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The Impacts of Energy Use, Tourism and Foreign Workers on CO_2 Emissions in Malaysia

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Abstract: Previous studies have investigated various determinants of CO_2 emissions, such as energy use, economic expansion and population growth. However, foreign workers have not been treated as a potential determinant. Therefore, this research embarks on an investigation into the impacts of energy use, foreign workers and tourist arrivals on CO_2 emissions in Malaysia from 1982 to 2018. An ARDL approach was employed, and the findings showed that natural gas and electricity use insignificantly influence CO_2 emissions. Tourist arrivals, coal use and oil use were found to positively influence CO_2 emissions, while foreign workers and population growth insignificantly influence CO_2 emissions. It was found that in the early stages of development, higher GDP negatively influences CO_2 emissions, but in the final stages, higher GDP positively influences CO_2 emissions. These findings are important for formulating policies to reduce environmental degradation stemming from higher CO_2 emissions. Malaysia should use more renewable energy sources, and a carbon tax could be imposed to reduce environmental degradation.

Keywords: energy use; foreign workers; tourist arrivals; CO_2 emissions

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Citation: Rahman, A.R.A.; Shaari, M.S.; Masnan, F.; Esquivias, M.A. The Impacts of Energy Use, Tourism and Foreign Workers on CO_2 Emissions in Malaysia. *Sustainability* **2022**, *14*, 2461. https://doi.org/10.3390/su14042461

Academic Editor: Grigorios L. Kyriakopoulos

Received: 19 January 2022
Accepted: 17 February 2022
Published: 21 February 2022

1. Introduction

Carbon emissions are responsible for ozone depletion, having an unfavourable impact on the environment. An inexorable increase in carbon emissions can lead to higher global temperatures [1]. Compared with other gas emissions, such as CH_4, N_2O and F-gases, CO_2 is the primary catalyst for global climate change, contributing 65% of the total greenhouse gas emissions. What sets alarm bells ringing regarding whether global climate change is taking place, is that it may lead to natural disasters, such as hurricanes, great fires, serious droughts and deadly heatwaves. The global temperature is rising, influencing agricultural yields and natural wildlife habitats. According to Dava [2], the average temperature in Malaysia has increased by about 1.2 °C in the last 50 years. If no prompt action is taken to control CO_2 emissions, the temperature may continue to rise until 2030. This will cause rice yields to drop by about 12% to 31.3%.

Due to the environmental issue, it is vital to reduce CO_2 emissions urgently. Therefore, factors such as energy use, economic growth, tourism, etc., that can contribute to CO_2 emissions, must be investigated to formulate the right policies [3–5]. Most previous studies used the IPAT model to examine how population growth, energy use and economic growth influence the environment. The model that has been introduced by Ehrlich and Holdren [6] provides a theoretical framework that emphasises three determinants of the environment (I): population (P), affluence (A) and technology (T). Energy use represents technology (T) in the model. Technology, such as machines, computers and vehicles, consumes energy, and this can have undesirable impacts on CO_2 emissions [7,8]. The burning of fossil energy, such as coal, oil and natural gas, can release CO_2 into the air, thus harming the environment. Some studies examined the impacts of energy use by type, especially non-renewable energy, such as oil, gas and coal, on CO_2 emissions [9]. They found that these types of energy may lead to CO_2 emissions.

Besides technology, economic expansion representing affluence (A) can also cause CO_2 emissions to rise [10]. Figure 1 shows total GDP at constant prices in Malaysia from 2009 to 2019. Based on the figure, it can be observed that GDP in the country exhibited an upward trend, with the highest GDP recorded in 2019 at RM1.424 trillion.

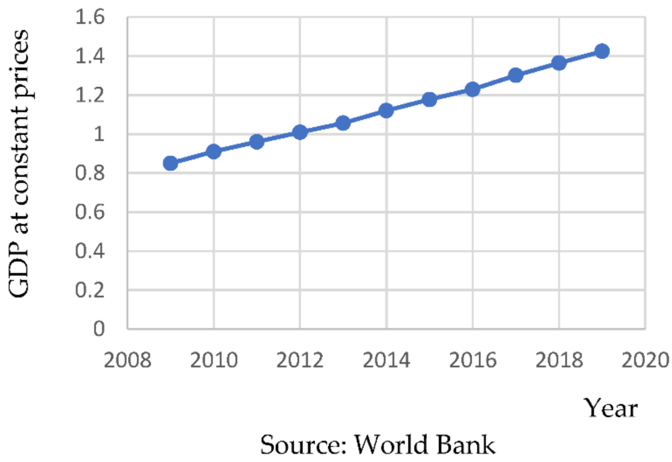

Figure 1. Gross domestic product (GDP) at constant prices (RM trillion).

Figure 2 shows the trend in total energy demand by sector. Energy plays an important role in all sectors as it exhibits an upward trend from 2008 to 2019. The transportation sector consumes the biggest proportion of total energy use, followed by the manufacturing sector. The agricultural sector is the smallest energy consumer. Energy is compressed, liquefied and finally used in automobiles, buses, trucks and ships.

