An environmental assessment of the impacts of corruption, foreign investment inflow and trade liberalization in the rapidly emerging Malaysian Economy

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Bright Akwasi GYAMFI [a]
a. School of management, Sir Padampat Singhania University
Bhatewar, Udaipur-313601, Rajasthan, India
Email: brightgyamfi1987@gmail.com

Stephen Taiwo ONIFADE [b, c]
b. School of Finance and Accounting, University of Vaasa, FI-65200, Vaasa-Finland.
c. Faculty of Economics and Administrative Sciences, KTO Karatay University, Konya, Turkey
E-mail: stephentaiwo.onifade@gmail.com
ORCID ID (https://orcid.org/0000-0003-1497-7835) (**Corresponding Author**)

Abdul Rahim RIDZUAN [d,e,f,g,h]
d. Faculty of Business and Management, Universiti Teknologi MARA, Melaka Campus, Malaysia,
e. Institute for Big Data Analytics and Artificial Intelligence, Universiti Teknologi MARA, Malaysia,
f. Faculty of Economics and Business, Universitas Negeri Malang, Indonesia,
g. Centre for Economic Development and Policy, Universiti Malaysia Sabah, Malaysia,
h. Institute for Research on Socio Economic Policy, Universiti Teknologi MARA, Malaysia
Email: rahim670@uitm.edu.my

Mohd Shahidan SHAARI [i]
i. Faculty of Business & Communication
Universiti Malaysia Perlis, Malaysia
Email: shahidanshaari@unimap.edu.my

Pabitra Kumar JENA [j]
j. School of Economics
Shri Mata Vaishno Devi University, Katra, India
Email: pabitrakumarjena@gmail.com

Abstract

In the wake of various catastrophic consequences of climate change, Malaysia, a rapidly developing economy, is also inevitably experiencing environmental degradation that merits prompt and serious attention from policymakers and its government. Hence, this study simultaneously highlights the short and long-run dynamic connections between carbon emission in Malaysia and the trio of corruption levels, foreign investment inflow, and trade liberalization. The study also controls for a combination of other factors including energy use, GDP, and urbanization. A robust empirical analysis was conducted on time series observations for the country based on the recent Dynamic ARDL simulation. It was observed that Malaysia's per capita pollution levels significantly reduces based on the corruption perception levels during the sampling period while the economic expansion's effect on emission levels is positive. Additionally, urbanization, trade levels and energy use all aggravate the emission levels. On the other hand, although FDI poses an insignificant environmental damage in the short run, its environmental sustainability enhancement roles were supported by its long-run negative impacts on carbon emission. Lastly, the EKC was established and as such, essential policy directions were provided for stakeholders in the rapidly emerging Malaysian economy.

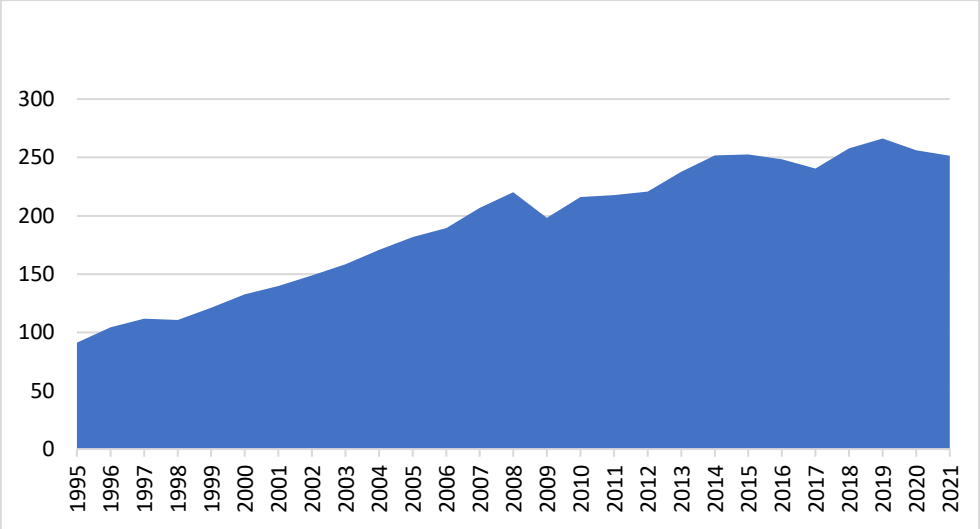
Keywords: Carbon emission, Corruption, Foreign investment inflow, Trade liberalization, Malaysia

1.0 Introduction

The global efforts that have been made to reduce climate change challenges have not produced sufficient desired results as the trend in CO_2 emissions continues to spiral out of control. CO_2 emissions plunged significantly in 2020 owing to the COVID-19 epidemic that affected the world, suggesting that the pandemic also had a silver lining. However, they increased again by 6% in 2021 to 36.3 billion tonnes (International Energy Agency, 2022) amid economic recovery, indicating that economic activity is a catalyst for higher CO_2 emissions. When the demand for coal, oil, and gas grew as a result of the post COVID-19 economic recovery, CO_2 emissions related to energy rebounded by 4.8%. Climate change resulting from CO_2 emissions raises the global temperature, causing 5 million people to die each year (Lombrana, 2021), which should set alarm bells ringing. Besides, Murthy et al. (2021) have also added that greater environmental degradation could reduce life expectancy.

The Malaysian economy, being a rapidly developing economy, is also inevitably experiencing environmental degradation, which merits prompt and serious attention from policymakers and its government. Figure 1 shows an upward trend of CO_2 emissions in Malaysia from 1995 to 2021. The country recorded the highest CO_2 emissions in 2019 at 266.215 Mt, while the lowest CO_2 emissions were registered in 1995 at 91.307 Mt. Emissions dropped by 3.77% to 256.191 Mt in 2020 due to the Movement Control Order (MCO) following the COVID-19 outbreak. This, however, plunged the country into a recession with economic growth of -5.6%. During the 2009 economic recession, the country also experienced a decline of 9.92% in CO_2 emissions, implying that economic activity plays an important role in influencing environmental degradation.

Figure 1: Total CO_2 emissions in Malaysia

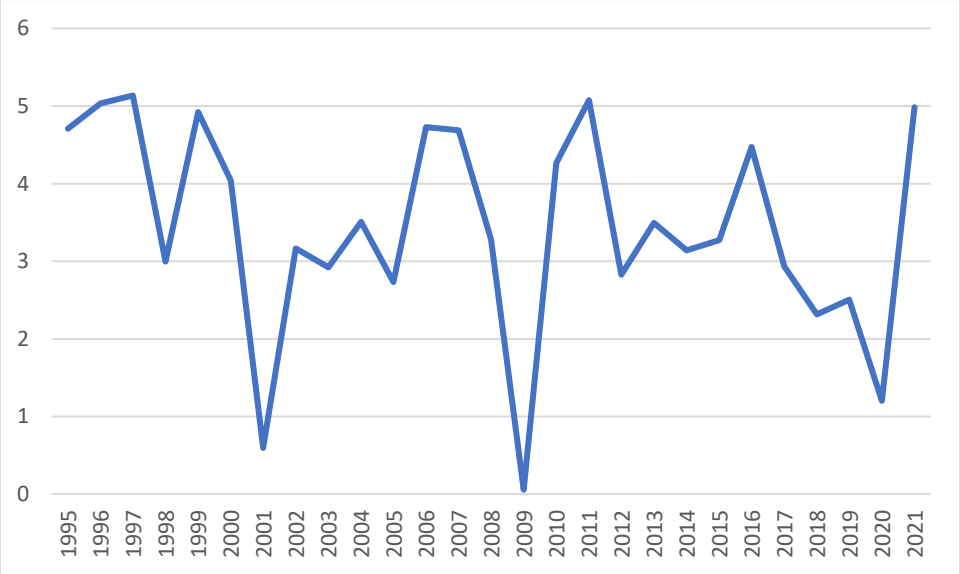


Source: countryeconomy.com

Hence, a lot of research has been conducted to investigate factors that can contribute to increased CO_2 emissions, and some of the identified factors are economic expansion (Osadume, 2021; Ilham et al. 2021; Onofrei et al., 2022; Onifade, 2022; Gyamfi et al. 2022), population growth (Namahoro et al. 2021; Zeng et al., 2022; Erdoğan et al. 2021), energy use (Liu & Yuan, 2022; Onifade & Alola, 2022; Agboola et al. 2022a), and so forth. Besides, FDI, perceived as a catalyst for economic growth, job creation and technology transfer, might also harm the environment when non-green technology is brought into host countries as more non-renewable energy is consumed (Dingru et al. 2023). Apergis et al. (2022) acknowledged that FDI inflows could be a menace to the BRICS

countries' environment. Several studies, such as Wang et al. (2021), argued that the environment could be conserved when green technology is transferred through FDI. Investors from developed countries are interested in investing in developing countries due to less stringent environmental policies, thus implying that FDI can harm the environment in developing countries such as Malaysia. Shaari et al. (2022) discovered that Malaysia's FDI inflows have a negative impact on the environment, suggesting that technology transferred into the region through FDI is not environmentally friendly. Figure 2 shows an uncertain trend of FDI as a percentage of GDP in Malaysia from 1995 to 2021, with the highest value in 1997 at 5.14%. The country experienced not only a drop in CO_2 emissions during the 2020 recession but also a decline of 52% in FDI inflows. The lowest FDI inflows were registered in 2009 during an economic recession, standing at 0.06%, and they rebounded to 4.27% in the following year.

