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Reinvestigating the Presence of Environmental Kuznets Curve in Malaysia: The Role of Foreign Direct Investment

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ABSTRACT

Over the past forty years, Malaysia has achieved tremendous economic growth because of higher investment from foreigners such as China, Japan, and the US. Many multinational companies (MNC) have allocated their factories, especially in more developed states such as Selangor, Penang and Johor, to focus on their operation. The country can receive various benefits from this investment in job creation, technological advancement, and better income distribution. However, at the same time, negative externalities such as environmental degradation can also occur from those operations. Given this situation, it is interesting to investigate Malaysia's current state of sustainable development by considering the impacts of FDI. This paper focused on investigating the presence of the Environmental Kuznets Curve (EKC) and Pollution Haven Hypothesis (PHH) for Malaysia using a latest annual dataset from 1971 to 2019. The study used the Bound test to determine the impact of FDI and other selected macroeconomic variables on environmental quality proxied by Carbon emission (CO_2). The outcomes show that the country showcased the U shape of EKC, and higher FDI inflows have worsened the country's environmental pollution. These outcomes posit a bad alarm for the country's policymakers to be more aware of the consequences of development that cause higher carbon emissions release and how MNC in the country contributes to more emissions by worsening the scenario. Therefore, heavy environmental rules should be imposed on foreign investors. Furthermore, the country needs to be directing their economic development by following the principles set out by United Nations in pursuing sustainable development.

Keywords: Environmental Kuznets Curve, Pollution Haven Hypothesis, Sustainable Energy, Energy Consumption, Sustainable Economic Growth, Sustainable Infrastructure
JEL Classifications: F230, O1, O11, Q5

1. INTRODUCTION

Numerous international organisations have invested in identifying the cause of carbon dioxide (CO_2) emissions. As a result, in 1992, the United Nations Conference on Environment and Development signed the United Nations Framework Convention on Climate Change (UNFCCC) to reduce the number of greenhouse gases in the atmosphere. Besides, in 1997, with the charge of UNFCCC, the Kyoto Protocol was signed and was regarded as a law to stabilise the volume of greenhouse gases in the atmosphere. As a result, cutting carbon emissions has shown to be a successful strategy for combating climate change. However, there are many ways to emit CO_2 into the environment, including from aircraft, factories, automobiles, and more.

Additionally, CO_2 will be released during human and animal respiration. According to global research on carbon emissions, CO_2 is known as the main cause of global climate change, and this has garnered considerable attention worldwide (Abeydeera et al., 2019). Because climate change is a big issue and the earth's surface temperature continues to rise, greenhouse gas reduction has become a major worldwide community priority (Heede, 2013). Even though there are many kinds of greenhouse gases, carbon dioxide is the main one and accounts for around three-quarters of emissions.

The number of carbon emissions had increased fourfold to 22 billion tonnes by 1990. The globe now emits more than 36 billion tonnes of carbon dioxide annually as carbon dioxide emissions have continued to climb quickly. Furthermore, there has been a noticeable change in addition to the significant increase in global carbon emissions. Furthermore, highly developed countries, namely Europe and the United States, accounted for around 90% of worldwide carbon emissions in 1900 and even more than 85% of emissions annually by 1950. This dominance continued throughout the first half of the 20th century. However, other parts of the world, particularly Asia as a whole, while China was the largest carbon emissions county, made up the world's total carbon emissions in the 2000s (Huang et al., 2022). Global warming, ecosystem imbalance, macroeconomic problems, technological problems, and socioeconomic issues are problems brought on due to climate change. The primary cause of the problems above is an increase in the concentration of greenhouse gas emissions.

Additionally, from 1990 to 2014, carbon dioxide emissions rose from 22.15 Gt to 36.14 Gt (Abeydeera et al., 2019). It is widely acknowledged that governments worldwide must immediately implement efficient countermeasures to reduce the harmful effects of climate change in light of this increasingly critical issue. This environmental issue has also been observed in developing countries such as Malaysia.