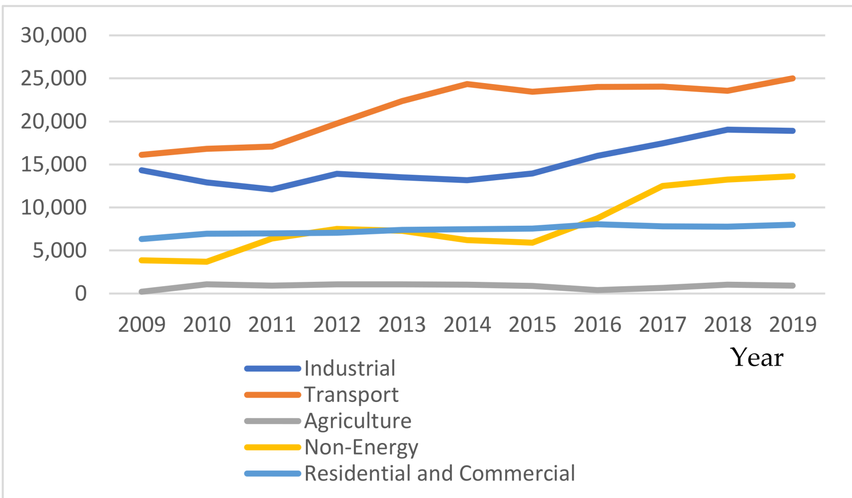

Figure 2. Final Energy Demand by Sectors (Ktoe).

According to the IPAT model, population growth can also harm the environment. Over decades, a rapid escalation in the population can enhance CO_2 emissions [11]. The world has experienced a rapid increase in the total global population over the last three centuries. We must bear in mind that environmental issues, such as growing CO_2 emissions in the atmosphere, may emerge. As the global population grows, the demand for energy, such as oil, gas, coal, etc., also increases. As a result, CO_2 will be released into the atmosphere when energy is burned. China has the biggest population in the world, and it is the biggest emitter of CO_2. The country contributes the largest share of the total global CO_2 emissions at 28%. This suggests that its large population may be detrimental to the environment.

Considering the local population as a determinant of CO_2 emissions is not adequate without also considering foreigners. An increase in foreigners, including tourists and foreign workers, may potentially harm the environment. Zaman et al. [12] found that tourist arrivals can also adversely influence the environment despite its favourable contribution to economic growth. The tourism industry acts as a catalyst for economic expansion in developing countries [13,14]. However, boosting the sector entails extensive energy use, which may release CO_2. Peeters et al. [15] supported the negative effect of tourism on CO_2 emissions, as fuel is consumed in transportation for tourists. Tourists who travel inevitably use aeroplanes, vehicles, trains, boats and even hot air balloons, significantly impacting the environment. Transportation in the tourism industry can contribute to greenhouse gas emissions. Aircraft and cars emit the highest CO_2 per passenger, followed by buses, ferries and trains. Due to transportation development, tourism has increased dramatically. Hence, greater CO_2 emissions have ensued. Tourism is still one of the most important industries in Malaysia; it contributed 13.3% of GDP in 2020. Figure 3 shows tourism receipts in Malaysia from 2009 to 2019. Tourism receipts in the country showed an upward trend during this period. Malaysia received RM53.4 billion in 2009, and this figure increased by 61.23% to RM86.1 billion in 2019.

Figure 3. Tourism receipts (RM billion).

Previous studies did not include foreign workers, although this variable can also potentially harm the environment. Foreign workers have been perceived to play a pivotal role in boosting economic growth. They do not necessarily compete with local workers who prefer to work in critical sectors, such as agriculture, mining, quarrying and construction, because jobs in these sectors are deemed not to be sufficiently lucrative. Most jobs require workers to spend time outdoors under the sun, which many local workers are unwilling to do. Hence, in Malaysia, the number of foreign workers increased by 2.44%, from 2,183,400 in 2018 to 2,236,600 in 2019 [16]. Malaysia receives foreign workers from various nations, such as Indonesia, India, Nepal, Bangladesh, etc., to contribute to various economic sectors. According to the Department of Statistics, the manufacturing sector employed the largest share of total foreign workers at 36.58% in 2018, followed by the construction sector (18.8%), the plantation sector (15.07%), the services sector (13.63%), and the agriculture sector (8.8%). More foreign workers are needed to work in these sectors and this implies that more CO_2 will be released, with environmental degradation ensuing as a result.

2. Literature Review

This section explains the theoretical framework and previous empirical studies on the determinants of environmental degradation.

2.1. Theoretical Framework

The IPAT model was introduced by Ehrlich and Holdren [6] to explain the impacts of population growth (P), affluence (A) and technology (T) on the environment (E). The model provides a theoretical framework that can serve as a building block for this study. It is expected that the use of technology can result in higher environmental degradation. Environmental degradation can also stem from population growth. Besides, increasing affluence can also contribute to environmental degradation. Besides the IPAT model, the environmental Kuznets curve (EKC) is also used to explain environmental degradation. Grossman and Krueger [17] proposed an EKC that represents a non-linear connection between GDP per capita and environmental degradation. The curve suggests that in the early stages of development, environmental degradation deteriorates and then reaches a turning point. The stages are connected to developing countries that focus on boosting their industrial output by relying only on non-renewable energy. In the following stages, environmental degradation is believed to fall, and these stages are related to developed countries that have a high awareness of the environment. They have advanced technology to reduce environmental degradation. Furthermore, their economy is driven by the service sector, which does not produce much pollution.

2.2. Empirical Studies on the Nexus of CO_2 Emissions, Energy Consumption, and Economic Growth

Innumerable past studies have examined the influences of energy consumption, population growth and economic expansion on environmental degradation, such as Shikwambana et al. [18], Sulaiman and Abdul-Rahim [19] and Antonakakis et al. [20]. However, their findings are mixed, and thus it remains complex to formulate the right policies. Various methods have been employed to analyse data. Sulaiman and Abdul-Rahim [19] employed the autoregressive distributed lag (ARDL) technique to evaluate whether population growth, GDP and energy use affect CO_2 emissions in Nigeria. The influences were observed for the following three time periods: 1971–2000, 1971–2005 and 1971–2010. The VECM Granger causality approach was also employed to investigate the association between the variables in the short and long run. The results showed that greater CO_2 emissions are primarily due to economic expansion. Population growth and energy use were discovered to be minor contributors to CO_2. Economic development, population growth and energy use were also discovered to influence CO_2 emissions in the short run.