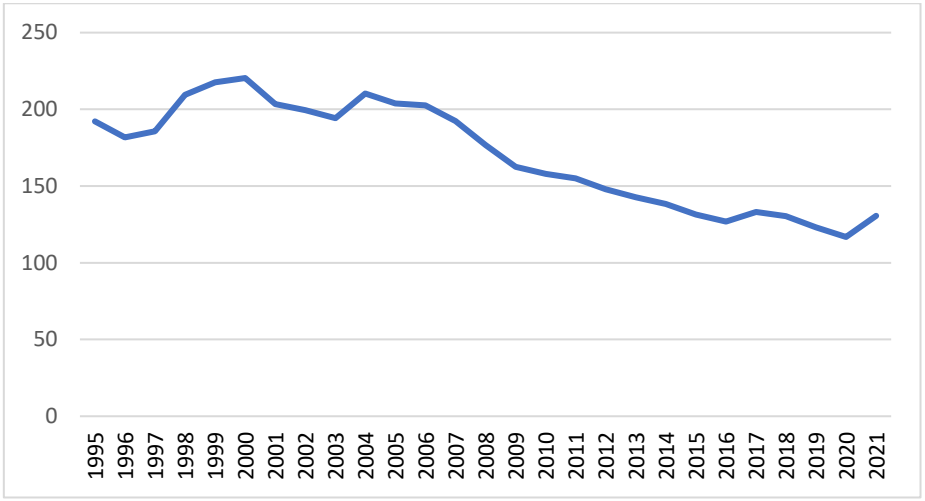
Figure 2: FDI inflows as a percentage of GDP



Source: World Development Indicators (WDI)

International trade levels have also been observed to have escalated in a bid to boost the global economy (Erdoğan et al. 2022; Yussif et al. 2022; Khatir et al. 2022). Innumerable countries, especially developing nations, have opened up their economies to trade. However, the issue that needs to be addressed by all nations when trade openness intensifies is environmental degradation. Previous studies have found that trade can pave the way for environmental degradation (Chen et al., 2021; Cetin et al., 2018a; Alagöz et al. 2021). As the desire for exports grows, goods produced in the domestic market will simultaneously increase. Consequently, the use of more energy, especially non-green energy, is needed, which can adversely impact the environment. Malaysia is also following up on aggressive trade developments by boosting exports just like other trade-intensive countries such as China. The country, therefore, must bear in mind that environmental degradation might loom on the horizon. Figure 3 exhibits total trade as a percentage of GDP over a period of 26 years ranging from 1995 to 2021 in Malaysia, with the highest percentage increase in 2000 at 220.41%. A decreasing trend in trade can be observed over the post COVID-19 period, with the lowest trade of 116.83% recorded in 2020 during Malaysia's economic recession.

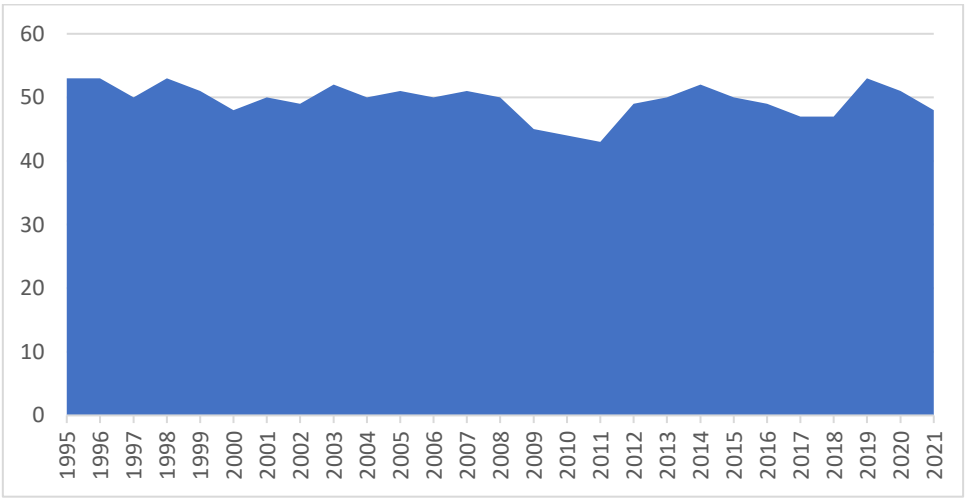
Figure 3: Trade as a percentage of GDP



Source: World Development Indicators (WDI)

As for the effects of corruption in this discuss, a limited number of studies have proven that this factor can also be one of the determinants of CO_2 emissions (Sekrafi & Sghaier, 2018; Pei, 2021; Xie, 2023), suggesting that investigation into the issue is still relevant. It is also said believed that corruption disrupts economic progress since collective developmental resources are often diverted for personal interest (Appiah et al. 2022; Appiah et al. 2023). Corruption might prompt development mismanagement. Corrupt governments or countries may threaten the environment by approving illegal projects or activities that can release CO_2 emissions as they are not concerned about environmental quality. Hence, firms that do not comply with environmental regulations can continue to operate in the long run despite harming the environment and this can be more prominent in corruption-prone environments (Sekrafi & Sghaier, 2018). Figure 4 shows Malaysia's corruption perceptions index (CPI) from 1995 to 2021. From the figure, it can be observed that the trend of CPI in the region remained uncertain. As the CPI declines, the country is regarded as more corrupt. The lowest CPI was recorded in 2011, standing at 43 points. Due to the 1 MDB case, Malaysia's CPI started to decline, and even during the 2020 economic recession stemming from the COVID-19 pandemic, the CPI continued to decrease.

Figure 4: Corruption perceptions index



Source: countryeconomy.com

Currently, the literature is broad on the case of well-known environmental influencers in term of emission levels, and several studies have already established some of these emission determinants like energy use, urbanization, and economic growth among others (Dogan & Aslan, 2017; Alola & Onifade, 2022; Dogan et al. 2022; Raihan, 2023). This study, however, significantly draws the attention of major stakeholders to the potential roles of the afore analyzed factors (corruption, foreign investments, and trade) given their influential significant roles in the rapidly emerging Malaysian economy. Besides, despite previous literature investigating the determinants of CO_2 emissions, most analysis on the Malaysian case study have often failed to show how CO_2 emissions can counterfactually respond to any shock in an understudied factor when other determinants are kept constant. Furthermore, extant studies mostly utilized the traditional ARDL that is limited in this regard. Therefore, this study takes a forward step by utilizing the dynamic ARDL simulation in investigating the impacts of identified determinants on CO_2 emissions. Using the approach provides several advantages in comparison with the traditional ARDL approach as it predicts how CO_2 emissions can counterfactually respond to any shock in a specific determinant factor when others remain constant (Sarkodie & Owusu, 2020; Udeagha & Ngepah, 2022; Ahakwa, 2023). Lastly, the study also controls for other salient emission determinant within the analysis at least for a more robust specification and more importantly to avoid any potential damages of variables omissions in the estimations.

The rest of the study is divided into 4 sections after the introduction in section 1. Literature review was presented in section 2 and both the data information and methodology were presented in section 3. The empirical results were discussed in section 4 while the study concludes with the relevant policy recommendations in section 5.

2.0 Literature Review

The existing studies that testify to the evidence of Environmental Kuznets in Malaysia are reviewed in this section. In addition, various variables such as technology innovation, renewable and non-renewable energy, corruption, foreign investment, trade openness, financial development, human capital and others have been introduced to complete the investigation. However, in this section, besides evaluating the past studies on EKC, our main emphasis will be on a few selected variables such as corruption, FDI and trade openness and its relationship with environmental degradation.

2.1 Theoretical Background in the EKC Perspective for the Malaysian Economy

A review of the literature shows that several studies have emphasized the validation of the EKC hypothesis in the context of Malaysia. Malaysia is one of the leading developing countries among the members of the Association of Southeast Asian Nations (ASEAN). The country has experienced tremendous growth since the 1990s. The country has undergone a structural transformation from agriculture to services and manufacturing. The country is actively pursuing the Sustainable Development Goals proposed by the United Nations. This arouses the global interest of researchers to test the country's SDG targets against the EKC hypothesis. In their studies, Mohd Suki et al. (2022) highlighted the role of technological innovation and renewable energy as potential determinants of environmental quality in Malaysia. Using a boot-strapped autoregressive distributed lag (BARDL) model based on the sample data from 1980 to 2018, the authors found that the use of the highlighted variables could reduce carbon emissions, moreover, the presence of an inverted U-shape for EKC was confirmed. Recent studies by Ridzuan et al.