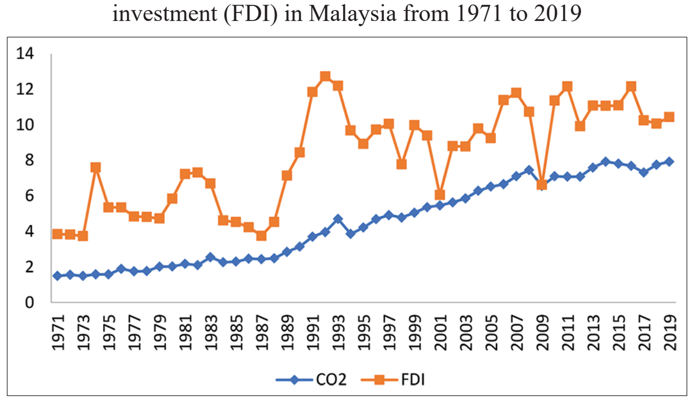
Over the past four decades, Malaysia, a high-income emerging nation in South East Asia, has seen impressive economic progress. Based on the information from the World Bank, the trend across the nations is similar. It shows a consistent rise in GDP and carbon dioxide emissions beginning in 1999. Additionally, it was noted that during the peak stages of economic growth, carbon dioxide emissions per capita also tended to rise. This is so that a country's increased production can be attributed to its high GDP, which shows that its citizens have more money to spend. Such effect has been studied under the environmental Kuznets curve (EKC), where it is hypothesised that CO_2 emissions rise with economic growth and begin to decline once the GDP per capita exceeds the threshold value (Heidari et al., 2015). The EKC highlights the trade-off between promoting economic growth and environmental quality, with previous studies in Malaysia finding supporting evidence for the EKC (Etokakpan et al., 2020; Aslam et al., 2021). However, empirical evidence also suggests that the relationship between GDP growth and CO_2 emissions does not always follow the so-called inverted U-shaped curve (Rahman et al., 2022). Different factors can affect pollution levels (Chang et al., 2021), suggesting the need for new empirical evidence.

Foreign direct investment (FDI) has increased frequently as economic globalisation has accelerated. In the context of Malaysia, the rising in FDI is also due to the benefits that this country received from being a member of the Association of Southeast Asian Nations (ASEAN). ASEAN consist of 10 member countries, and it was formed in 1967. This group, among others, aimed to boost FDI in this region. As a result, FDI Inflows will spur economic growth, new businesses will be established, and current businesses will be expanded. FDI not only cause the rise in the economic growth of host nations but also causes a sharp rise in CO_2 emissions (Omri et al., 2014). FDI inflows, known as one of the most substantial global investment activities, has been a key factor in achieving sustainable development, a hot topic in current research (Azam et al., 2021; Esquivias et al., 2022; Rahman et al., 2022). In addition, global climate change may be related to the rise in FDI inflows. As a result, many earlier studies focused on determining how FDI inflows affect carbon emissions.

Figure 1 shows Malaysia's total CO_2 (metric tons per capita) emitted and FDI flow. From the figure, Malaysia emitted the largest amount of CO_2 from 1971 to 2019. CO_2 emissions increased by as much as 7.927 mt, reaching its highest amount of CO_2 in 2019. The country that emitted the least CO_2 in 1971 with 1.491 mt. The amount of CO_2 released was found to be slightly reduced by the country in 2012 by 7.09 mt to 7.08 mt, and the largest amount of CO_2 that the country emitted increased rapidly in 2014 with 7.924. All the countries exhibited an overall trend in CO_2 emissions from 1971 to 2019. In 2009, Malaysia emitted around 6.56, but then it drastically went up by as much as 7.924 mt, reaching 7.924 mt in 2014. For FDI, there is a fluctuating trend in Malaysia. The highest FDI flow (% of GDP) was in 1991 and 1992, and the lowest was during the financial crisis, equivalent to 0.60% of GDP in 2001 and 0.06 in 2009.

Through the trend between FDI inflows and CO_2 in Malaysia seems reasonable to examine whether FDI has accompanied the growth of carbon dioxide emissions. The link has been studied in previous studies across regions (Suki et al., 2020). As the Pollution Haven Hypothesis (PHH) argues, FDI inflows could hasten environmental

Figure 1: Annual carbon dioxide emissions (CO_2) and foreign direct investment (FDI) in Malaysia from 1971 to 2019



degradation (Huang et al., 2022; Esquivias et al., 2022). According to the theory, businesses in industries with high pollution levels are most frequently located in nations or areas with lax environmental regulations, which could result in excessive or inadequate pollution levels. However, some studies found that FDI can be a channel of transferring superior technology to emerging economies, leading to positive effects on environmental quality (Demena and Van Bergeijk, 2019; Arif et al., 2022). Studies focusing on Malaysia have validated the PHH (Faheem et al., 2022) and rejected the PHH (Rahman et al., 2022; Ridzuan et al., 2018), suggesting that the nexus remains an empirical debate.

