-2015. The study uses the generalized method of moments (GMM) to verify the PHH as well as to verify the existence of an N-shaped association between FDI and CO2 emissions. The results of the study indicate that an N-shaped association between FDI and CO2 emissions exists. This article verifies the existence of PHH and that FDI and CO2 emissions are causally related in a single direction, and FDI significantly affects CO2 emissions.

Malik et al. (2020) studied the effect of oil prices, foreign direct investment and economic growth on CO2 emissions in Pakistan from 1971 to 2014. The study investigates the long-run and short-run effects between these these explanatory and explanatory variables by using ARDL and non-linear ARDL cointegration methods and Granger causality tests. The results show that with the growth of FDI increases CO2 emissions in both the short and long run. On the contrary, Lee (2013) analyzed panel data for 19 of the 20 countries from 1971 to 2009 and used a fixed effects model to examine the impact of FDI on CO2 emissions. The test results show that FDI has a direct impact on economic expansion, but no significant effect on CO2 emissions. Liu et al. (2021) argue that since one of the world's greatest economies is that of China, the role of foreign direct investment (FDI), technological innovation (TI), and trade are critical to achieving its carbon neutral goal. Liu et al. (2021) aim to present the role of trade levels, renewable energy consumption (REC), and FDI from 1995-2017 to promote new determinants of sustainable environment in China. The research uses a sophisticated panel technique based on tests for cross-sectional dependency and slope homogeneity. The findings support the cointegration links between each research model. The findings demonstrate a negative correlation between carbon emissions and the combined term of FDI with REC and TI.

Another study from developing country, Nigeria, Zubair et al. (2020) investigated the impact of FDI on CO2 emissions in Nigeria over the period 1980-2018, which analyzed the data by using ARDL method tests of covariance and an improved vector autoregressive (VAR) approach. It was found that there is a long-term relationship between FDI and CO2 emissions before. The results of this study showed that the increase in FDI inflows reduced CO2 emissions in Nigeria. Paramati et al. (2017) analyzed yearly data for G20 nations from 1991 to 2012 and applied a number of reliable panel econometric approaches. For instance, Fisher-type Johansen panel cointegration tests are used to look at the long-term equilibrium relationship between variables, fully corrected ordinary least squares (FMOLS) are used to look at the long-term emissions and output elasticities, and heterogeneous panel non-causality tests are used to look at the short-term running dynamic causality. The purpose of the study is to investigate how FDI inflows and stock market expansion affect CO2 emissions. The study's findings demonstrate

that long-run elasticities suggest that FDI considerably lowers CO2 levels.

Mohsin et al. (2022) studied the impact of energy consumption and foreign direct investment in addition to economic growth on CO2 emissions in European and Central Asian countries from 1971 to 2016. The study uses the ARDL method to determine the short- and long-term relationships between the explanatory and explanatory variables. The results of the study show that there is a short-run and long-run relationship between the variables and that the rapid growth of FDI leads to an increase in CO2 emissions. Also Granger causality test shows that FDI is the Granger cause of CO2 emissions. In contrast, in the study by Xie et al. (2020), which combines panel data for 11 emerging countries from 2005 to 2014, the connection between FDI inflows and CO2 emissions is explored in more depth from a dynamic perspective using an extension of the PSTR model. The results show that the association between FDI inflows and CO2 concentrations is inverse "S-shaped" and that CO2 emissions decrease only when FDI inflows reach a certain level of accumulation.