(2022) focus on the FDI-emissions link in Malaysia. Due to FDI, more and more companies are located in the country, which may lead to negative externalities such as pollution. The authors provide a unique result by confirming the U-shape of EKC instead of the inverted version. The authors remind policy makers to always keep in mind the development of the country in term of long run sustainability. Meanwhile, Sharif et al. (2020) has earlier introduced tourism, transportation, and globalization to test the presence of EKC in the context of Malaysia based on quarterly data from 1995 to 2018. Among the interesting findings of this study is that higher tourism activities lead to lower carbon emissions at higher quantiles. In contrast, both globalization and transportation services lead to environmental degradation. The authors can also confirm the existence of EKC in this paper. Similar studies were conducted by HowGo et al. (2020) to determine the EKC hypothesis in Malaysia. The authors used annual data from 1990 to 2017 and introduced corruption as a possible determinant of environmental degradation. Carbon emission released from transportation was used as the dependent variable, as they believe it is the dirtiest sector that consumes large amounts of fossil fuels. The results showed that higher corruption worsens environmental quality. In addition, EKC was debunked. Loganathan et al. (2020) introduced total productivity factor, natural resources, and eco-tax as influencers of carbon levels in Malaysia. Based on the period 1970-2018, the authors found that green taxation can reduce carbon emissions in the country. However, the study has no bearing on the EKC. Mohd Suki et al. (2020) verify the EKC using globalization as a determinant of carbon emissions in Malaysia. The authors used quarterly data from 1970 to 2018 using a Quantile Autoregressive Distributed Lag method. Overall, the results showed that economic globalization increased environmental degradation, while political and social globalization improved conditions. Based on previous studies based on similar variables, the authors mention that the results between globalization and environmental quality could vary depending on income level and globalization degree. Next, Ridzuan et al. (2020) checked the emission effects of fossil fuel consumption and hydropower generation in Malaysia. Annual data from 1980 to 2014 were used for the studies. The existence of an inverse form of EKC is confirmed. It was also found that only hydropower can reduce carbon emissions, similar to the studies of Jahanger et al. (2022), but there is no meaningful connection with fossil fuel-based energy usage. Yuaningshih & Febrianti (2021) examined the effects of economic growth, energy use, financial development, and technological progress on carbon emissions from 1985 to 2019. Using the ARDL approach, the authors documented the EKC and opined that development in the financial sector improves the problem of environmental degradation. Next, Ali et al. (2019a) examined technological innovations and structural changes as potential determinants of environmental quality in Malaysia. Using sample data from 1985 to 206, the results showed that improving technological innovation helps to reduce environmental degradation, while there is no significant relationship between structural changes captured by industry value added and carbon emissions. These studies negate the hypothesis in Malaysia. Gill et al. (2018) examined the evidence of EKC in Malaysia from 1970 to 2011, and the authors introduce renewable energy sources as determinants of carbon emissions. The long-term results reject the presence of EKC due to the non-significant GDP squared. Higher GDP leads to higher release of carbon emissions and greater use of renewable energy to reduce the country's environmental degradation.

2.2 Corruption and Environmental Degradation

Corruption has become a highlighted component of environmental degradation in recent years. According to Sahli and Rejab (2015), corruption can affect the process of protecting the natural environment, and weakening this cause has a great impact on the country's goal of achieving

sustainable development. In addition, corruption can reduce the stringency of environmental regulations, leading to more land abuse, deforestation, and desertification. However, like other variables, there are mixed results for these variables. This section reviews several previous studies on corruption-environment linkages. Wang et al. (2020) examine corruption and ecological efficiency of selected regions in China using GMM panel estimation and the former negatively affects ecological efficiency due to resource misallocation. Hao et al. (2020) examined similar variables in thirty Chinese provinces with spatial and panel threshold models. The authors found that corruption does not affect environmental energy performance but promotes inhibitory effects on labor and resource misallocation. In contrast, Wawrzyniak and Doryń (2020) observed that the corruption-environment link is inconsequential. The authors used panel GMM for 93 countries based on data from 1995 to 2014. Meanwhile, studies by Yahaya et al. (2020) showed that corruption plays meaningful increasing roles in degrading sub-Saharan Africa's environment. The authors used FMOL method, and the sample data ranged from 2000 to 2014. Contrarily, Zandi et al. (2019) found a direct effect of corruption in the environment of six ASEAN countries. The authors used FMOLS and DOLS estimates based on sample data from 1995 to 2017. More recently, Pujiati et al. (2023) noted that corruption contributes to higher levels of environmental degradation in Indonesia. This claim is also supported by the claim that corruption increase carbon emission levels in India as seen in the study of Hamid et al. (2023). Based on the above results, the majority of studies found that corruption causes environmental degradation, and corruption is notoriously known as one of the main causes of natural environment degradation, especially for most developing economies that have large collection of natural resources, and this sparked the interest of this paper to assess this relationship in the context of Malaysia.

2.3 Foreign Direct Investment and Environmental Degradation

Empirical studies have shown that foreign direct investment spurs economic growth in host countries through spillover effects and technology transfer. However, the impact on environmental degradation is mixed. The linkages between FDI and the environment are mainly captured by two competing hypotheses: the "pollution heavens" hypothesis and the "pollution halo" hypothesis. Most of the empirical work to date demonstrates that foreign industries cause air pollution through their production of goods and services in line with the pollution haven proposition (Behera and Dash, 2017) for South and Southeast Asia; (Sapkota and Bastola, 2017) for Latin America; (Solarin et al. 2018) for selected developed and developing countries; (Ridzuan et al. 2022) for Malaysia. Solarin et al. (2017) claimed that countries with strict environmental laws tend to gain more investment influx than others since they could be costly and disadvantageous to these investors. However, in the recent study of Pujiati et al. (2023), it was discovered that FDI can reduce environmental degradation in the case of Indonesian economy in the long run. Therefore, considering all these evidence and claims, this study examines whether foreign investments is detrimental to the environment in Malaysia or otherwise.

2.4 Trade Openness and Environmental Degradation

Trade openness, also known as trade liberalization, removes cross-border barriers such as subsidies, tariffs, and quotas, thereby increasing the volume of trade between countries (Lee, 2005). Ineffective trade liberalization policies may have adverse effects on the environment and the economy. On the other hand, effective trade liberalization could improve environmental protection and thus contribute to environmental quality. Several studies have examined these relationships and have reached mixed and inconclusive results. The positive impact of trade liberalization on environmental quality has similar significance to that of the pollution halo

hypothesis. In contrast, the negative impact of trade liberalization on environmental quality is related to the Pollution Haven Hypothesis (PHH). Previous studies have found that the effects of trade liberalization may vary depending on the level of development of the country. For example, the cushioning environmental roles of liberalization is greater in developing countries than in advanced economies (Le et al. 2016; Managi et al. 2009). This is due to the fact that MNCs produce environmentally intensive goods because of the weak environmental impact in developing countries. On the other hand, Shahbaz et al. (2012) found that international trade activities increase the use of scarce resources and thus benefit the environment.

Overall, going by this broad review of extant studies, it can be seen that most analysis on the Malaysian case study is yet to draw the attention of stakeholders to the potential environmental roles of the identified primary factors in the current investigation and most especially in the case of corruption and foreign investment. Besides, most studies have often failed to show how CO_2 emissions can counterfactually respond to any shock in an understudied factor when other determinants are kept constant. Furthermore, many extant studies mostly utilized the traditional ARDL, and this approach is limited in this regard. Therefore, this study fills the research gaps relating to the state of works done on the Malaysian economy by not only drawing the attention of all stakeholders to these factors, but also by utilizing the novel dynamic ARDL simulation in investigating the impacts of the identified determinants on the Malaysian economic environmental performance in terms of emission levels. Using the approach provides several advantages in comparison with the traditional ARDL approach as it predicts how emissions can counterfactually respond to any shock in a specific determinant factor when others remain constant. (Sarkodie & Owusu, 2020).

3.0 Methodology

3.1 Empirical model

In this study, we adopted the conventional EKC model introduced by Kuznets (1955) as follows in equation 1.0:

$$CO2_t = f(GDP_t, GDP^2_t)...(1.0)$$

Where the details of the variables are as follows:

$CO2_t$ indicates environmental quality,
GDP_t indicates economic growth,
GDP^2_t indicates growths' squared values
The EKC assertion is broadened via the roles of corruption, energy consumption and other macroeconomic determinants for Malaysia's environmental quality level. The extended version of the model is introduced as in equation 2.0.

$$CO2_t = f(GDP_t, GDP^2_t, FDI_t, TO_t, URB_t, ENG_t, COR_t)...(2.0)$$

Where the details of the variables are as follows:

$CO2_t$ indicates environmental quality,
GDP_t indicates economic growth,
GDP^2_t indicates the sum of squares for economic growth,
FDI_t indicates foreign direct investment inflows
TO_t indicates trade openness

URB_t indicates urbanisation
ENG_t indicates energy used
COR_t indicates corruption

The EKC hypothesis assumes that the country will release more carbon emissions in the early levels of economic growth. However, as they develop, they may replace dirty energy-based technology with cleaner energy in production, resulting in lower carbon emissions thus affirming the EKC stance as supported by most recent studies such as Steve et al. (2021), Onifade, 2023, Ohajionu et al. (2022), and Ramzan et al. (2022).