Realising the importance of FDI towards Malaysia's economic development and how it is linked to environmental degradation, this paper examines the presence of the Environmental Kuznets Curve (EKC) and the Pollution Haven Hypothesis (PHH) for Malaysia, covering the period 1971 until 2019. Furthermore, the study applies the Bound test to determine the impact of FDI and other selected macroeconomic variables on environmental quality. Specifically, we introduce economic growth, FDI, domestic investment, energy consumption, trade openness, and infrastructure development as potential determinants of CO_2 emissions in Malaysia. The structure of this paper is arranged as follows: Section two focuses on the literature review, section three emphasises methodology, section 4 addresses all the outcomes and discussion, and the last section highlights conclusions and policy recommendations.

2. LITERATURE REVIEW

Numerous empirical findings have documented the impact of economic growth on CO_2 emissions. One of the popular themes based on this theme of studies is exploring the validation of the Environmental Kuznets Curve (EKC). Various research, including several countries, factors, and methodologies, were considered. However, the outcomes are mostly diverse from one country to another country across the globe. Several researchers have confirmed the presence of the inverted U-shaped Environmental Kuznets Curve relationship in their studies. These researchers include Chang et al. (2021), Zanin and Marra (2012), Ahmed et al. (2022), Aslam et al. (2021), Sultana et al. (2022), and M. Suki et al. (2020). For instance, Chang et al. (2021) tested the environmental Kuznets curve for 284 cities in China from 2004–2015 by using a dynamic spatial model. As a result, the authors confirmed the existence of EKC for CO_2 emission in this country.

Similarly, Zanin and Marra (2012) have discovered that the inverted-U-shaped EKC are seen in France and Switzerland. Sultana et al. (2022) also discovered positive evidence of the EKC in Bangladesh. Ahmed et al. (2022) attempt to study the relationship between economic growth and CO_2 emission in Pakistan using yearly data from 1984 to 2018. He interpreted the short and long-run elasticities using the novel augmented ARDL estimation. The results suggest that the EKC hypothesis exists in both the short and long run in Pakistan. Further, Aslam et al. (2021) also found the same results for Malaysia using data from 1971 to 2016 after applying ARDL bound testing and the VECM approach. In their recent studies, M. Suki et al. (2020) confirmed the existence of inverted EKC in Malaysia. The authors adopt a more complex econometric technique known as Quantile Autoregressive Distributed Lag (QARDL) method to testify this curve based on quarterly data from 1970 to 2018.

In contrast to the above findings, a direct relationship is attained by Ansari et al. (2020a). They explored the relationship between CO_2 emission and GDP per capita in the Gulf countries (GCC) from 1991 to 2017. The result indicates that EKC's inverted "U" shape is not present in GCC countries. Neither Ansari et al. (2020b) found evidence of the EKC when using ecological footprint as a proxy for environmental quality in West, South, and Southeast Asian regions. Similarly, Akbostanci et al. (2008) argue that there is a monotonically increasing relationship between CO_2 emissions and per capita income in Turkey for the period 1968– 2003 with the help of a time series model using cointegration analysis. Furthermore, the author also converted the air pollution data into PM10 and SO2 and tested it for Turkish provinces using panel data estimation. Again, the outcome does not support the EKC hypothesis. However, it showcases an N-shape relationship between SO2 and PM10 emissions.

Moreover, Saboori and Sulaiman (2013) put their interest in investigating the existence of inverted EKC for Malaysia by using the ARDL approach from 1980 until 2009. The authors include other variables such as energy consumption besides economic growth to testify to this curve. The outcomes from their analysis do not support an inverted U shape of EKC when energy consumption is tested together. However, EKC is supported when the authors used disaggregated energy data such as oil, coal and electricity. More recent studies in Malaysia found similar evidence for the EKC hypothesis (Etokakpan et al., 2020). Other studies also support that increasing energy consumption levels are positively linked to CO_2 emissions (He et al., 2019; Ahmad and Zhao, 2020). Therefore, based on the previous outcomes, the mixed evidence of the EKC hypothesis in the past is related to the choice of variables as control variables used by the authors.

Besides using energy consumption as one of the independent variables for environmental degradation, it is worth noting that other potential macroeconomic determinants are rarely used in previous studies, especially in Malaysia. These two additional variables are foreign direct investment (FDI) and trade openness (TO). The increased reliance of countries' economic growth on FDI due to globalisation has led to corrosion of environmental quality. Besides that, foreign trade has also been confirmed to be a factor causing environmental degradation. Therefore, even though the study focuses on EKC, foreign direct investment and trade openness are considered to control variables in the analysis as the variables are potentially able to influence environmental quality. FDI may contribute to the linkages between CO_2 emission and economic performance via two channels. First, foreign direct investment may increase national income and thus be positively related to per capita CO_2 emission. However, according to Acharyya (2009), although FDI can contribute to better economic growth, it may cause more industrial pollution and environmental degradation. This evidence is found in India.