The nexus between energy and environmental degradation has also been examined in a large number of countries. Employing the PVAR and impulse response methods for a sample of 106 countries, Antonakakis et al. [20] found evidence on the environmental Kuznets curve (EKC) hypothesis. The study demonstrated that continuous economic expansion exacerbates greenhouse gas emissions. The findings cast doubt on current government policies to promote renewable energy use as a measure of achieving long-term growth. In a study covering 68 emerging countries, including the Middle East and North Africa, Muhammad [21] employed Seemingly Unrelated Regressions (SUR) and System Generalised Method of Moments (SGMM). The empirical results find that the economy escalates in both developed and emerging countries as energy consumption rises. Energy use rises as CO_2 emissions increase, and the economy also grows. Dong et al. [22], using unbalanced panel data for 128 nations from 1990 to 2014, found that population and economic growth positively and significantly impact CO_2 emissions. Dong et al. [22] pointed out that increasing renewable energy use can reduce CO_2 emissions in six nations. The impacts in Latin America, Europe and Eurasia are much higher than in other regions.

Previous studies also investigated the relationships between CO_2 emissions, energy use, population growth and economic expansion in the Association of Southeast Asian region (ASEAN). Chontanawat [23] employed co-integration and causality methods and found a significant long-run nexus between energy use, CO_2 emissions and economic expansion in the ASEAN. The findings suggested that policies to reduce energy use, whether through improving energy efficiency or exploring new energy sources, should be considered because they could reduce environmental degradation while having no negative influences on economic growth. Meanwhile, Vo et al. [24] supported the EKC hypothesis in the long run for the ASEAN-5 countries. Using data from 1971 to 2014, the findings showed a significant nexus between the variables in Indonesia, Myanmar and Malaysia. In Indonesia and Malaysia, the EKC hypothesis was confirmed. However, the causal relationship between the variables differs greatly across the nations, suggesting single-country studies. There is no causal relationship between emissions and renewable energy use in Malaysia, the Philippines and Thailand.

The nexus between energy consumption, economic growth and emissions in the ASEAN has also been examined in single-country studies. Shaari et al. [25] explored whether national output and electricity use can affect CO_2 emissions in Malaysia from 1971 to 2013. Employing the ARDL approach, both electricity use and national output impact CO_2 emissions in the long run. The findings also demonstrated that Malaysia's energy use and national output have no short-run impacts on CO_2 emissions. Sasana and Putri [26] explored whether CO_2 emissions are influenced by fossil fuel use, population growth and renewable energy use. Annual data from 1990 to 2014 were analysed employing the Ordinary Least Squares (OLS) approach. The results revealed that Indonesia's fossil fuels and a higher population might harm the environment. However, the use of renewable energy may help to lessen environmental degradation.

Single-country studies outside the ASEAN have also been carried out to examine the Kuznets curve (EKC) hypothesis. Shikwambana et al. [18] delved into factors in various emissions, such as CO_2, BC, SO2 and CO in South Africa, and applied the sequential Mann-Kendall (SQMK) method. The correlation coefficient suggests a positive linear relationship between GDP and CO_2 emissions, but there is no significant linear relationship between GDP and other emission variables (e.g., CO). Shikwambana et al. [18] found an N-shaped EKC for SO_2 and CO, concluding that emissions are linked to economic growth. Khan, Hou and Le [27] studied the influences of natural resource use, energy use and population growth on the United States' (US's) footprint and CO_2 emissions from 1971 to 2016. The Generalised Method of Moments (GMM), Generalized Linear Model (GLM) and Ordinary Least Squares (OLS) methods were employed. The results showed that natural resource use and renewable energy sources enhance the quality of the environment over time, while population growth and the use of non-renewable energy sources, on the other hand, worsen the quality of the environment.

2.3. The Effects of Energy Use, Tourism and Foreign Workers on Carbon Dioxide Emissions

A few studies, such as Kocak et al. [28], Jebli et al. [29] and Paramati et al. [30], included tourism as a determinant of CO_2 emissions. They concluded that tourism could influence CO_2 emissions. Jebli et al. [29] examined the causal relationships among CO_2 emissions, international tourism from energy use, transportation and real GDP in the top ten international tourism destinations from 1995 to 2013, the VECM and the Granger causality tests procedure were employed. The findings showed that CO_2 emissions can cause economic growth without feedback. Economic expansion can affect energy use without feedback. There is also a bidirectional relationship between economic growth, international tourism and energy use. Kocak et al. [28] explored how CO_2 emissions, the essential driver of global warming and environmental change, react to tourism development. From 1995 to 2014, the influence of tourism development on environmental degradation in the most visited nations was examined by employing Continuously Updated and Fully Modified (CUP-FM) and Continuously Updated Bias-Corrected (CUP-BC) estimators. The findings revealed that tourist arrivals might increasingly influence CO_2 emission, while tourism receipts decreasingly influence CO_2 emissions.

Based on the previous literature, there are various factors that can influence CO_2 emissions, such as population growth, tourism, economic expansion and energy use. However, none of the prior literature investigated the impact of foreign workers on CO_2 emissions. The use of more foreign workers can potentially result in CO_2 emissions escalating. Many companies prefer to employ foreign workers because of low wages, which can increase output, leading to an increase in CO_2 emissions.