Next, foreign direct investment (FDI) inflow is expected to affect carbon emissions positively or negatively. If the sign is positive, the theory of Pollution Haven Hypothesis is valid. According to this theory, some multinational companies relocate their operations to a country that does not impose strict environmental laws on producers. In this way, the companies can reduce their production costs by using dirty energies such as fossil fuels and coal to generate energy for their production. As mentioned earlier, heavy use of cheap energy sources releases higher emissions. In other words, a higher inflow of foreign direct investment leads to a higher release of CO2 emissions. This result has been found in previous studies such as Kocak and Sargunesi (2018) in Turkey, Hanif et al. (2019) for Asian developing countries, and Shahbaz et al. (2019) in (MENA) region. If the contrary is seen, then, the halo effect hypothesis is present when the expected sign is negative. According to this hypothesis, multinational companies from advanced countries that establish operations there will generally adopt better and cleaner technologies, thereby assisting the local government in reducing carbon emissions (Stretesky and Lynch, 2008). Previous studies showing an inverse FDI-CO2 paths include Essandoh et al. (2020) for 52 countries using a panel estimate, Jebli et al. (2019) for a panel of 22 Central and South American countries and Sung et al. (2018) for 28 subsectors of the Chinese manufacturing sector in China.

Next, we included TO because many previous studies have also included this variable as a determinant of carbon emissions. The expected sign for this indicator is positive. According to Baek et al. (2009), globalization has led to an increase in active pollution from intensive industries, including in Malaysia. Other examples include Tiwari et al. (2013) for India, and Halicioglu (2009) for Turkey, and Onifade et al. (2023) for African economies. URB is also included as one of the possible determinants of carbon emissions. The expected sign is positive, indicating that a higher level of urbanization leads to a higher release of carbon emissions in a country. Most studies have positive signs, such as (Cetin et al. 2018b; Aslan et al. 2021; Ali et al. 2019; Mahmood et al. 2020).

Lastly, the two other crucial variables we include in the model are energy consumption (ENG) and corruption (COR). Both variables are expected to have a positive impact on the level of Malaysia's carbon emissions. Therefore, the inclusion of energy consumption is a must. The model is considered to have a bias if this variable is omitted. In Malaysia, which still relies heavily on cheap energy sources, it cannot be denied that higher energy consumption can increase environmental impact. Studies conducted include Saboori and Sulaiman (2013) for Malaysia, Al-Mulali and Che-Sab (2012) for Sub-Saharan Africa, and Hossain (2011) for selected emerging economies. Higher corruption could also lead to higher pollution in a country. As Callen and Long (2015) noted, corrupt public officials tend to work for their interests at the detriment of environmental damages. According to the Transparency International report, Malaysia is ranked 62nd in the world, which has prompted the government to monitor and punish any corruption practices found among its

citizens. Including corruption in the indicators will provide meaningful results to policy makers. Recent studies that include corruption include HowGo et al. (2020) for Malaysia.

For equation 2, log-linear forms (LN) were used to express the variables. The variables in Equation 2 were converted to log-linear forms (LN) as suggested by Shahbaz et al. (2012), who argued that reliable and consistent estimation can be achieved by using the log version of the variables tested. Thus, the equation 2.0 is further expressed as follows:

$$LNCO2_t = \delta_0 + \alpha_1 LNGDP_t + \alpha_2 LGDP2_t + \alpha_3 LNFDI_t + \alpha_4 LNTO_t + \alpha_7 LNURB_t + \alpha_8 LNENG_t + \alpha_9 LNCOR_t + \mu_t ...(2.0)$$

Then, the Jordan and Philips (2018) recent dynamic ARDL method was adopted to estimate both the short-term and long-term coefficients of the variables. This model instinctively plots both positive and negative graphs indicating changes in the variables and estimates their long- and short-term relationships. The first analysis is a stationarity test to determine the integration order of the variables before applying the novel dynamic ARDL simulation approach. There are three types of unit root tests used to determine the stationarity of the data: the Augmented Dickey-Fuller (ADF) test, the Phillips-Perron (PP) test, and the Kwiatkowski-Phillips-Schmidt- Shin (KPSS) test. After stationarity of all variables was established, linear cointegration was estimated. For long-term cointegration, Bayer and Hanck's (2013) combined cointegration test was used to analyse the long-term cointegration between variables. Individual tests such as Engle and Granger (1987), Johansen (1991), Boswijk (1995), and Banerjee et al. (1998) were performed. The Fisher equation is presented as follows:

$$EG - JOH = -2[\ln(\lambda EG) + (\lambda JOH) ...(3.0)$$

$$EG - JOH - BO - BDM = -2[\ln(\lambda EG) + (\lambda JOH) + (\lambda BO) + (\lambda BDM)] ...(4.0)$$

Where λBDM, λBO, λJOH, and λEG are the odds of diagnosing individual cointegration tests where EG is Engle and Granger (1987) cointegration test, JOH is Johansen (1991) cointegration test, BO is Boswijk (1995) cointegration test, and BDM is Banerjee et al. (1998) cointegration test respectively. The ARDL bound test as proposed by Pesaran et al., (2001) is able check long-run links in varying integration orders including I(1) as well as I(0) and it can support the usefulness of (Bayer & Hanck, 2013) cointegration method. ARDL bound testing can ensure effective findings, even in small-size samples. Also, this test allows simultaneous running for short-run and long-run impacts computation following the in equation (5.0).

$$\Delta LNCO2_t = \beta_1 + \theta_0 LNGDP_{t-1} + \theta_1 LNGDP^2_{t-1} + \theta_2 LNFDI_{t-1} + \theta_3 LNTO_{t-1} + \theta_4 LNURB_{t-1} + \theta_5 LNENG_{t-1} + \theta_5 LNCOR_{t-1} +$$
$$+ \sum_{i=1}^{a} \beta_i \Delta LNCO2_{t-i} + \sum_{i=0}^{b} \gamma_i \Delta LNGDP_{t-i} + \sum_{i=0}^{c} \delta_i \Delta LNGDP^2_{t-i} + \sum_{i=0}^{d} \lambda_i \Delta LNFDI_{t-i} + \sum_{i=0}^{e} \vartheta_i \Delta LNTO_{t-i} + \sum_{i=0}^{f} \psi_i \Delta LNURB_{t-i} + \sum_{i=0}^{g} \varpi_i \Delta LNENG_{t-i} + \sum_{i=0}^{h} \varsigma_i \Delta LNCOR_{t-i}$$
$$+ \upsilon_t ...(5.0)$$

Here the difference operator is the Δ meanwhile, the u_t is the stable error component that are not correlated. Both conditions can be checked using the diagnostic tests discussed in the analysis section. The final version of the above model (Equation 4.0) can alternatively be viewed as an ARDL of order (a b c d e f g h). The signs of each independent variable are expected to be mixed for the dependent variable. The model suggests that carbon emissions (LNCO2) can be influenced and explained by their past values, which could be due to disturbances or shocks. The null case that there is no cointegration in the long-term relationship is defined by: H_0: $\theta_0=\theta_1=\theta_2=\theta_3=\theta_4=\theta_5= \theta_6=\theta_7=0$ (there is no long-run relationship), and it is tested against the

alternative of H_1: $\theta_0 \neq \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq \theta_5 \neq \theta_6 \neq \theta_7 \neq 0$ (there is a long-run relationship) using the well-known F test. The derived F-statistics were equated with the critical values of the lower and upper bounds. This result indicates the presence of a long-term relationship because the computed f-values outgrow the critical bounds. The dynamic ARDL simulation method, as introduced by Jordan and Philips (2018), was used to evaluate the long-term and short-term coefficients. The dynamic simulated ARDL approach can be used to generate plots to show counterfactual changes in a predictor variable and its impact on the dependent variable ceteris paribus (Abbasi et al., 2021). In this study, five thousand simulations were conducted using the dynamic ARDL error correction term technique following equation (6.0).

$$(LNCO2)_t = \beta_0 + \theta_0 LNCO2_{t-1} + \nu_1 LNGDP_t + \theta_1 LNGDP_{t-1} + \nu_2 LNGDP^2{}_t + \theta_2 LNGDP^2{}_{t-1} + \nu_3 LNFDI_t + \theta_3 LNFDI_{t-1} + \nu_4 LNTO_t + \theta_4 LNTO_{t-1} + \nu_5 LNURB_t + \theta_5 LNURB_{t-1} + \nu_6 LNENG_t + \theta_6 LNENG_{t-1} + \nu_7 LNCOR_t + \theta_7 LNCOR_{t-1} + \xi ECT_{t-1} + \eta_t \ldots (6.0)$$

where ECT_{t-1} and the ξ are the adjustment term and the coefficient in that order. The latter should be inversely significant. Thereafter, several diagnostic computations like the serial correlation, heteroscedasticity, and the Ramsey reset test were examined to ensure the reliability of the analyzed data outcomes.

3.2. Data description and source

This study used annual time series data from 1984 to 2020, covering 37 years of observation Table 1 displays the overall summary.