Furthermore, to reduce the cost of environmental controls, polluting industries and businesses will tend to be shifted to underdeveloped regions where environmental standards are relatively low and turn these regions into pollution slums. Second, more efficient production technology may be used, especially when there is a higher foreign direct investment into the country, and thus causes a reduction in per capita CO_2 emission. For example, Arif et al. (2022) conclude that FDI inflows in developed countries improve the environment. Similarly, Perkins and Neumayer (2008) conclude that the inflow of FDI improves environmental quality due to the enhancement of energy efficiency. The authors used econometric techniques to examine the dynamics and determinants of two pollutants, namely CO_2 and SO, by using a panel comprising up to 114 countries from 1980 to 2000.

Besides FDI, TO also plays a vital role in affecting environmental quality. Copeland and Taylor (2004) suggest that the impact of trade liberalisation on environmental quality can be classified into three independent effects: scale, technique, and composition effects. First, the scale effect suggests that an increase in the magnitude of the economy's outputs and inputs will substantially increase environmental degradation in the form of pollution. Thus, it can be argued that economic growth has a negative impact on environmental quality. Second, the composition effect depends on a change in the economy's structure. According to Rezek and Rogers (2008), environmental quality improves as the economy's structure changes from industrialisation to services and knowledge technology-intensive industry. In other words, it indicates that the effect of economic development on environmental pollution is positive. Finally, the technology or productivity effect implies that wealthy nations can afford to spend more on research and development (R&D) activities (Komen et al., 1997), which facilitate higher economic growth. Therefore, improving technological progress and replacing obsolete and dirty technologies with new and cleaner technologies could improve environmental quality.

This study, therefore, attempts to fill the gap by examining the relationship between economic growth and CO_2 emissions in the presence of foreign direct investment and trade openness in the context of Malaysia. Malaysia is chosen for two reasons. First, Malaysia has experienced substantial growth for the past 40 years, with higher FDI inflows and expanding international trade activities. This progress probably has a direct implication on its environmental quality. A single country study examines the impact of exogenous factors such as environmental policies and trade over time.

3. METHODOLOGY

The general functional form of the environmental quality model for Malaysia is derived as follows:

$$CO2_t = f(GDP_t, DI_t, FDI_t, ENC_t, TO_t, INF_t) \qquad (1)$$

where

CO_{2t} represents environmental quality,
GDP_t represents economic growth,
DIt represents domestic investment,
FDIt represent foreign direct investments inflows,
ENY_t represents energy used,
TO_t represents trade openness,
INF_t represents infrastructure

Next, we transformed equation 1 into a quadratic function by including GDP^2. This variable is included to validate the presence of the Environmental Kuznets Curve for Malaysia. The new equation will be as follows

$$CO2_t = f(GDP_t, GDP^2, DI_t, FDI_t, ENC_t, TO_t, INF_t) \qquad (2)$$

The variables in equation 2 are transformed into log-linear forms (LN). The log version of the variables will indicate the short-run and long-run elasticity. According to Shahbaz et al. (2012), the log version of the tested variables can produce a consistent and reliable estimation. The log version of the model derived from Equation 1.0 can be seen as follows:

$$LNCO2_t = \delta_0 + \alpha_1 LNGDP_t + \beta_2 LNGDP^2{}_t + \sigma_3 LNDI_t + \phi_4 LNFDI_t + \lambda_5 LNENY_t + \nu_6 LNTO_t + \tau_7 LNINF_t + \mu_t \qquad (3)$$