3. Materials and Methods

This research uses time-series data from 1982 to 2018 on electricity use, oil use, natural gas use and coal use from Malaysia Energy Hub, real GDP per capita and CO_2 emissions from country.economy. The model specification in this study is derived from a combination of two economic models, namely, the environmental Kuznets curve (EKC) and IPAT. The EKC model is used in this study to investigate the inverted U-shaped EKC. The model is described as follows:

$$\ln E_t = \varphi GDP_t + \varnothing \ln GDP_t^2 + v_1 \quad (1)$$

where E is environmental degradation, GDP is GDP per capita in the early stages of development, GDP^2 is GDP per capita in the final stages of development, v is the error term, and φ and $\varnothing$ are parameters, such that $\varphi > 0$ and $\varnothing < 0$. Besides the EKC model, this research also uses the IPAT model, and the model is as follows:

$$I = f\,(P, A, T) \quad (2)$$

Many previous studies have investigated the impacts of energy use and economic expansion on CO_2 emissions using the IPAT and EKC models. Therefore, this study also uses the same proxies whereby CO_2 emissions are a proxy for environmental degradation, GDP per capita is a proxy for affluence, population growth is a proxy for population and energy consumption is a catalyst for technology. This study divides energy into several types, particularly electricity, natural gas, oil and coal. Therefore, our model specification is as follows:

$$\begin{aligned} \ln CO_{2t} = \partial_0 + \partial_1 \ln GDP_t + \partial_2 \ln GDP_t^2 + \partial_3 \ln POP + \partial_4 \ln TA + \partial_5 \ln FW \\ + \partial_6 \ln E + \partial_7 \ln C + \partial_8 \ln O + \partial_9 \ln NG + \upsilon_t \end{aligned} \quad (3)$$

where $\ln CO_2$ represents the log of CO_2 emissions, and lnGDP is the log of GDP per capita. lnPOP is the log of population growth, lnTA is the log of tourist arrivals, lnFW is the log of foreign workers, lnE is the log of electricity use, lnC is the log of coal use, lnO is the log of oil use and lnNG is the log of gas use. The variables used in this study are described in Table 1.

Table 1. Variable Descriptions.

Variable	Description	Source	Symbols
CO_2 Emissions	CO_2 emissions metric tonne	Country.economy	CO_2
Coal Use	Final Coal Use (ktoe)	Malaysia Energy Information Hub	C
Oil Use	Final Oil Use (ktoe)	Malaysia Energy Information Hub	O
Foreign employment	Increase in foreign employment	Department of Statistics	FW
Population	Population growth	Department of Statistics	POP
Gas Use	Final Gas Use (ktoe)	Malaysia Energy Information Hub	NG
Tourist Arrivals	Tourist arrival in country	Department of Statistics	TA
Electricity use	Final Electricity Use (ktoe)	Malaysia Energy Information Hub	E
Economic expansion	Constant LCU	Country.economy	GDP

This study examines the long-run and short-run relationships between tourist arrivals, foreign workers, population growth, energy use (oil, electricity, gas and coal), economic expansion and CO_2 emissions using the ARDL approach introduced by Pesaran et al. [31]. ARDL models are ordinary least squares regressions, with lags of the dependent variable and independent variables as regressors. The method can be used to examine the co-integrating relationship between the variables. The employment of the ARDL method provides more advantages in comparison with the Johansen approach and Engle-Granger methods. One of the advantages is that the model can be estimated regardless of whether the variables are integrated of order I (0), I (1), or mixed order I (0) and I (1). Therefore, it is important to conduct a unit root test to ensure that the order of integration is not I (2). Hence, the Augmented Dickey-Fuller (ADF) test is employed to check the existence of a unit root in the time-series data analysis as follows:

$$\Delta Z_t = \alpha_0 + \alpha_1 Z_{t-1} - Z_{t-1} + \epsilon_t \tag{4}$$

where Δ is the first differential operator,ϵ_t is the white noise and X_t is a time-series variable. The hypotheses that need to be tested are the null hypothesis (η1 = 0), which means the existence of a unit root (non-stationary), and the alternative hypothesis (η1 < 0), which indicates that the time-series variable is stationary. If the null hypothesis is rejected, the time-series variable Xi is stationary.

Next, to estimate the ARDL model, three steps must be followed. The first step is to estimate the long-run relationships (co-integration) among the time-series variables. Therefore, the equation can be written as follows:

$$\begin{aligned}\Delta LNCO_{2t} = \beta_0 + & \sum_{i=1}^{j} \beta_i \Delta\ LNCO_{2t-1} + \sum_{i=0}^{k} \gamma_i \Delta + LNGDP_{t-i} + \sum_{i=0}^{l} \delta_i \Delta LNGDP^2_{t-i} + \sum_{i=0}^{m} \lambda_i \Delta LNPOP_{t-1} \\ & + \sum_{i=0}^{n} \omega_i \Delta LNTA_{t-1} + \sum_{i=0}^{o} \mu_i \Delta LNFW_{t-1} + \sum_{i=0}^{p} \varphi_i \Delta LNE_{t-1} + \sum_{i=0}^{q} \vartheta_i \Delta LNC_{t-1} + \sum_{i=0}^{r} \rho_i \Delta LNO_{t-1} \\ & + \sum_{i=0}^{s} \tau_i \Delta LNNG_{t-1} + \forall_o LNCO_{2t-1} + \forall_1 LNGDP_{t-i} + \forall_2 LNGDP^2_{t-i} + \forall_3 LNPOP_{t-i} \\ & + \forall_4 LNTA_{t-1} + \forall_5 LNFW_{t-1} + \forall_6 LNE_{t-1}\ \ \forall_7 LN\ C_{t-1} + \forall_8 LNO_{t-1}\ \forall_9 LNNG_{t-1} + \upsilon_t\end{aligned} \tag{5}$$