Table 1: Source of data

Variable	Details	Sources
CO2	CO2 emissions (metric tons per capita)	WDI
GDP	GDP per capita (constant 2015 US$)	WDI
FDI	Foreign direct investment, net inflows (% of GDP)	WDI
TO	Trade (% of GDP)	WDI
URB	Urban population growth (annual %)	WDI
ENG	Energy intake (in term of the kg of oil equivalent per capita)	WDI
COR	Corruption perception index	International Country Risk Guide

Note: WDI stand for World Development Indicator

4.0 Result and Discussion

4.1 Summary statistic and pre-test

This section reports the empirical finding of the study beginning with the summary statistics. From table 2 which shows the basic measurement of the coefficients under study it was observed that, except for carbon emission and FDI which have negative skewness, the remaining variable confirms a positive skewness for the analysis span. In respect of the dataset's highest levels, as

indicated by Kurtosis, apart from the FDI, most factors have light tails when examined. When we fail to reject the Jarque-Bera likelihood function, the normality evaluation assessment demonstrates that all series are normally distributed, which is a desirable result. Moreover, the VIF shows that there is no multicollinearity among the selected coefficients.

Table 2. Basic Descriptive statistics

	CO_2	GDP	FDI	TO	URB	ENG	CUR
Mean	0.331	7.686	0.183	3.938	1.266	7.638	3.218
Median	0.384	7.640	0.269	3.935	1.150	7.708	2.750
Maximum	0.891	8.262	1.070	4.566	1.688	8.100	5.000
Minimum	-0.328	7.096	-2.601	3.495	0.802	6.904	2.375
Std. Dev.	0.370	0.340	0.752	0.203	0.300	0.364	0.832
Skewness	-0.371	0.082	-1.574	0.502	0.029	-0.624	0.560
Kurtosis	2.061	2.000	6.384	4.316	1.407	2.186	1.893
Jarque-Bera	2.147	1.540	32.061	4.115	3.807	3.329	3.722
VIF	-	0.039	0.000	0.009	0.030	0.035	0.002

Note: [a], and [b] denote the significance at 1%, and 5% level, respectively.

Next, the stationarity characteristics of the research factors are investigated using the ADF unit root technique, the PP unit root technique, and the KPSS confirmatory non-unit root analysis, as detailed in Table 3. After accounting for the initial discrepancy, all stationarity tests including KPSS confirmatory analyses agree on stationarity at the I(1) state. Thus, the analysis of dataset authorizes the test of I~(I) and not I~ (2). This is therefore crucial when examining the long-run features. The best model is determined at lag two according to the Akaike information criterion (AIC) as presented in Table 4. From here, as seen in Tables 5 and Table 6, we apply the ARDL bounds technique and Bayer & Hanck (2013) technique for our level linkages assessment. The results of all the tests indicate that, across the time range examined, the analyzed factors coexist in a state of long-run equilibrium.

Table 3. Findings for Unit root Checks

Methods	The ADF		The PP		The KPSS	
Variable	Using I(0)	Using I(1)	Using I(0)	Using I(1)	Using I(0)	Using I(1)

$lnCO_2$	0.404	-5.308a	0.372	-5.311a	-0.011	13.145a
lnGDP	5.134	-2.895a	5.134	-2.848a	0.018	4.239a
lnFDI	-3.827a	-9.925a	-3.827a	-12.348a	-0.001	5.048a
LnTO	-0.508	-8.076a	-0.620	-8.076a	-0.011	5.519a
lnURB	-3.108a	-4.796a	-3.150b	-4.857a	0.072	9.957a
lnENG	3.653	-4.458a	4.082	-4.528a	0.000	4.970a
CUR	-2.557b	-4.788a	-2.472b	-4.849a	0.002	4.170a

Notes: [a], [b] and [c] define significance level of 1%, 5%, and 10%, respectively. The critical values and probability of KPSS test based on Kwiatkowski et al. (1992).

Table 4. Lag length criteria for ARDL model.

Lag	LogL	LR	FPE	AIC	SIC	HQ
0	113.790	NA	4.41e-12	-6.281	-5.967	-6.174
1	297.298	280.659	1.72e-15	-14.194	-11.680c	-13.336
2	365.947	76.7257c	8.02e-16c	-15.349c	-10.636	-13.742c

LR: sequential modified LR test statistic; FPE: final prediction error; AIC: Akaike information criterion; SIC: Schwarz information criterion; HQ: Hannan-Quinn information criterion. [c] Symbolises lag order selected by the criterion.

Table 5. Results of ARDL bounds test.

F-statistics	Level of significance	Lower Bound I(0)	Upper Bound I(1)	Long-run connection
5.282	10%	2.12	3.23	Confirmed
	5%	2.45	3.61	
	2.5%	2.75	3.99	
	1%	3.15	4.43	

Table 6: Results of Bayer-Hanck (2013) co-integration test

Projected Model:	$lnCO_2 = f$ (lnGDP, lnFDI, lnTO, lnURB, lnENG, CUR)

Fisher Type	Check Statistics	CV@1%	CV@5%	CV@10%	Outcome
EG-JOH	42.066 a	10.804	8.023	6.640	Co-integrated
EG-J-BO-BDM	42.076a	20.025	12.016	8.447	Co-integrated
Note: a shows the outcome are significant at the 1% level					

4.2 Results Analysis on short and long run effect

Moreover, table 7 is the breakdown of the baseline regression which simultaneously highlights the short and long-run dynamic connections between carbon emission in Malaysia and a combination of factors including corruption, FDI, trade liberalization, urbanization, growth and energy use. The existence of EKC is confirmed by the present investigation based on the regression analysis from the baseline equation. The increased desire for growth over environmental protection is pointed out by the GDP's effect on emission but the EKC validity is an indication that sustained growth may later be environmentally beneficial in Malaysia. The result of Musah (2022) and Agboola et al. (2022b) have all confirmed this inference from the Ghanian and the Turkish economy accordingly. Thus, our study's analysis shows that a percentage increase in economic growth will enhance pollution by 98.4% while at its square, pollution will reduce by 20.1% in the long run which has similar outcomes for the short run of these variables. Therefore, the chances of simultaneously attaining environmental sustainability with the current aggressive economic expansion is low in the Malaysian case. As for FDI, in the short term, Malaysia faces a positive but insignificant threat to environmental quality from the entry of foreign direct investment. This study confirms the research conducted by Gyamfi et al (2021) and Agboola et al. (2022b) who found that foreign investment inflow can positively enhance environmental quality especially over the long-term basis. Hence, as a country that is in need of a healthier environment, more enlightenment should be provided to the public on the need for green FDI while adequate vigilance is placed on FDI influx that endangers environmental quality.

Table 7. Findings of ARDL simulations model.

Variables	Coefficients	Stand. Error	T-Stat.
Cons.	10.855a	2.609	4.159
lnGDP	0.984b	0.432	2.274
△lnGDP	1.359a	0.422	3.219

$lnGDP^2$	-0.201b	0.147	-2.301
$\triangle lnGDP^2$	-0.084c	0.061	-1.782
lnFDI	0.059b	0.050	1.177
△lnFDI	0.004	0.017	-0.266
lnTO	0.170a	0.255	0.667
△lnTO	-0.054	0.113	-0.473
lnURB	0.431b	0.438	0.985
△lnURB	0.084	0.206	-0.406
lnENG	0.341b	0.352	0.970
△lnENG	0.181	0.211	0.859
CUR	-0.075c	0.105	-0.713
△CUR	-0.039c	0.051	-0.768
ECT(-1)	-0.531a	0.172	-3.079
R^2	0.987	Prob > F	0.0 00[a]
Adj. R^2	0.979		
Simulation		5000	

[a], [b] and [c] denote significance at 1%, 5% and 10% level, respectively.

Furthermore, on long run observation, trade is seen to have a positive significant connection with pollution from carbon emission while in the short run on the contrary, a negative insignificant connection is observed. The positive relation involving trade and CO_2 emissions in Malaysia are explainable. A huge amount of oil, for instance, is imported from less developed nations and used in the manufacturing process. Moreover, the food and construction industries in this country rely substantially on imports which make up a significant portion of consumer spending and, as such, contribute significantly to pollution levels. Lin and Huang (2022) also confirmed similar outcomes.

Similarly, Table 7 shows that the ecological cost of urbanization of the Malaysian economy—which includes a rise in the urban population—is higher than its perceived benefits. Increasing urbanization by 1%, reduces environmental quality by 43.1% in the long run and 8.4% in the short run, with the magnitude of the coefficient increasing from the former time period to the latter. The harmful effect of undomesticated urban cities validates with the analysis of Agboola et al. (2022b) and Ozatac et al. (2017). Moreover, energy use positively affects carbon emission in the long-run but its short run influences are actually insignificant. A large portion of Malaysia's environmental deterioration may be traced back to the country's high yearly per capita energy usage of around 200 KgOE. Even though it has lately evolved as an emerging market, Malaysia still relies on coal, natural gas, and oil to generate its electricity. Natural gas accounts for 62.9%, diesel 10%, coal 5%, heavy oil 3%, and other renewables 3% of all electricity production (Taheruzzaman & Janik, 2016). The current energy scenario in Malaysia, which relies heavily on fossil fuels, does not promote ecological safety. This outcome is in line with the findings of Islam et al (2021) and Abbasi & Adedoyin (2021). Lastly, the corruption index which denotes institutional quality has a negatively significant relationship with carbon emission for both long and short run. There is widespread agreement that corruption is bad for a country's economy especially in a long-term basis (Ren et al., 2021). Corruption has a number of negative effects on economic development (Ali and Sassi, 2016). As the "sand wheel" hypothesis explains, when money changes hands corruptly, it ends up being spent on things that do not add value to society (Mauro, 1998). Also, corruption undermines eco-regulation, but this effect fades with rising political stability (Ren et al. 2021). The rate at which carbon emissions fall is inversely proportional to the rate at which technology and the rules governing them improve. Increases in income and prosperity tend to lower the prevalence of bribery. As a result, a stronger economy in Malaysia will contribute to less corruption and fewer greenhouse gas emissions. It's important to remember that corruption has an impact on both GDP per capita and carbon pollution in the long term, despite the fact that it helps lower Malaysia's per capita pollution during the sampling period. Corrupt practices will have an impact on the correlation between carbon pollution and economic expansion (Ren et al., 2021). The error correction term (ECT) characterizes the rate of adaptation. Its estimated value is negative and statistically significant, suggesting a lasting relationship between the factors under investigation. The predicted value of ECT is -0.531, which means that 53.1% of the disequilibrium will be corrected in the long run.