Higher economic development (LNGDP) is expected to increase environmental degradation (LN CO_2) or exhibit positive signs, especially in developing countries. This expected sign can be seen in the past studies conducted for Malaysia, such as Ridzuan et al. (2018), Ridzuan et al. (2019), and Raihan and Tuspekova (2022). $LNGDP^{2,}$ on the other hand, is expected to have a significant and negative relationship with LN CO_2. When the result shows $\alpha 1 = \beta 2 = 0$, a level relationship is concluded, $\alpha 1 < 0$ and $\beta 2 = 0$ display the evidence of a monotonically decreasing linear relationship, $\alpha 1 > 0$ and $\beta 2 = 0$ account for the presence of a monotonically increasing linear relationship, $\alpha 1 < 0$ and $\beta 2 > 0$ yield the evidence for U-shaped relationship, and $\beta 2 < 0$ portrays an inverted U-shaped relationship, which accounts for EKC about carbon emissions. Accessing this condition is crucial for Malaysia if this country is serious about pursuing sustainable development goals, having development but sustaining environmental quality simultaneously. Next, (LNDI) is expected to have a positive relationship with LN CO_2, where a higher amount of domestic investment will boost economic activities, which can also cause a higher release of carbon emissions (LN CO_2). Next, LNFDI is expected to have either a positive or negative link with LN CO_2 for Malaysia. Therefore, the presence of the Pollution Haven Hypothesis is validated if the expected sign between LNFDI and LN CO_2 is positive. In contrast, if the sign is negative, it validates the existence of the Pollution Halo Hypothesis. The pollution Haven Hypothesis is a situation where foreign investors decide to invest more money into the country with less stringent environmental policies. The validation of the Pollution Halo Hypothesis, on the other hand, is the result of the engagement of foreign companies to use better management practices and advanced technologies that result in a clean environment in host countries.

Similar to LNGDP, energy used also exhibits a positive relationship with LN CO_2. Higher energy generated for the combustion of fossil fuels will lead to a higher release of carbon emissions in the country. Trade openness (TO) is also expected to affect LN CO_2 positively. Greater international trade activities will lead to a greater emission release in the countries, as proven by Copeland and Taylor (2004), Jalil and Mahmud (2009) and Schmalensee et al. (1998). Lastly, the development of infrastructure (LNINF) can cause environmental degradation. When more construction and development take place in the country, it will contribute to the number of carbon emissions in the country.

$$\Delta LNCO2_t = \beta_0 + \theta_0 LNCO2_{t-1} + \theta_1 LNGDP_{t-1} + \theta_2 LNGDP^2{}_{t-1} + \theta_3 LNDI_{t-1} + \theta_4 LNFDI_{t-1} + \theta_5 LNENY_{t-1} + \theta_6 LNTO_{t-1} + \theta_7 LNINF_{t-1} + \sum_{i=1}^{a} \beta_i \Delta LNCO2_{t-i} + \sum_{i=0}^{b} \gamma_i \Delta LNGDP_{t-i} + \sum_{i=0}^{c} \delta_i \Delta LNGDP^2{}_{t-i} + \sum_{i=0}^{d} \lambda_i \Delta LNDI_{t-i} + \sum_{i=0}^{e} \vartheta_i \Delta LNFDI_{t-i} + \sum_{i=0}^{f} \psi_i \Delta LNENY_{t-i} + \sum_{i=0}^{g} \tau_i \Delta LNTO_{t-i} + \sum_{i=0}^{h} \vartheta_i \Delta LNINF_{t-i} + \upsilon_t \quad (4)$$

The ARDL model based on the Unrestricted Error Correction Model (UECM) is stated below:

Where Δ is the first difference operator, and u_t is the white-noise disturbance term. Residuals for the UECM should be serially uncorrelated, and the model should be stable. This validation can be addressed with a series of diagnostic tests shown in the analysis section. The final version of the model represented in Equation (4.0) above can also be viewed as an ARDL of order (a b c d e f g h i). The model indicates that environmental degradation (LN CO_2) can be influenced and explained by its past values. Hence, it involves other disturbances or shocks. From the estimation of UECM, the long-run elasticity is the coefficient of the one lagged explanatory variable (multiplied by a negative sign) divided by the coefficient of the one lagged dependent variable.

The short-run effects are captured by the coefficients of the first differenced variables. The null of no co-integration in the long-run relationship is defined by:

H_0: $H_0=H_1=H_2=H_3=H_4=H_5= H_5=H_{6=}0$ (there is no long-run relationship), is tested against the alternative of

H_1: $H_0 \neq H_1 \neq H_2 \neq H_3 \neq H_4 \neq H_5 \neq H_6 \neq H_7 \neq 0$ (there is a long-run relationship exists), employing the familiar F-test. Suppose the computed F-statistic is less than the lower bound critical value. In that case, we do not reject the null hypothesis of no co-integration. However, suppose the computed F-statistics is greater than the upper bound critical value of at least the 10% significant level. In that case, we reject the null hypothesis of no co-integration.