Thus, the hypothesis for this research is as follows:

H2: There is a positive relationship between foreign direct investment and CO2 emissions

Economic Growth and CO2 Emissions

Mohsin et al. (2022) Used yearly data sets from 1971 to 2016, researchers examined the connection between a sustainable environment and economic growth in European and Central Asian nations. The short- and long-term associations between the chosen set of variables were ascertained using the ARDL approach. Energy consumption, individual remittances, GDP, and FDI are independent variables and patterns of economic expansion, whereas CO2 emissions reflect environmental sustainability. The results of the study indicate that CO2 emissions are the primary factor influencing GDP, and the significant positive relationship between CO2 emissions and GDP suggests that environmental damage is due to economic growth. When the economies of European and Central Asian countries grow, CO2 emissions increase. Malik et al. (2020) studied the effect of oil prices, foreign direct investment and economic growth on CO2 emissions in Pakistan from 1971 to 2014. The study investigated the long-run and short-run effects between these explanatory and explanatory variables by using ARDL and non-linear ARDL cointegration methods and Granger causality tests. The results of the study indicate that there is a positive relationship between economic growth and CO2 emissions. In addition, the causality suggests that there is a feedback effect between economic growth and CO2 emissions. According to Sikder et al. (2022), the combined effects of energy use, industrialization, gross domestic product (GDP) growth, and urbanization on CO 2 emissions in 23 developing countries from 1995 to 2018 were analyzed using the panel autoregressive distributed lag (ARDL) method and heterogeneous causality tests. From the analysis of this study, the long-term results show that 1% economic growth is associated with 0.17% increase in CO2 emissions. In order to verify the long-term results of panel ARDL, both dynamic ordinary least squares (DOLS) and completely modified ordinary least squares (FMOLS) are used in the study to conduct robustness tests. The results confirm that for developing countries, CO 2 emissions are affected by GDP growth. Raihan and Tuspekova (2022) studied the effect of economic growth, renewable energy use and forest area on CO2 emissions by using time series data from 1990 to 2019 in Malaysia. The study used dynamic ordinary least squares (DOLS) and the

results showed that there is a positive relationship between economic growth and CO2 emissions and that economic growth deteriorates the environmental quality of Malaysia.

Mendonca et al. (2020) aimed to verify the impact of GDP, population growth and renewable energy use on CO2 emissions. The study selected the 50 largest economies of the world from 1990 to 2015 as data for the study and conducted it by using hierarchical regression modeling. The results of the study show a positive correlation between GDP and CO2 emissions, with CO2 emissions increasing by 0.27% with each 1% increase in GDP. Aslam et al. (2021) assessed the correlation between GDP per capita and CO2 emissions, gross domestic product per capita squared, trade accessibility, industrialization degree, and density of the people in China from 1962 to 2018. The study examines China's long- and short-term ARDL strategies based on the U-shaped or inverted U-shaped EKC hypothesis. The results of the study indicate that the long-term vector coefficients imply that GDP per capita and GDP per capita squared have an impact on CO2 emissions favorably.

Liu et al. (2021) aim to present the role of trade levels, use of renewable energy, and foreign direct investment from 1995-2017 to promote new determinants of a sustainable environment in China. The research used a sophisticated panel technique based on tests for cross-sectional dependency and slope homogeneity. The findings support the cointegration links between each research model. The study shows a link between rising carbon emissions and economic development. The results imply that all growth-oriented strategic goals will have an effect on carbon emissions and that economic expansion will cause a rise in CO2 emissions. Shi et al. (2022) investigated data on per capita consumption expenditure, energy consumption per unit of GDP, energy consumption per capita and CO2 emissions per capita in China from 1978 to 2017 to research what causes CO2 emissions and used Bayesian networks and scenario analysis to meet the requirements. The results of the study suggest that the continuous increase in CO2 emissions is due to the increase in per capita consumption expenditure.