Using dynamic ARDL simulations, we can automatically depict the predicted effects of a genuine regressor modification on the regressand, while keeping all other explanatory factors fixed. This analysis shows how CO_2 levels in Malaysia change when various independent variables are

increased or decreased by 10%. The growth-emission link is well depicted in Figure 5 (impulse response graph). The situation in Malaysia always worsens whenever economic growth increases or decreases by 10% in the short term. However, the ecological impact brought on by accelerated economic growth is becoming increasingly obvious as time passes. Conversely, for each ten % cut in economic growth, CO_2 amounts decline, and the ecosystem eventually gets better. The degradation of the environment cannot be stopped with just a 10% cut in economic development.

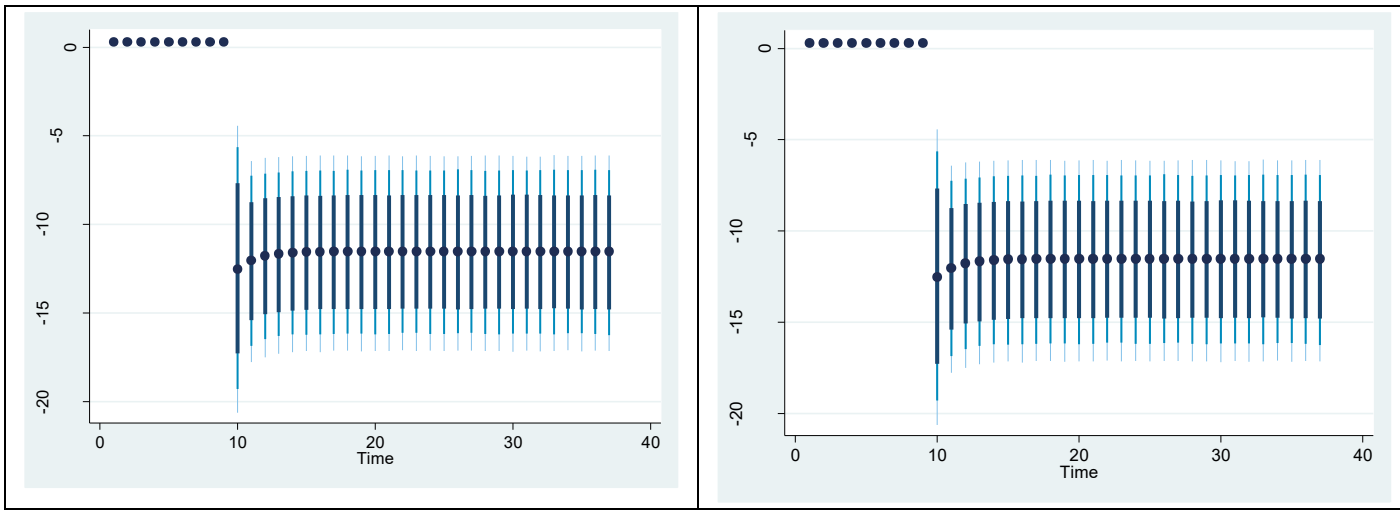


Figure 5. Growth & pollution levels

As observed in Figure 6, there is a ± ten % change in Malaysian pollutants level with the influence of trade liberalization. The tick points denote the predicted assessment, while the tick blue ray up to the light lines designate the corresponding confidence intervals at 75%, 90%, & 95%, correspondingly. As crucial as trade liberalization is to Malaysia's economy, it inevitably has negative effects on the country's natural resources. For every 10% change in trade, environmental destruction increases or decreases in the short run (Figure 6), but an increase in trade is worse for the ecology in the long run. Therefore, regulators should carefully monitor new trade into the Malaysian economy to enhance the ecosystem's long-term health.

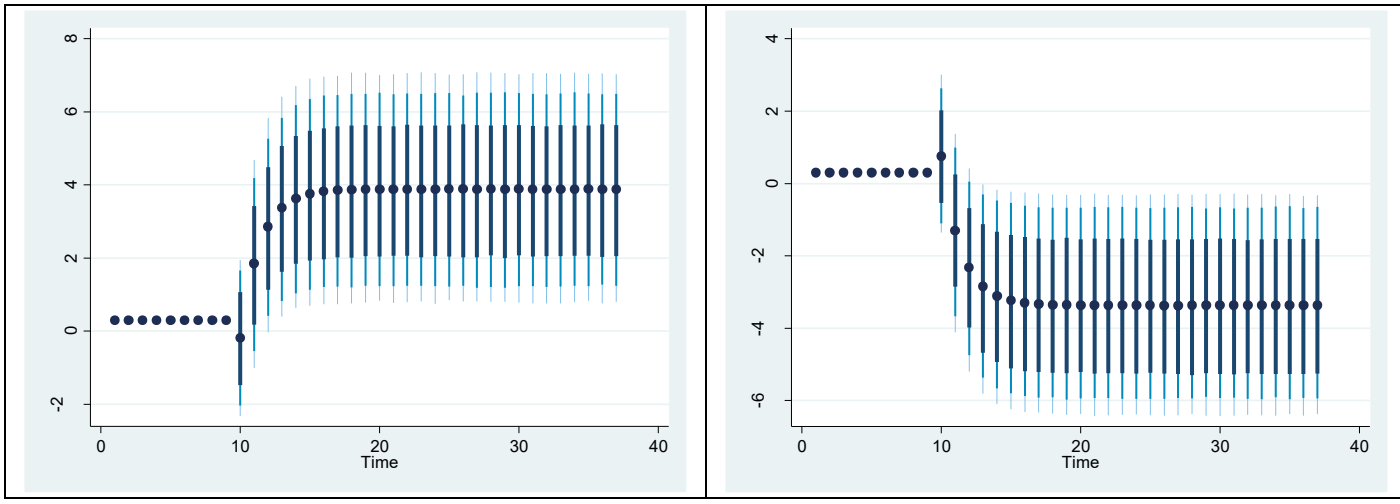


Figure 6. Trade libralization and ecological dilapidation.

The figure 7 indicates ± ten % change in urbanization and its influence on Malaysian pollutants level. The dots denote the predicted assessment, while the deep blue to light blue lines designate the 75%, 90%, and 95% confidence intervals, correspondingly. Variations in urbanization, both positive and negative, will induce alterations in carbon dioxide levels, as seen in Figure 7. Whether the urbanization grows or shrinks by 10%, it is evident that this will have no noticeable impact on ecological quality in the near future. In contrast, growing amounts of carbon dioxide emissions into the atmosphere harm environmental quality with every 10% rise in Urbanization. Each 10% decline of Urbanization to the horizon enhances ecological integrity, but this is still insufficient to fully neutralize carbon pollution and produce a healthier society.

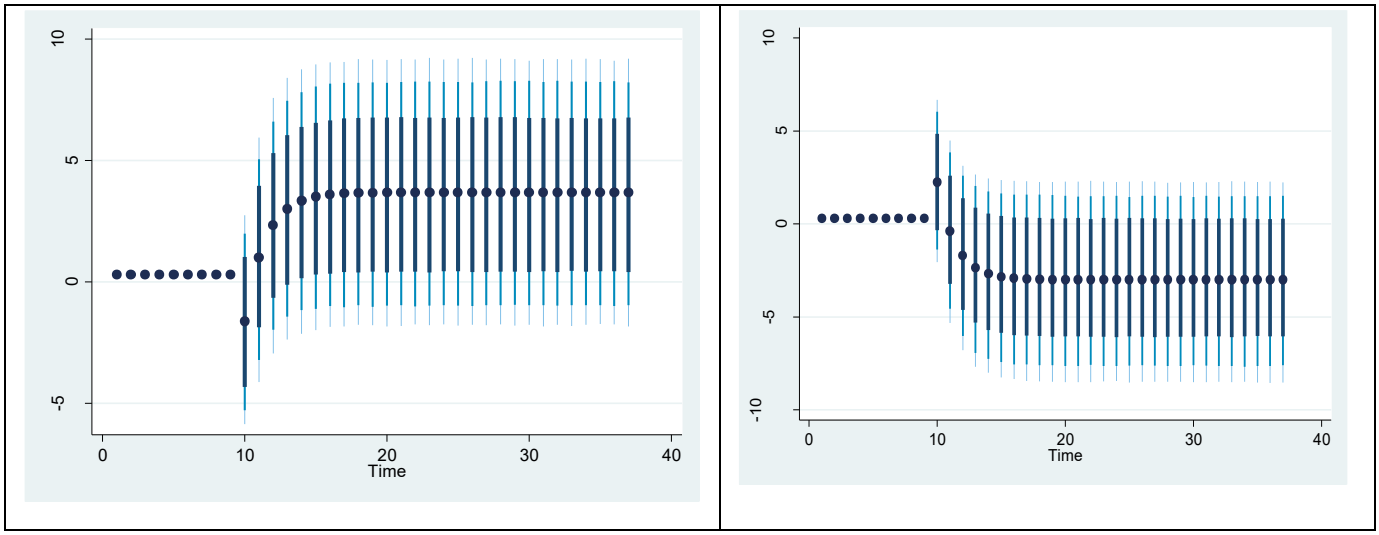


Figure 7. Urbannization and ecological dilapidation.