In this work, we aim to test the Environmental Kuznets Curve (EKC) hypothesis for Malaysia, where previous literature, using panel data analysis, has presented mixed and ambiguous evidence for each nation (Narayanan and Narayanan, 2010; Hossain, 2012). To get around some of the issues with panel data analysis, we used time series analysis in our study. Furthermore, to deliver reliable results, country-specific analyses like this study are required (Chandran et al., 2010). In addition, our study strongly emphasises the causal links between FDI and CO_2 emissions, which gives us less insight into the pollution haven theory. According to previous literature, FDI may increase global CO_2 emissions if environmental regulations are loosened in developing nations (Pao and Tsai, 2011).

This study uses annual data ranging from 1971 up to 2019 (49 years) as a sample period. A summary of the data and its sources are shown in Table 1:

4. RESULT AND DISCUSSION

The ADF and PP unit root tests are used to examine the stationarity of all the variables. The results are displayed in Table 2. Based on ADF and PP unit root, it is found that most of the variables are not significant at level except for LNFDI and LNINF. All the variables are stationary at a 1% significant level at the first difference for both ADF and PP unit root tests. Based on these two types of unit roots tests, we concluded that there is a mix stationary of data. Thus, the outcomes of unit root tests allowed us to proceed with the cointegration analysis using ARDL estimation.

Next, the ARDL cointegration test based on F stat is run to validate the presence of a long-run relationship in the ARDL model. Based on the outcomes revealed in Table 3, the F-statistic for the bound test is 5.699, which is significant at 1% level, thus confirming the existence of the long-run relationship in the model. Hence, the null hypothesis is rejected, and the alternative hypothesis for the bound test is accepted.

Next, several diagnostic tests were performed to ensure that the model's output produces non-spurious results. Table 4 confirms that the proposed model has no evidence of serial correlation, no normality issue, and heteroscedasticity effect in disturbances. The model's specifications are well specified, given that the P value of all tests is greater than the 10% significant level. Passing all diagnostic tests allows us more reliable short and long-run elasticities.

To ensure the goodness of the model, CUSUM and CUSUM of Square (CUSUMSQ) are performed to confirm the parameter constancy of the model as proposed by Brown et al. (1975). The CUSUM graph confirms that the model is structurally stable at a 5% significance level, given that the blue line lies between the

Table 1: Sources of data

Variables	Description	Sources
LNCO2	CO2 emissions (metric tons per capita)	WDI
LNGDP	GDP per capita (constant 2015 US$)	WDI
LNDI	Gross fixed capital formation (% of GDP)	WDI
LNFDI	Foreign direct investment, net inflows (% of GDP)	WDI
LNENC	Energy use (kg of oil equivalent per capita)	WDI
LNTO	Trade (% of GDP)	WDI
LNINF	Manufacturing, value added (% of GDP)	WDI

WDI: World Development Indicator 2022

two dotted red lines. Meanwhile, the blue line for CUSUMSQ is not as smooth as CUSUM. However, it is considered fine if the blue line moves back inside the two dotted red lines (Figure 2).

The results of short- and long-run elasticities are presented in Table 5. Short-run elasticities' outcomes are being emphasised based on its present coefficient value only (without lag). The significant and positive sign for LNGDP and negative sign for $LNGDP^2$ indicated Malaysia's inverted U-shaped Environmental Kuznets Curve in the short run. For example, a 1% increase in economic growth (LNGDP) increases carbon emissions by 11.717%. In contrast, at the later stage of economic development, it reduces carbon emissions (LN CO_2) by 0.655%.

A positive sign is also seen in the case of foreign direct investment inflows (LNFDI) and energy used (LNENY). A 1% increase in LNFDI and LNENY increases the carbon emissions released by 0.032% and 0.780%, respectively. Therefore, we can confirm the Pollution Haven Hypothesis in Malaysia with a positive sign of FDI. Higher energy use might link to the growing energy consumption demand due to industrialisation and urbanisation in a country like Malaysia. The rest tested variables do not exhibit any significant outcomes does it does not influence the carbon emissions in the short run. The empirical evidence in this study supports that foreign direct investment inflows in Malaysia positively impact CO_2 emissions. Therefore, the evidence supports the Pollution Haven Hypothesis, similar to previous results for Malaysia (Faheem et al., 2021) and studies including large panels of countries (Azam et al., 2020; Ahmad et al., 2020; Huang et al., 2022).