However, Zubair et al. (2020) investigated whether gross domestic income, trade integration, foreign direct investment (FDI) inflows, gross domestic product (GDP) and capital reduced carbon emissions in Nigeria. The study used data over the period 1980-2018 and employed ARDL methods to multicollinearity and improve VAR methods. The results of the study found that the increase in FDI inflows, GDP, and capital reduced CO2 emissions in Nigeria. Furthermore, according to Li and Wei (2021), this study examines the relationship between renewable energy, fossil fuel consumption, economic growth, urbanization, and CO2 emissions in China over the period 1990 to 2020 through an autoregressive distribution lag (ARDL) model commonly used under the environmental Kuznets curve (EKC) assumption. The objective of this work is to test the role of long- and short-term dynamics of renewable energy consumption in reducing CO2 emissions in China. The findings strongly support an inverted U-shaped relationship between CO2 emissions and GDP per capita in the long and short term. Bekhet and Othman (2018) validated the relationship between GDP and CO2 by using data from Malaysia for the period 1971 to 2015 and investigated the environmental Kuznets curve in Malaysia. The study applied F-bounds and VECM Granger causality methods and DOLS and FMOLS were used to confirm the robustness of the long-term results. The results show a significant short-term bivariate causality between GDP and CO2 emissions and confirm the existence of the EKC curve in Malaysia.

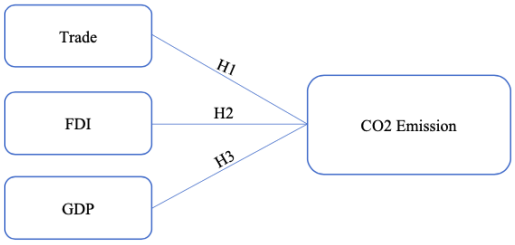
Thus, the hypothesis for this study is as follows:

H3: There is a positive relationship between economic growth and CO2 emissions

RESEARCH FRAMEWORK

The independent variables of this research are trade, FDI, and economic growth, while the dependent variable is CO2 emissions. Trade, FDI, and economic growth in Malaysia, China, Singapore, and Korea are suggested to correlate and have a positive impact on CO2 emissions. Figure 3 illustrates the conceptual framework constructed for this study.

Figure 2: Conceptual Framework



RESEARCH METHODOLOGY

This study aims to investigate the causal relationship between trade, foreign direct investment (FDI), economic growth, and carbon dioxide (CO2) emissions in Malaysia, China, Singapore, and Korea. In order to obtain sustainable data to study this relationship, the study adopts a quantitative research approach. The quantitative data used in this study are panel data for Malaysia, China, Singapore, and Korea from 1990 to 2019. These data are secondary data, and the source is the World Development Indicators (WDI) of the World Bank. In addition, since this study aims to examine the relationship between economic indicators on the impact of CO2 emissions, the quantitative research methodology will give a suggested interpretation of the relationship between the variables tested by the researcher (Creswell, 2009). Therefore, the use of quantitative research methods will be the most appropriate for this study because it will provide an accurate and reliable measurement to reflect the given data. This study will demonstrate conclusive results based on the data collected and analyzed.

Dependent Variable and Independent Variables

The dependent variable is carbon dioxide emissions. The independent variables in this study are trade, foreign direct investment (FDI), and economic growth. According to Creswell. (2009), quantitative research methods are measurable. According to the literature review, a positive relationship is expected between GDP, foreign direct investment (FDI), trade, and CO2 emission.

Table 1. Variable description.

Variable	Measures	Symbol	Source	Period
CO2 emission	CO2 emissions (Kt)	lnCO2	WDI	1990-2019
Trade	Trade (current US$)	lntTrade	WDI	1990-2019
Foreign direct investment (FDI)	FDI, net inflows (Bop, current US$)	lnFDI	WDI	1990-2019
Economic growth (GDP)	GDP (current US$)	lnGDP	WDI	1990-2019

Source: WDI (2022).

Regression Model

This study employed the panel data analysis method to study the impact of trade, FDI and GDP on the CO2 emissions. The regression model used in this study is as follows:

$$\ln CO2 \ \text{emissions}_{it} = \alpha + \beta_1 \ln \text{Trade}_{it} + \beta_2 \ln \text{FDI}_{it} + \beta_3 \ln \text{GDP}_{it} + \beta_4 E_{it}$$

Where

$\alpha = \text{Intercept of the regression model}$

$\ln CO2 \ \text{emissions}_{it} = CO2 \text{ emissions in country i in year t.}$

$\ln \text{Trade}_{it}$= CO2 trade volume in country i in year t.