The figure 8 indicates ± ten % change in energy use and its influence on Malaysian pollutants level. The dots denote the predicted assessment, while the deep blue to light blue lines designate the 75%, 90%, and 95% confidence intervals, correspondingly. Figure 8 displays the impulse response

graph of Malaysia's energy consumption and carbon dioxide emissions. The energy usage graph clearly demonstrates that an increase of just 10% in energy usage has a significant negative effect on both the immediate and distant future state of the ecology. But in the long and short run, a 10% cut would have a negative effect on CO_2 pollution. This suggests that increased energy use in Malaysia has a negative impact on ecological integrity. Thus, Malaysia should monitor the shift toward alternative energy use from fossil fuels in order to preserve ecological integrity.

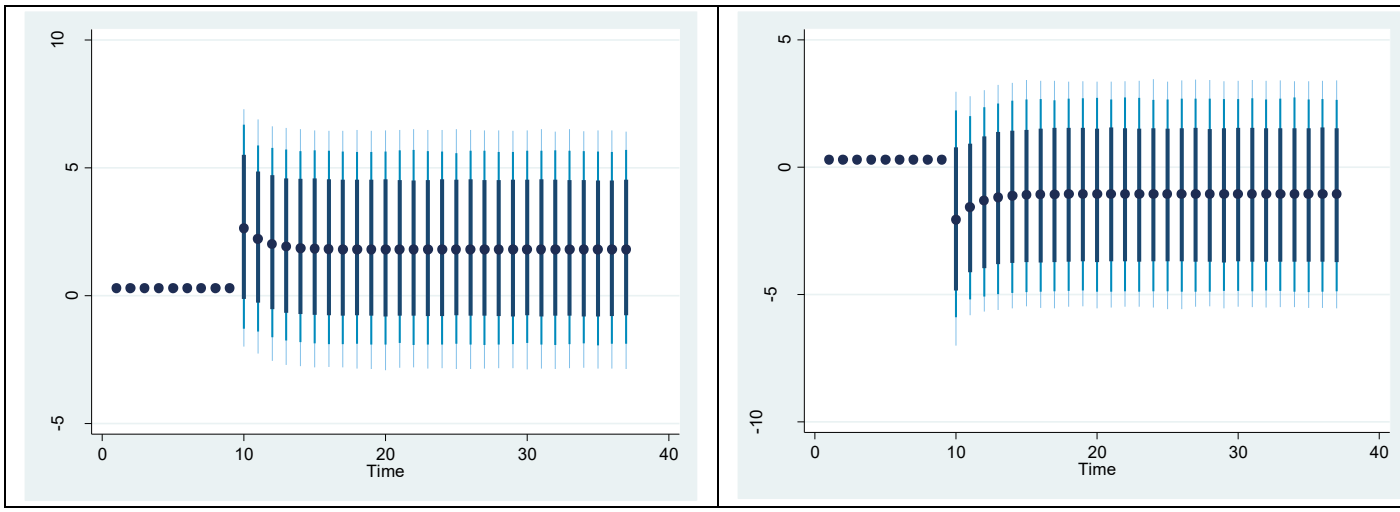


Figure 8. Energy use and Pollution.

As observed in Figure 9, there is a ± ten % change in Malaysian pollutants level with the influence of FDI. The tick points denote the predicted assessment, while the tick blue ray up to the light lines designate the corresponding confidence intervals at 75%, 90%, & 95%, correspondingly. As crucial as foreign direct investment is to Malaysia's economy, it inevitably has negative effects on the country's natural resources. For every 10% change in FDI, pollution increases or decreases in the short run (Figure 9), but an increase in FDI is worse for the environment in the long term. Undoubtedly, foreign direct investment is responsible for the ongoing ecological crisis in Malaysia. Therefore, regulators should carefully monitor new FDI into the Malaysian economy to enhance the ecosystem's long-term health.

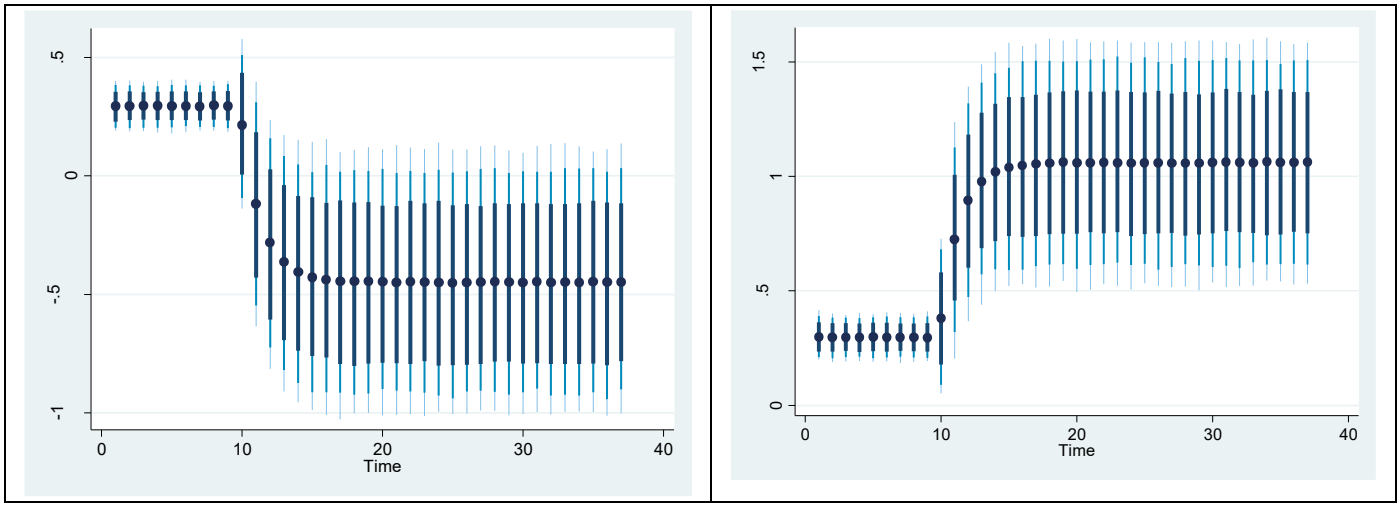


Figure 9. FDI and Pollution.

The figure 10 indicates ± ten % cnage in the corruption and its influence on Malaysian pollutants level. The dots denote the predicted assessment, while the deep blue to light blue lines designate the 75%, 90%, and 95% confidence intervals, correspondingly. The relationship between corruption and CO_2 emissions is depicted in Figure 10's impulse response graph. The situation in Malaysia always worsens whenever corruption increases or decreases by 10% in the short term. However, the environmental effects brought on by accelerated corruption is becoming increasingly obvious as time passes. Conversely, for every 10% cut in corruption, CO_2 levels decline, and the ecosystem heals itself. The degradation of the environment cannot be stopped with just a 10% cut in corruption level.

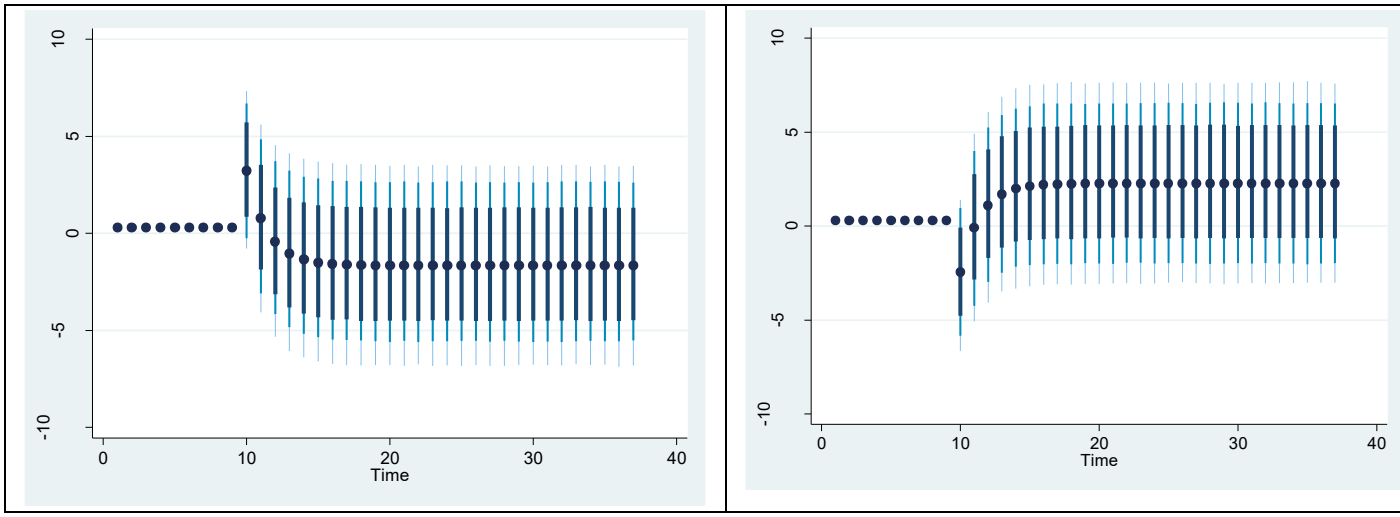


Figure 10. Coruption and ecological dilapidation.