Next, based on the long-run elasticities outcome, we got a U-shaped Environmental Kuznets Curve (EKC) with a negative sign for LNGDP and a positive one for LNGDP2. 1% increase in economic growth (LNGDP) reduces the emissions by 5.43%. However, it increases by 0.294% at the later stage of economic development. This result contradicted the present studies by Ridzuan et al. (2020) and Etokakpan et al. (2020). They validate the presence of EKC in the case of Malaysia. The country failed to sustain their economic development with better environmental conditions, which might be due to its policy's unstructured economic development plan. Improvement in LINF or infrastructure has also reduced the carbon emissions in the country. Based on statistical interpretations, a 1% increase in LNINF reduce carbon emissions (LN CO_2) by 0.5%.

Table 2: Testing ADF and PP unit root

Level I (0)	ADF unit root		PP unit root	
	Intercept	Intercept and trend	Intercept	Intercept and trend
LNCO2	−1.109 (0)	−1.866 (0)	−1.250 (5)	−1.590 (2)
LNGDP	−1.519 (0)	−2.468 (0)	−1.473 (1)	−2.597 (3)
LNDI	−2.515 (1)	−2.705 (1)	−2.217 (2)	−2.329 (1)
LNFDI	−5.901 (0)***	−5.912 (0)***	−5.903 (1)***	−5.912 (1)***
LNENC	−1.386 (0)	−1.446 (0)	−2.238 (12)	−1.169 (4)
LNTO	−2.300 (1)	−0.574 (1)	−1.799 (2)	−0.020 (3)
LNINF	−2.734 (1)*	−1.757 (1)	−2.787 (4)*	−1.607 (4)
First difference I (1)	ADF unit root		PP unit root	
	Intercept	Intercept and trend	Intercept	Intercept and trend
LNCO2	−9.448 (0)***	−9.513 (0)***	−9.448 (0)***	−9.716 (2)***
LNGDP	−6.006 (0)***	−6.062 (0)***	−5.971 (2)***	−6.061 (1)***
LNDI	04.922 (0)***	−4.917 (0)***	−4.859 (3)***	−4.851 (3)***
LNFDI	−7.790 (1)***	−7.715 (1)***	−24.728 (26)***	−26.194 (26)***
LNENC	−7.214 (0)***	−7.444 (0)***	−7.353 (6)***	−10.675 (16)***
LNTO	−5.232 (0)***	−6.253 (0)***	−5.232 (0)***	−6.258 (5)***
LNINF	−4.464 (0)***	−5.208 (0)***	−4.401 (3)***	−5.211 (3)***

*** and * are 1%, 5% and 10% of significant levels, respectively. The optimal lag length is selected automatically using the SIC for the ADF test. The bandwidth was selected using the Newey–West PP and KPSS unit root test method. SIC: Schwarz Info Criteria

Table 3: Detecting the presence of long-run cointegration based on F statistics

Model	Maximum Lag	Lag order	F statistics
LNCO2=f (LNGDP, LNGDP2, LNDI, LNFDI, LNENC, LNTO, LNINF)	4, 4	1, 1, 1, 0, 0, 2, 3, 3	5.699***
Critical values for F statistics		**Lower I (0)**	**Upper (1)**
10%		2.033	3.13
5%		2.32	3.5
1%		2.96	4.26

The critical values are based on Pesaran et al. (2001), Case III: Unrestricted intercept and no trend. k is a number of variables equivalent to 5. *,** and *** represent 10%, 5% and 1% significance, respectively

Table 4: Diagnostic tests

(A) Serial correlation [P]	(B) Functional Form [P]	(C) Normality [P]	(D) Heteroscedasticity [P]
2.166 (0.104)	0.018 (0.893)	0.847 (0.654)	0.840 (0.643)

The diagnostic test is performed as follows A. Lagrange multiplier test for residual serial correlation; B. Ramsey's RESET test using the square of the fitted values; C. Based on a test of skewness kurtosis of residuals; D. Based on the regression of squared fitted values