$\ln \text{FDI}_{it} = \text{FDI volume in country i in year t}$

$\ln \text{GDP}_{it} = \text{The amount of economic growth in country i in year t}$

E_{it} =Error terms assumed to be normally distributed

Analysis

This study applies the OLS regression analysis to investigate the relationship between trade, FDI, GDP, and CO2 emissions. Since the regression of the original data was not good, the data were regressed by first-order difference and the first level of the data. In addition, diagnostic analyses were performed to detect the presence of multicollinearity, heteroskedasticity, and autocorrelation problems in the model. Finally, Granger causality tests were performed on the variables to determine the interrelationships between the variables.

RESULT AND DISCUSSION

This section presents and discusses the result obtained throughout this study. The dependent variable used in this study was CO2 emissions. Section 4.1 present the result of descriptive statistics. Section 4.2 present the result of the regression test. Section 4.3 present the result of the correlation test and multicollinearity test. Section 4.4 present the results of the heteroscedasticity test and serial correlation test. Lastly, Section 4.5 present the result of the granger causality test.

Descriptive Statistics

The descriptive statistics for the dependent and independent variables used in the study are shown in Table 2. Based on Table 2, China has the highest average CO2 emissions between 1990 and 2019, with average CO2 emissions of 15.467. China is followed by South Korea and

Malaysia, with average CO2 emissions of 13.052 and 11.876, respectively. emissions are the lowest among these four countries, with average CO2 emissions of 10.590.

In terms of FDI, Singapore has the highest average FDI among the four countries with an average FDI of 25.666, followed by China and South Korea with an average FDI of 25.034 and 22.488 respectively. Malaysia has the lowest average FDI with an average FDI of 22.301. According to the observation, the average FDI of China and Singapore are more similar to each other. The average FDI of Malaysia and South Korea are more similar.

In terms of GDP, China has the highest average GDP level among these four countries with an average GDP of 28.528, followed by South Korea with an average GDP of 27.404, and then Malaysia with an average GDP of 25.706. Finally, Singapore has the lowest average GDP level among the four Asian countries with an average GDP of 23.8.

Table 2: Descriptive Statistics

Country	Description	CO2 Emissions	FDI	GDP	TRADE
China	Mean	15.467	25.034	28.528	32.224
	Median	15.514	25.157	28.380	32.488
	Maximum	16.186	26.396	30.290	33.889
	Minimum	14.592	21.972	26.612	29.712
	Std. Dev.	0.560	1.175	1.223	1.397
Singapore	Mean	10.590	25.666	23.800	31.527
	Median	10.563	25.521	23.672	31.539
	Maximum	10.802	26.656	25.437	32.437
	Minimum	10.274	24.311	21.514	30.152
	Std. Dev.	0.127	0.689	1.056	0.711
Malaysia	Mean	11.876	22.301	25.706	30.833
	Median	12.000	22.354	25.620	30.953
	Maximum	12.442	23.439	26.624	31.477
	Minimum	10.908	18.558	24.508	29.498
	Std. Dev.	0.457	0.976	0.670	0.588
Korea	Mean	13.052	22.488	27.404	31.635
	Median	13.089	22.931	27.482	31.718
	Maximum	13.354	23.609	28.176	32.545
	Minimum	12.420	20.540	26.370	30.297
	Std. Dev.	0.259	0.902	0.547	0.758

Regression Analysis

The results of regression analysis between dependent variables and independent variables are shown in Table 3. Based on Table 3, The analysis results of FDI and trade both rejected the null hypothesis. GDP and CO2 emissions have a positive correlation. Based on the coefficient obtained under the Feasible Generalized Least Square estimation, if GDP increases by 1%, the average CO2 emission will increase by 0.186%, holding other variables constant. This result is consistent with the findings of Mohsin et al. (2022) and Malik et al. (2020) and Sikder et al.

(2022) and Mendonca et al. (2020). Moreover, r-square and adjusted r-square indicate that the model explains Over 31% of variable relationships.