Lastly, Table 8 shows that the foundation model is fit, as it satisfies all diagnostic checks (such as the serial correlation test, ARCH check, heteroscedasticity check, and model specification test). As a result, our adjusted model can be used to guide policymaking. The blue lines in Figure 11's

CUSUM and CUSUMsq graphs, which are presented to show model durability, are inside the acceptable 5% threshold, showing that the equipped model is reliable.

Table 8. Residual diagnostic technique

Diagnostic test	Chi-square (Prob.)	Outcomes
Breusch-Godfrey Serial Correlation LM	0.4190	No outcome of serial auto correlations
Breusch-Pagan-Godfrey	0.6497	No outcome of heteroscedasticity
ARCH technique	0.4862	No issue of heteroscedasticity
Ramsey RESET technique	0.6163	Specification is fine

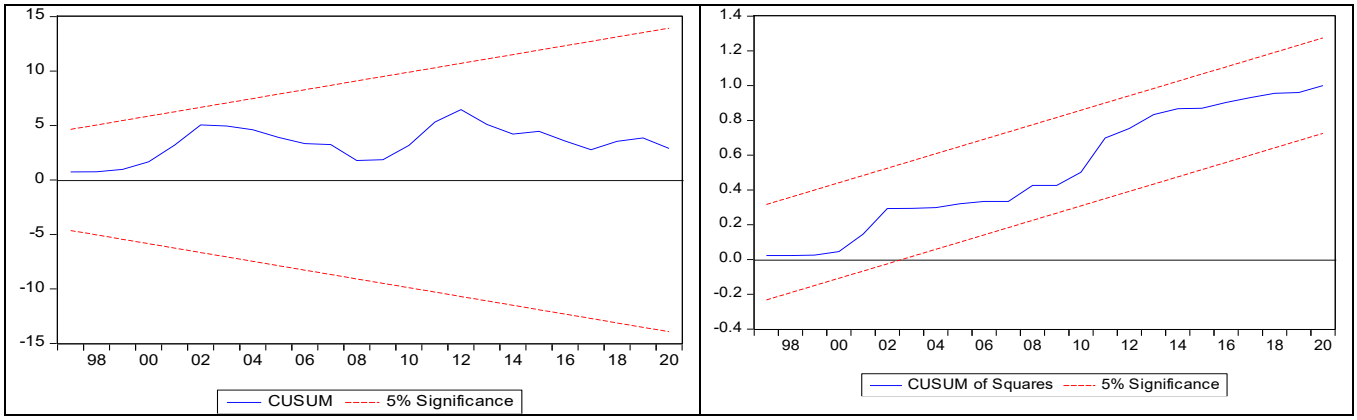


Figure 11. CUSUM and CUSUM square technique.

5. Conclusion and Recommendations

5.1 Conclusion

When compared to other East Asian and Southeast Asian countries, corruption levels in Malaysia are low[1]. Many Malaysians believe that all politicians in the country are rife with corruption, based on a study taken by Transparency International in 2013. According to a recent survey (Global Corruption Barometer 2013), 25% of households believe that there is ineffectiveness in fighting corruption[2]. Moreover, per the Transparency International's 2021 Corruption Perception Index, the nation is placed 62nd out of 180 in terms of overall perception levels of corruption within the

[1] https://www.ganintegrity.com/portal/country-profiles/malaysia/
[2] https://web.archive.org/web/20160510232254/http://www.business-anti-corruption.com/country-profiles/east-asia-the-pacific/malaysia/show-all.aspx

public sector[3]. The World Economic Forum's Global Competitiveness Report 2013-2014 found that dishonest corporate practices were a barrier to conducting business in Malaysia, based on responses from polled business leaders[4]. To this effect, this study investigates the impact of corruption, foreign direct investment and trade liberalization on carbon emission from 1984 to 2020 using the novel dynamic ARDL simulation technique while accounting for urbanization and energy use for Malaysia. From the empirical findings, it was observed that both the long and short run of economic growth have positive connection with carbon emission while it's square have negative connection with carbon emission for short and long run. This confirms the inverted U-Shaped EKC for the study. Moreover, FDI was seen to have a positively significant long run relationship with carbon emission while its short run was positively insignificant. This affirms the PHH for the Malaysian economy. On the other hand, corruption was seen to have a negative significant relationship with carbon emission for both the short and long run. Nevertheless, both urbanization and energy use were seen to have a positive connection with carbon emission.

5.2 Policy Recommendations

Some policy recommendations are made in light of the findings, especially with regard to the desired roles of FDI and corruption control. One assertion makes the case that decreasing corruption in emerging economies has a more significant impact on the rising trend of emissions than in the rich nations (Akhbari & Nejati 2019). Theoretically, the degree of corruption in advanced economies has already dropped to an acceptable level thanks to the formation of governmental authorities, and any additional efforts to reduce corruption would be prohibitively expensive. Attaining lower pollution level is dependent on the improvement of other components, so small adjustments in corruption will not have a big impact on either. However, in emerging economies like Malaysia, where regulatory institutions have not yet been established and corrective legislation has not yet been enacted, greedy conduct is still rampant. This would lead to ecological deterioration and a rise in pollution in developing nations within the context of the PHH. Low manufacturing costs for emissions reduction and subsequent transfers of assets in the form of dirty businesses from industrialized countries are a direct result of a lack of preventative and regulatory policies on damaging economic activities. The idea states that this method only worsens environmental conditions in underdeveloped and less developed nations. It is critical to enhance the regulation of corruption and boost openness in municipal governments. As a result, the Discipline Inspection Department's oversight and investigation must be bolstered, and the

[3] Hii,Veena Babulala and Faustina (25 January 2022). "Malaysia drops five spots to 62 in TI-M's corruption index rankings | New Straits Times"
[4] "Global Competitiveness Report 2013-2014". The World Economic Forum.

framework for mutual oversight must be enhanced. Additionally, employing the watchdog roles of public opinion is crucial for guiding against dishonest regulators from abusing their power and ensuring that appropriate policies are put into place. In addition, the work of foundational government agencies should be thoroughly inspected in order to increase responsibility at the departmental level. To keep the government's credibility at a high level, it is imperative that corrupt officials be severely punished. We therefore recommend that public institutions should be strengthened so that they can fully discharge their responsibilities.

Furthermore, the "drive-off dividend" of FDI regarding carbon emission efficiency needs more investigation. While increasing FDI across the board in different areas, it is essential to enhance both FDI and the low-carbon economic structure board in different areas, it is essential to enhance both FDI and the low-carbon economic structure. Increased alignment among FDI and the building of a low-carbon economic structure strengthens the interacting channel connecting FDI and low-carbon economic progress in the country of residence and boosts the boosting influence of FDI on carbon pollution efficiency in the nation. But local authorities also need to push for "green" innovations in how FDI is used, embracing the chance to lead the world in environmentally friendly technology.

The study also shows that increased trade openness increases carbon dioxide emissions in Malaysia. It follows that the country's trading system must be modified in order to accomplish a carbon reduction goal. In particular, financial incentives should be provided to promote the exchange of low-carbon items and discourage the exchange of high-carbon products. Additionally, the positive economic output-CO_2 nexus suggests that the country should integrate energy-saving and emission-reduction programs into its efforts to promote productivity expansion if it is to attain green and sustainable economic expansion.

Limitations and Direction for Future Study

While the empirical findings for Malaysia in the present study are intriguing, the study suffers from the commonplace assumption that CO_2 emissions are the only cause of environmental degradation. Therefore, more study is required to investigate alternate proxies of environmental degradation.

Declarations:

Ethics approval and consent to participate: NA

Consent for publication: NA

Authors' contributions: The first author (Bright Akwasi GYAMFI) was responsible for the conceptual construction of the study's idea. The second author (Stephen Taiwo ONIFADE) alongside the third and Fourth author (Abdul Rahim RIDZUAN), (Mohd Shahidan SHAARI) handled the introduction and literature sections. The data gathering, preliminary analysis, simulation was carried out by the first author and last author (Pabitra Kumar JENA), while the general result interpretation, policy framework and manuscript editing were carried out by the second author.

Availability of data and materials: The data for this present study are sourced from the database of the World Development Indicators (WDI) Available at: https://data.worldbank.org, and International Country Risk Guide data. Available at (https://www.eui.eu/Research).

Competing interests: The authors wish to disclose here that there are no potential conflicts of interest at any level of this study.

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