where Δ is the first differential operator, (j, k, l, m, n, o, p, q, r, s,) is the optimum lag and υ_t refers to the error term. The null and alternative hypotheses are tested using the F-statistic to examine the existence of a long-run relationship among the variables as follows:

$$H_{0=}\forall_0 = \forall_1 = \forall_2 = \forall_3 = \forall_4 = \forall_5 = \forall_6 = \forall_7 = \forall_8 = \forall_9 = 0 \text{ (Long} - \text{run relationship does not exist)}$$

$$H_{1=}\forall_0 \neq\ V_1 \neq\ \forall_2 \neq\ \forall_3 \neq \forall_4 \neq \forall_5 \neq \forall_6 \neq \forall_7 \neq \forall_8 \neq \forall_9\ \neq 0 \text{ (Long} - \text{run relationship exists)}$$

The null hypothesis must be rejected if the estimated value of the F-statistic exceeds the upper bound critical value, which explains the existence of a long-run relationship (co-integration) among the time-series variables. In contrast, if the estimated value of the F statistic is less than the lower bound critical value, the null hypothesis is not rejected. However, if the estimated value of the F-statistic falls between the upper and lower bound critical values, the results remain inconclusive. Thus, it is impossible to determine whether there is a co-integration. After establishing the existence of the co-integration, the next step is to estimate the long-run ARDL model, and the equation is as follows:

$$\begin{aligned}CO2 = \propto_0 + & \sum_{i=1}^{j} \propto_1 LNCO_{2t-1} + \sum_{i=0}^{k} \propto_2 LNGDP_{t-i} + \sum_{i=0}^{l} \propto_3 LNGDP^2{}_{t-i} + \sum_{i=0}^{m} \propto_4 LNPOP_{t-1} + \sum_{i=0}^{n} \propto_5 LNTA_{t-1} \\ & + \sum_{i=0}^{o} \propto_6 LNFW_{t-1} + \sum_{i=0}^{p} \propto_7\ LNE_{t-1} + \sum_{i=0}^{q} \propto_8\ LNC_{t-1} + \sum_{i=0}^{r} \propto_9 LNO_{t-1} \\ & + \sum_{i=0}^{s} \propto_{10} LNNG_{t-1} + \upsilon_t\end{aligned} \tag{6}$$

In the final step, the short-run ARDL model must be estimated by taking the error correction term (ECT) into account, and it is derived from the long-run estimated ARDL model. The error correction model (ECM) can be expressed in the following equation:

$$\begin{aligned}\Delta LNCO_{2t} = \gamma_0 + & \sum_{i=1}^{j} \gamma_1 \Delta \mathrm{LNCO}_{2t-1} + \sum_{i=0}^{k} \gamma_2 \Delta \mathrm{LNGDP}_{t-i} + \sum_{i=0}^{l} \gamma_3 \Delta \mathrm{LNGDP}^2{}_{t-i} \sum_{i=0}^{m} \gamma_4 \Delta \mathrm{LNPOP}_{t-1} \\ & + \sum_{i=0}^{n} \gamma_5 \Delta \mathrm{LNTA}_{t-1} + \sum_{i=0}^{o} \gamma_6 \Delta \mathrm{LNFW}_{t-1} + \sum_{i=0}^{p} \gamma_7 \Delta \mathrm{LNE}_{t-1} + \sum_{i=0}^{q} \gamma_8 \Delta LNC_{t-1} + \sum_{i=0}^{r} \gamma_9 \Delta \mathrm{LNO}_{t-1} \\ & + \sum_{i=0}^{s} \gamma_{10} \Delta \mathrm{LNNG}_{t-1} + \upsilon_t + \varphi_2 + \mathrm{ECT}_{t-1} + \mu_t\end{aligned} \tag{7}$$

The coefficient value of the ECT can explain two results. First, it can describe the speed of adjustment towards the long-run equilibrium (time taken by the explanatory variables to converge towards the long-run equilibrium). Second, it can confirm the existence of a long-run connection between the variables (tourist arrival, foreign employment, population, energy use (oil, electricity, gas and coal), economic expansion and CO_2.

4. Results

Table 2 indicates the results of the descriptive statistics for all variables used in this investigation. The table shows the maximum, minimum, mean and standard deviation values for $LNCO_2$, LNC, LNO, LNT, LNG, LNP, LNT, LNGDP, $LNGDP^2$ and LNE. Based on the table, there is a significant difference in the variation of each variable. $LNGDP^2$ has the highest mean at 101.5998, while LNP has the lowest mean at 0.7796. LNT has the biggest disparity between the highest and lowest values, with a difference of 2.2916. LNP shows the smallest difference between the maximum and minimum values. The difference stands at 0.9178.

Table 2. Descriptive Statistics Results.

Variables	Mean	Median	Max.	Min.	Std. Dev.	Observations
$LNCO_2$	4.7214	4.8867	5.5515	3.4430	0.7034	37
LNC	6.6970	6.8845	7.5099	4.5325	0.7585	37
LNO	9.7029	9.8823	10.3489	8.7368	0.5308	37
LNF	13.4678	13.7593	14.6238	11.8226	0.8781	37
LNG	7.9033	8.2589	9.8443	3.8067	1.4624	37
LNP	0.7796	0.8990	1.0340	0.1162	0.2510	37
LNT	16.1297	16.1400	17.1274	14.8358	0.7794	37
LNGDP	10.0729	10.1252	10.6742	9.4547	0.3756	37
$LNGDP^2$	101.5998	102.5213	113.9382	89.3918	7.5359	37
LNE	10.7822	11.0076	11.8961	9.2595	0.8353	37

Note: $LNCO_2$ is the log of CO_2 emissions, LNC is the log of coal use, LNO is the log of oil use, LNF is the log of the number of foreign workers, LNG is the log of gas use, LNP is the log of population growth, LNT is the log of tourist arrivals, LNGDP is the log of GDP per capita, and $LNGDP^2$ is the log of GDP^2 per capita.