Table 3: Result of Regression Analysis

Variable	Coefficient	t-Statistic	Prob.
C	0.016	2.983	0.004
FDI	0.009	1.497	0.137
GDP	0.186	2.966	0.004***
TRADE	0.073	1.470	0.145
	R^2 = 0.334		Adj R^2 = 0.316

Note: *** represents the significant level at 0.01 level.

Correlation Test and Multicollinearity Test

Table 4 shows the correlation between each variable. Based on Table 4, there is a positive correlation between independent variables and dependent variables. The correlation coefficient between FDI and CO2 emissions is 0.481. The correlation coefficient between GDP and CO2 emissions is 0.883. The correlation coefficient between Trade and CO2 The correlation coefficient between FDI and CO2 emissions is 0.481.GDP and CO2 emissions is 0.883. Trade and CO2 emissions is 0.501. The highest correlation is between GDP and CO2 emissions.

Table 4: Results of correlation analysis. (Period: 1990–2019)

Correlation Probability	CO2 EMISSIONS	FDI	GDP	TRADE
CO2 EMISSIONS	1.000			
FDI	0.481***	1.000		
GDP	0.883***	0.640***	1.000	
TRADE	0.501***	0.763***	0.816***	1.000

Note: *** represents the significant level at 0.01 level.

However, there may be problems of multicollinearity between variables, which is a situation in which the explanatory variables in a linear regression model are highly correlated with each other. If the case of multicollinearity between explanatory variables may affect the estimation of regression coefficients and statistical significance tests.

Two methods were used in this study to test for the existence of multicollinearity in the variables. The first is to observe the correlation coefficient of each variable in the correlation analysis, if the correlation coefficient between the variables is greater than 0.9, then there may be multicollinearity (Hair et al., 2019). According to Table 4, the correlation coefficient between each variable is lower than 0.9, then it indicates that there may not be multicollinearity between the variables.

To further examine whether there was multicollinearity among the independent variables,

Variance inflation factor (VIF) was examined to identify the multicollinearity issue. Hair et al. (2019) recommended that multicollinearity is a concern if VIF value is higher than 5. Table 5 shows the VIF of each variable. Based on Table 5, the VIF value of each variable is less than 5. Since all the VIF values are less than 5 as Hair et al. (2019) recommended, there is no multicollinearity issue in this study.

Table 5: Variance Inflation Factors

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	2.79E-05	1.707701	NA
FDI	3.33E-05	1.158773	1.141863
GDP	0.003923	4.330472	2.582817
TRADE	0.002444	3.859014	2.625660

Heteroscedasticity Test and Serial Correlation Test

The data were tested for unit root by ADF method, and all variables were stationary at first level.

Table 6: Result of Unit Root Test

Variables	At Level		At 1st	
ADF	t-statics	p-value	t-statics	p-value
lnCO2 Emissions	14.0003	0.0818*	29.0819	0.0003***
lnFDI	19.1711	0.0140**	75.4423	0.0000***
lnGDP	3.06367	0.9303	35.5243	0.0000***
lnTrade	8.86686	0.3537	36.1435	0.0000***
Note: ***, **, and * significant at level 1%, 5% and 10% respectively.				

Based on Table 7, the Null hypothesis is that residuals are homoskedastic. The value of likelihood ratio is 1.336, and the probability is 0.856>0.05. Hence accept the null hypothesis. So there is no heteroscedasticity problem in this model.

Based on Table 7, Durbin Watson statistic tells that the model is free from serial correlation defect.

Table 7: Result of Heteroskedasticity LR Test and Durbin-Watson statistic

Likelihood ratio	Durbin-Watson sta
1.336 (0.856)	1.390

Granger Causality Test

Table 8 shows the Granger causality between the independent and dependent variables after first-order differencing. Based on Table 8, FDI is not a Granger cause of CO2 emissions and CO2 emissions are not a Granger cause of FDI. Therefore, there is no causal relationship between FDI and CO2 emissions. In terms of GDP, GDP is not the Granger in of CO2 emissions and CO2 emissions are not the Granger in of GDP. Therefore, there is no causal relationship between GDP and CO2 emissions. Finally, in terms of trade, trade is not a Granger cause of

CO2 emissions and CO2 emissions are not a Granger cause of trade. Therefore, there is no causal relationship between trade and CO2 emissions. In summary, there is no Granger causality between dependent variables and independent variables.