Figure 2: CUSUM and CUSUM square

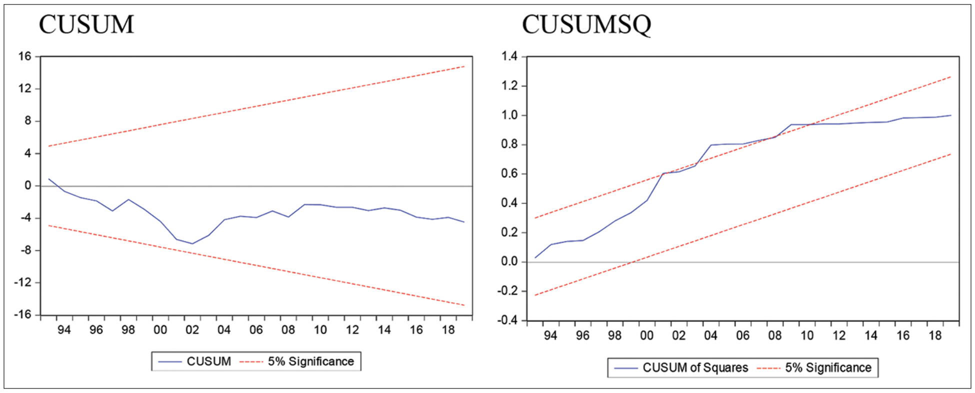


Table 5: Short run and Long run Elasticities

Short run Elasticities		Long run Elasticities	
Variables	Coefficient	Variables	Coefficient
ΔLNGDP	11.717*	LNGDP	-5.430**
ΔLNGDP2	-0.655*	LNGDP2	0.294**
Δ LNDI	0.053	LNDI	0.055
ΔLNFDI	0.032***	LNFDI	0.033**
ΔLNENC	0.780***	LNENC	1.311***
$\Delta LNENG_{(-1)}$	-0.259	LNTO	0.556***
ΔLNTO	-0.480**	LNINF	-0.500**
$\Delta LNTO_{(-1)}$	-0.006	C	15.129
$\Delta LNTO_{(-2)}$	-0.467		
ΔLNINF	0.328		
$\Delta LNINF_{(-1)}$	-0.533		
$\Delta LNINF_{(-2)}$	0.986		
ECT	-0.971***		

1. ***, ** and * are 1%, 5% and 10% of significant levels, respectively. 2. Δ refer to difference.

LNFDI is again positing a positive sign, like its outcome in the short run with an almost similar degree of elasticities.

On the other hand, a 1% increase in foreign direct investment inflows has increased the country's environmental degradation (LN CO_2) by 0.033%. This result supports the existence of Pollution Haven Hypotheses for this country. It is not a good sign since the foreign companies are taking advantage of building their factories without utilising the clean types of technology for their production, given a lax environmental rule from the country. Energy used (LNENY) contributes the largest impact toward LN CO_2, where a 1% increase in this variable lead to a 1.311% increase in emissions. Besides LNENC, trade openness (LNTO) also denotes a positive relationship with carbon emissions. Statistically, a 1% increase in LNTO contributes 0.556% increase in emissions. The only variable that failed to influence carbon emissions release for Malaysia is a domestic investment, LNDO.

Lastly, the long-run relationship of the model was supported by the negative and significant value of the error correction term (ECT). ECT represents the model's speed of adjustment, and the negative value means that the variables in the model will converge in the long run. The recorded speed of adjustment for the proposed model is 0.971. Approximately 97 per cent of disequilibria from the previous year's shock converge to the current year's long-run equilibrium.

5. CONCLUSION AND POLICY RECOMMENDATIONS

This study aims to investigate the existence of the EKC in Malaysia and the effects of trade openness and FDI on CO_2 emissions. Data for 49 years ranging from 1971 to 2019 were collected, and the ARDL approach was employed. The results of unit root tests indicate that all of the variables used in this study, namely CO_2 emissions, GDP, domestic investment, FDI inflows, energy use, trade openness and infrastructure, are not stationary at the level, except for FDI. However, all of the variables are stationary at first different, suggesting that the ARDL approach can be used. Furthermore, the results of the bound test show that there is a co-integrating relationship among the variables. Thus, the long-run and short-run relationship can be estimated. The findings reveal an inverted U-shaped EKC in the short run but a U-shaped EKC in the long run. However, in the final stage, higher economic growth increases environmental degradation. The findings also disclose a positive relationship between FDI inflows and environmental degradation in the long and short run. This indicates that bringing more FDI into Malaysia can harm the environment. Besides, energy use can also cause environmental degradation to intensify in the short run and long run in Malaysia. This is because Malaysia consumes more non-renewable energy sources, such as oil, gas, and coal will put the country at higher risk of harming the environment. Other than that, there is a negative relationship between trade openness and CO_2 emissions in the short run but a positive relationship in the long run. The results also show that infrastructure can reduce CO_2 emissions in the long run.

The findings are important for policymakers to formulate policies on reducing environmental degradation in Malaysia. FDI inflows can be harmful and good to the environment, depending on what technology is brought into the country. If green technology is brought as a result of FDI inflows, then environmental degradation can be reduced. As such, Malaysia should allow more green technology into the country to reduce environmental effects. Besides, using more renewable energy sources, such as biodiesel, solar and hydro, might help the country mitigate environmental degradation. Carbon pricing introduced by the country can also play an important role in conserving the environment.

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