Table 3 demonstrates the results of the unit root test. All the variables are not stationary at the level with no trend, while only LNC and LNG are stationary at the level with a trend. The results also reveal that all the variables are stationary at 1% at the first difference without any trend. With a trend, the findings show that all the variables are stationary at 1% except for $LNCO_2$, which is significant at 5%.

The bound test was performed before estimating the long-run coefficients. Table 4 shows the outcomes of the bound test. The R-squared value is 0.9985 and the adjusted R-squared value is 0.9977. The F-statistic value is 4.7270, higher than the critical value at the 5% significance level. It exceeds both the lower and upper bounds of −1.95 and −4.61, respectively. The null hypothesis is rejected, meaning the variables used in this study are co-integrated. The impacts of energy use, foreign workers, tourism arrivals, GDP, GDP^2 and electric use on CO_2 emissions can be investigated using the ARDL approach.

Table 3. Unit root test results.

Variable	Intercept		Intercept and Trend	
	Level	First Difference	Level	First Difference
$LNCO_2$	−2.5425 (0.1143)	−4.4152 *** (0.0013)	−0.0274 (0.9943)	−3.8660 ** (0.0249)
LNC	−21527 (0.2363)	−10.7204 *** (0.0000)	−5.7540 *** (0.0002)	−10.9009 *** (0.0000)
LNO	−2.1572 (0.2247)	−4.6135 *** (0.0007)	−0.4566 (0.9812)	−5.0810 *** (0.0012)
LNF	−1.5283 (0.5081)	−5.5926 *** (0.0000)	−1.7605 (0.7028)	−5.6132 *** (0.0003)
LNG	−2.2878 (0.1815)	−7.3232 *** (0.0000)	−4.0150 ** (0.0176)	−7.2485 *** (0.0000)
LNP	0.9003 (0.9943)	−8.1855 *** (0.0000)	−2.5322 (0.3118)	−8.5740 *** (0.0000)
LNT	−1.1758 (0.6742)	−6.5300 *** (0.0000)	−2.3403 (0.4029)	−6.5520 *** (0.0000)
LNGDP	0.4171 (0.8956)	−4.9905 *** (0.0003)	−1.7633 (0.7014)	−4.9161 *** (0.0018)
$LNGDP^2$	−0.2259 (0.9260)	−5.0626 *** (0.0002)	−1.8826 (0.6427)	−4.9858 *** (0.0015)
LNE	−2.565 (0.1096	−4.4028 *** (0.0013)	−0.4121 (0.9832)	−5.0166 *** (0.0014)

Note: *** and ** indicate significance levels of 1% and 5%, respectively. $LNCO_2$ is the log of CO_2 emissions, LNC is the log of coal use, LNO is the log of oil use, LNF is the log of the number of foreign workers, LNG is the log of gas use, LNP is the log of population growth, LNT is the log of tourist arrivals, LNGDP is the log of GDP per capita, and $LNGDP^2$ is the log of GDP^2 per capita.

Table 4. Bound Test Results.

F-statistic	4.7270 **	
Lag Model:	1, 0, 0, 0, 0, 1, 1, 1, 0, 0	
R-squared:	0.9985	
Adjusted R-squared	0.9977	
Critical Value	Lower Bound	Upper Bound
10%	−1.62	−4.26
5%	−1.95	−4.61
1%	−2.58	−5.25

Note: ** indicate the significance level of 5%, respectively.

Table 5 shows the findings of the long-run impacts of coal use, oil use, gas use, electricity use, foreign workers, population growth, tourist arrivals, GDP and GDP^2 on CO_2 emissions using the ARDL approach. The findings also reveal that tourist arrivals can positively influence CO_2 emissions in the long run, which is significant at 1%. The coefficient value is 0.2298, suggesting that a 1% increase in tourist arrivals can cause a 0.2298% rise in CO_2 emissions in the long run. It is also discovered that natural gas use has no long-run nexus with CO_2 emissions. This demonstrates that increasing natural gas use has no long-run influence on CO_2 emissions. The coefficient of natural gas use is −0.0175. Population growth is found to have no long-run relationship with CO_2 emission. This shows that an increase in population growth does not influence CO_2 emissions in the long run in Malaysia. The coefficient of population growth is −0.1567. GDP has a significant connection with CO_2 emissions at 1%, and the coefficient value is −1.7458. Based on the coefficient value, a 1% rise in GDP can prompt a reduction of 1.7458% in CO_2 emissions in the early stages of development. In the final stages, GDP has a positive and significant connection with CO_2 emission, which is significant at 1%, and the coefficient value is 0.0488. Based on the coefficient value, a 1% increase in GDP^2 can increase CO_2

emissions by 0.0488% in the long run. Thus, the results show a U-shaped EKC in the long run. Foreign workers have no nexus with environmental degradation, as it is not significant. The coefficient value is 0.1536. This indicates that an increase in foreign workers does not change CO_2 emissions in the long run.

Table 5. Results of long-run effects using ARDL approach.