Table 8: Result of Granger Causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
FDI does not Granger Cause CO2 Emissions	108	0.978	0.380
CO2 Emissions does not Granger Cause FDI		0.644	0.528
GDP does not Granger Cause CO2 Emissions	108	1.393	0.253
CO2 Emissions does not Granger Cause GDP		1.127	0.328
TRADE does not Granger Cause CO2 Emissions	108	0.463	0.631
CO2 Emissions does not Granger Cause TRADE		0.358	0.700

CONCLUSION

This study examines the effects of trade, foreign direct investment (FDI) and economic growth on CO2 emissions using panel data for four major Asian countries from 1990 to 2019. The paper investigates the relationship between the explanatory and explained variables by using the ordinary least squares (OLS) method. According to the results of the study, only GDP among the three independent variables significantly explains CO2 emissions, while trade and FDI are not significant in explaining CO2 emissions. The results of the study found that there is a positive relationship between GDP and CO2 emissions, If GDP increases by 1%, the average CO2 emission will increase by 0.186%, holding other variables constant.

This research also examined the relationship between GDP and CO2 emissions using the Granger causality test to examine whether there is a Granger causality relationship between the independent and dependent variables. The results show that there is no Granger causality between each independent variable and the dependent variable. In addition, this study performed multicollinearity test, heteroscedasticity test, and serial correlation test on the data. As shown in the results, the data in this study do not have problems with multicollinearity, heteroscedasticity, and serial correlation.

According to the results of this study, as economic growth increases, so does the increase in carbon dioxide, which inevitably causes some damage to the natural environment. Governments in both developing and developed countries should establish a comprehensive framework for the protection of the natural environment and need to address natural environmental issues from the national level to specific sectors. Based on the research background and empirical findings, this study provides the following policy recommendations to reduce CO2 emissions.

First, as the economy continues to grow, the government should establish better environmental regulations and legislation to strengthen the regulation of the chemical and heavy industry sectors. In addition, effective energy and environmental policies and regulations can also help to improve the level of foreign investment enterprises. This is because higher environmental standards raise the threshold for foreign investment to achieve better energy

security and more sustainable economic growth.

Second, the government should reduce the use of traditional energy sources and increase investment in renewable energy and the promotion and use of clean technologies. For example, the use of wind, solar, and hydrogen energy technologies should be enhanced. This will require national technological advances and investments in new energy technologies to achieve this. In order to restructure the energy mix, governments can reduce the use of traditional energy sources in the energy mix by increasing taxes on the use of fossil fuels. In addition, policymakers can increase the use of clean energy in the energy mix by providing subsidies to companies that use clean technologies.

Finally, the government should focus on energy efficiency and environmental initiatives in the corporate sector, for example, by encouraging companies to become more aware of sustainable development and to increase awareness of energy efficiency and environmental protection, and by educating investors to become more involved in environmental quality and green business practices. Increasing investor attention to environmental quality and renewable energy sources could lead to more investment, which would allow more clean energy to be explored and developed and find ways to make energy use more efficient and less costly.

This study is limited to assessing the impact of trade, FDI, and economic growth on CO2 emissions in four Asian countries; however, the study only analyzes 30 years of data, which may be subject to bias. Also, this study does not take into account the different economic crises and economic transitions between the regions studied between 1990 and 2019. There are also some limitations in the research methods used in this study. For example, the Granger causality test does not take into account the effect of confounding factors, and the results of the Granger causality test are only a statistical estimate and do not represent the true sense of causality nor the basis for affirming or denying causality (Bahadori and Liu, 2014).

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