Variable	Coefficient	Standard Error	Probability
LNC	0.1893 **	0.0756 **	0.0198 **
LNO	1.3863 ***	0.2547 ***	0.0000 ***
LNF	0.1536	0.1231	0.2244
LNG	−0.0175	0.0238	0.4691
LNP	−0.1567	0.1666	0.3566
LNT	0.2298 ***	0.0758 ***	0.0059 ***
LNGDP	−1.7458 ***	0.2044 ***	0.0000 ***
$LNGDP^2$	0.0488 **	0.0207 **	0.0270 **
LNE	0.2450	0.2466	0.3308

Note: *** and ** indicate significance levels of 1% and 5%, respectively. $LNCO_2$ is the log of CO_2 emissions, LNC is the log of coal use, LNO is the log of oil use, LNF is the log of the number of foreign workers, LNG is the log of gas use, LNP is the log of population growth, LNT is the log of tourist arrivals, LNGDP is the log of GDP per capita, and $LNGDP^2$ is the log of GDP^2 per capita.

Similarly, electricity consumption does not have any positive relationship with environmental degradation, as it is not significant. This shows that a rise in electricity use does not influence CO_2 emissions in the long run. The coefficient value for electricity use is 0.2450. Coal use is found to have a positive relationship with CO_2 emission, which is significant at 5%. The coefficient value is 0.1893, indicating that a 1% increase in coal use can result in a 0.1893% increase in the long run. Last but not least, crude oil use is found to have a positive relationship with CO_2 emission, which is significant at 1%. The coefficient value is 1.3863, indicating that a 1% increase in crude oil use can cause a rise of 1.3863% in the long run.

Table 6 shows the results of the error correction term (ECT) and the impacts of energy use, foreign workers, tourist arrivals, GDP and GDP^2 on CO_2 emissions in the short run using the ARDL approach. The coefficient of ECT is negative and significant at 1%. The value is –0.5192, implying that the long-run disequilibrium is adjusted by 51.92%. The findings also reveal that natural gas use has no significant connection with CO_2 emission, and the coefficient value is −0.0090. Electricity use has no significant connection with CO_2 emission. Therefore, a 1% increase in electricity use cannot cause any change in CO_2 emissions in the short run. Tourist arrivals can positively influence CO_2 emissions as the connection is significant at 5%. The coefficient value of tourist arrivals is 0.1193, suggesting that a 1% increase in tourist arrivals can cause a 0.1193% rise in CO_2 emissions in the short run. Crude oil use has a significant and positive connection with CO_2 emission at 5%. The coefficient value is 0.3223, suggesting that a 1% increase in crude oil use can contribute to a 0.3223% rise in environmental degradation in the short run.

Coal use is found to have a positive nexus with CO_2 emission, which is significant at 5%. The coefficient value is 0.0982, indicating that a 1% increase in coal use can cause a 0.0982% rise in the short run. Foreign workers are found to have no short-run relationship with CO_2 emission. This shows that any increase in foreign workers has no influence on CO_2 emissions in the short run. The coefficient of foreign workers is 0.0797, suggesting that an increase in foreign workers does not impact CO_2 emissions in the short run. In the early stages of development, GDP has a significant connection with CO_2 emission at 1%, and the coefficient value is −0.9064. Based on the coefficient value, a 1% rise in GDP can reduce environmental degradation by 0.9064% in the short run. However, in the final stages, GDP has a positive and significant connection with CO_2 emission at 1%. The coefficient value is 0.0572, suggesting that a 1% rise in GDP^2 can cause an increase of 0.0572% in CO_2 emissions in the short run. Lastly, population growth has no positive nexus with CO_2

emission. Therefore, a rise in population growth will lead to no change in CO_2 emissions in the short run.

Table 6. Results of short-run effects using ARDL approach.

Variable	Coefficient	Standard Error	Probability
LNC	0.0982 **	0.0358 **	0.0116 **
LNO	0.3223 *	0.1760 *	0.0801 *
LNF	0.0797	0.0601	0.1978
LNG	−0.0090	0.0122	0.4677
LNP	0.0019	0.0676	0.9775
LNT	0.1193 **	0.0494 **	0.0243 **
LNGDP	−0.9064 ***	0.2400 ***	0.0010 ***
$LNGDP^2$	0.0572 ***	0.0130 ***	0.0002 ***
LNE	−0.1272	0.1227	0.3106
ECT	−0.5192 ***	0.1249 ***	0.0004 ***

Note: ***, ** and * indicate significance levels of 1%, 5% and 10%, respectively. $LNCO_2$ is the log of CO_2 emissions, LNC is the log of coal use, LNO is the log of oil use, LNF is the log of the number of foreign workers, LNG is the log of gas use, LNP is the log of population growth, LNT is the log of tourist arrivals, LNGDP is the log of GDP per capita and $LNGDP^2$ is the log of GDP^2 per capita.

Table 7 summarises the findings of the diagnostic tests (Breusch-Godfrey Serial Correlation LM, Ramsey RESET stability and Heteroscedasticity). The outcomes reveal that the model is free of diagnostic issues, implying that it can explain the influences of energy use, foreign employment and tourist arrivals on CO_2 emissions. We used the Cumulative Sum of Recursive Residuals (CUSUM), and Cumulative of Squares of Recursive Residuals (CUSUMSQ) tests to determine whether the model is stable. Figure 4 depicts the plots of the CUSUM and CUSUMSQ graphs. The plots fall within the boundaries, indicating the appropriateness of the model.

Table 7. Results of diagnostic tests.

Statistics	F-Statistic/Jarque-Bera	Probability
Breusch-Godfrey Serial Correlation LM	0.6728	0.5209
Ramsey RESET stability	0.0227	0.8815
Heteroscedasticity	0.4016	0.5306
Normality	0.0188	0.9907

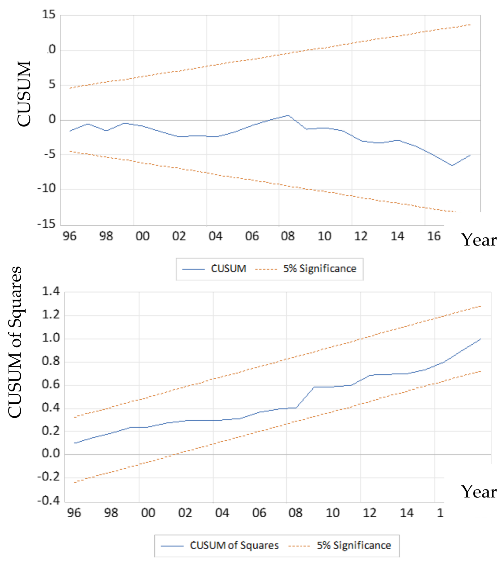

Figure 4. Cumulative Sum of Recursive Residuals (CUSUM) and Cumulative Sum of Square of Recursive Residuals (CUSUMSQ).

5. Discussions

Although previous studies [32] argued that natural gas consumption can reduce CO_2 emissions, our results conclude that natural gas use has no significant effect on CO_2 emissions. Similarly, we find no evidence that electricity use can significantly affect CO_2 emissions. Our findings are similar to the results of Shaari et al. [21]. Our findings are likely related to the shift of energy policy in Malaysia, in which the use of natural gas has been increased so that the country is not enormously dependent on oil. The use of natural gas to generate electricity is the least harmful to the environment. By contrast, crude oil use and coal use have a significant and positive effect on CO_2 emission. Our findings are consistent with the findings of Shaari et al. [33], that there is evidence on the crude oil—CO_2 emissions nexus, and the findings of Pata and Kumar [34] that there is a significant nexus between coal and CO_2 emissions in China and India. The burning of both types of energy (oil and coal) can be harmful to the environment as it can release CO_2 emissions.

Furthermore, we find that tourist arrivals can positively influence CO_2 emissions. This suggests that tourist arrivals cause the tourism and transportation sectors to grow, and thus more energy is consumed. Our result is in line with evidence provided by Sharif et al. [35] for the case of Pakistan. By contrast, foreign workers are found to have no short-run effect on CO_2 emissions. This is because most foreign workers in Malaysia work in low-energy intensive sectors, such as agriculture and construction. The findings do not support the EKC hypothesis, as GDP has a significant connection with CO_2 emissions in the early stages of development. However, GDP has a positive and significant connection with CO_2 emission in the final stages. Our results exhibit a U-shaped EKC and are similar to the findings of Jiang et al. [36] for the southwest, central and northeast regions of China. Lastly, population growth has no positive effect on CO_2 emission, which is in line with Begum et al. [37], who found no connection between population growth and CO_2 emissions in Malaysia.

6. Conclusions

This research investigated the impacts of energy use, foreign workers and tourist arrivals on CO_2 emissions in Malaysia from 1982 to 2018. A unit root test was performed, and the results show that all the variables are stationary at the first differences but not at the level. The findings of the bound test show that the variables are co-integrated. Natural gas consumption, electricity use and population growth do not have any short-run or long-run impacts on environmental degradation. Tourist arrivals as well as coal and oil use contribute to an increase in CO_2 emissions in the long and short run. As tourist numbers increase, the tourism industry will grow. The transportation sector will also flourish, and thus more energy will be consumed. Foreign workers do not influence CO_2 emissions in the short run or long run. This is because most foreign workers are employed in sectors that do not contribute a large amount of CO_2 emissions, such as construction and agriculture. GDP negatively influences CO_2 emissions in the short and long run. Lastly, GDP^2 positively influences environmental degradation in the long run and short run. The results of this research do not support the inverted U-shaped EKC.

These findings are important for policymakers in formulating the right policies, as energy use can cause greater environmental degradation. Malaysia continues to rely on non-renewable energy sources. We can see that natural gas and diesel use exhibits a steady increase. The transportation sector consumes the biggest proportion of the total energy, followed by the industrial sector. Its pattern of energy use will determine the country's future environment. Therefore, Malaysia should use more renewable energy sources, such as biodiesel, hydro and solar, instead of non-renewable energy. Malaysia's use of renewable energy is still very low. Thus, policies on increasing renewable energy are of utmost importance to reduce environmental degradation. As a result, Malaysia can attract more tourists to visit the country without having any unfavourable impact on the environment. Aside from this, the findings also show that in the final stages of development, higher GDP per capita can increase CO_2 emissions. Therefore, a carbon tax should be imposed on firms that emit CO_2. Most economists strongly advocate a carbon price policy as a profitable strategy to reduce CO_2 emissions. Firms have to pay higher taxes the more emissions they produce. This policy could discourage firms from producing more emissions. Additionally, Malaysia could utilise technology that can capture and store CO_2 deep underground to reduce environmental degradation.

Despite the fact that this study has successfully achieved its objective, there are several shortcomings that can be addressed in future research. This study only focuses on Malaysia, and thus future research may consider many countries, especially developing countries, in order to produce better results.

Author Contributions: A.R.A.R. carried out and wrote the experiment. M.S.S. provided guidance and edited the whole manuscript significantly. F.M. gave ideas and edited the introduction part. M.A.E. gave ideas and improved the manuscript, especially in the discussion part. All authors did revisions equally after receiving the comments from the reviewers. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Universitas Universitas Airlangga under the Program International Research Collaboration Tahun 2021. The APC was funded by Universitas Airlangga.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data that support the findings of this study are available from Malaysia Energy Information Hub, Department of Statistics Malaysia and country.economy.

Conflicts of Interest: The authors declare no conflict of interest.

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