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# Are Urbanisation, Trade Openness and Inward Foreign Direct Investment Alarming for $CO_2$ Emissions in Malaysia? A Study Using the Time series ARDL Approach

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The growing rate of CO2 emissions in developing countries, especially Malaysia, is becoming an area of concern for policy makers as well as researchers, because the need for analysing different predictors of CO2 emissions has become so prominent. In response to this emerging need, the current study examined the impact of urbanisation, inward foreign direct investment (IFDI), and trade openness on the CO2 emission levels in Malaysia. For this purpose, data was collected about urbanisation, IFDI, trade openness, and CO2 emissions of Malaysia for the last 30 years and a time series ARDL approach was adopted to assess the short-term and long-term relationships between variables. The unit root test, co-integration and ARDL modelling led the researcher to find that urbanisation, IFDI, and trade openness have significant positive effects on CO2 emissions in the long run however, there is no significant short-term impact of trade openness and IFDI on CO2 emissions in Malaysia. Therefore, it has been suggested through the findings of this study that urbanisation, IFDI, and trade openness are alarming for CO2 emissions in the long-run in Malaysia. These findings will contribute to theory and practice by setting guidelines for researchers and policymakers regarding the part played

by urbanisation, IFDI, and trade openness in enhancing the CO2 emissions of the country.

**Key words:** *Urbanisation, Inward foreign direct investment, Trade openness, CO2 emissions, Malaysia, ARDL modelling.*

## Introduction

Carbon is the most common element found on earth. Carbon is present in the air we breathe and the food we eat. Even our bodies are made up of carbon. The most important type of carbon that is released into the atmosphere is in the form of carbon dioxide (Al-Mulali & Ozturk, 2015). Carbon dioxide is released as a result of an exchange between atmosphere and oceans. Moreover, when humans and animals undergo respiration, they also release $CO_2$ into the air. To keep the amount of $CO_2$ in balance, plants take up $CO_2$ in the process of photosynthesis. $CO_2$ is a kind of greenhouse gas which prevents the heat from escaping the atmosphere, resulting in the overall increase in temperature and fluctuating and disturbed weather conditions as well.

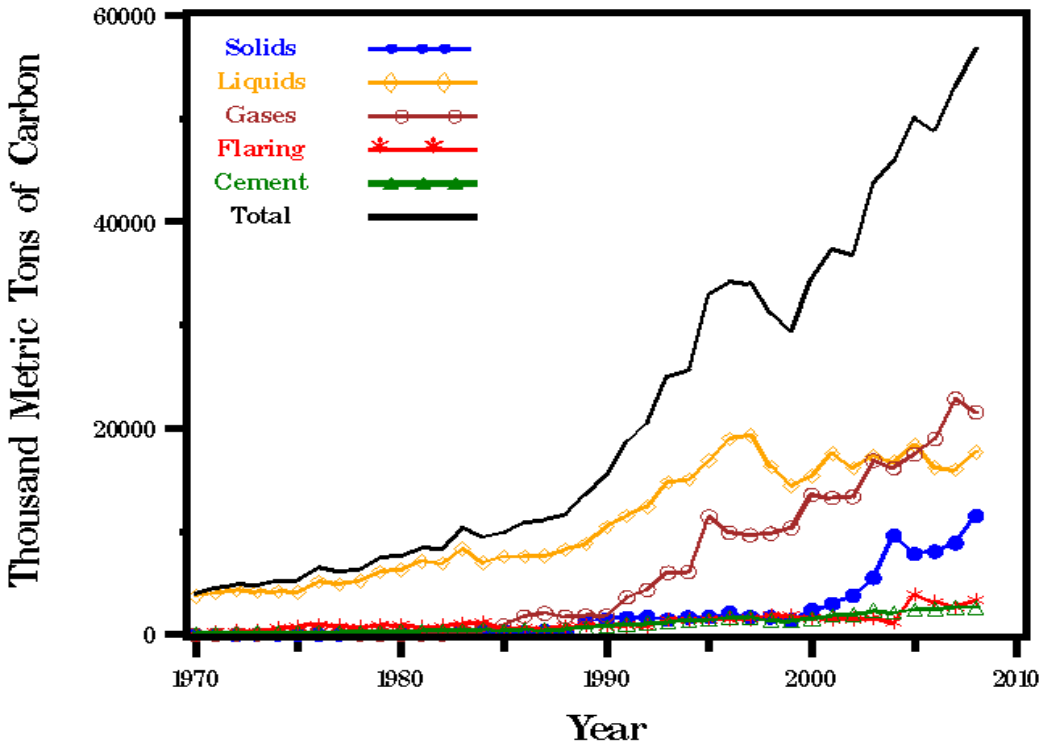


**Figure 1:** ***Carbon Dioxide Emission in Malaysia*** **(Source: cdiac.ess-dive.lbl.gov)**

Figure 1 shows that the emission of $CO_2$ has been increasing in the past few years in Malaysia. Urbanisation refers to the change from rural life style to urban life style. In other words, a simpler and more natural lifestyle, when converted into a complex and artificial life style, is called urbanisation (Al-Mulali, Ozturk, & Lean, 2015). It involves many changes, such as in modes of transport, in the building of houses, in trading and business processes and many other changes as well. As part of the urbanisation process, greenery and natural areas are converted into industrial areas that are the centres of air and water pollution. Trade openness is the consequence of globalisation, which means that two or more countries are engaged in the process of across countries trade (Alshehry & Belloumi, 2015). Trade openness has a very positive effect on the economic development of any country. Revealed openness is actually the ration of total foreign trade to the GDP of the country. The advantage of this ratio is that it is very clearly defined and well measured. Foreign direct investment refers to the arrival of investment from the other developed countries in order to invest them in different economic processes and increase and improve the economic condition of the country (Arneth et al., 2017). This investment is not only in the form of money, but also in the form of technology and the latest equipment to carry out different types of manufacturing and other business practices. These investments have a direct impact on the economy of the receiving company as well as that particular country (Bishop, 2016; Boateng, Hua, Nisar, & Wu, 2015; Brenner & Schmid, 2017).

$CO_2$ emissions can be controlled by controlling the processes of urbanisation, trade openness and FDI. But sadly, in Malaysia these processes are increasing the emission of $CO_2$ day by day, which ultimately results in harm to the atmosphere and increases the temperature of the atmosphere, resulting in global warming (Dear & Scott, 2018). Besides Malaysia, other developing and under developed countries are facing the same issues in this regard. If this situation prevails for a longer span of time, it will cause more and more harm to the environment in the form of $CO_2$. So it is the need of the hour to control the activities related to urbanisation, trade openness and FDI in order to reduce $CO_2$ emissions and preserve the environment effectively (Ertugrul, Cetin, Seker, & Dogan, 2016).

Much research has been conducted in order to study the activities in urbanisation, trade openness and FDIs and a few studies have related them to the economy of the country. But no study has been conducted to study the impact of these three variables collectively on $CO_2$ emissions in Malaysia. So a research paper has recommended studying the collective impact of these three variables on $CO_2$ emissions (Farhani & Ozturk, 2015). The most important objectives of this study are given below:

- To analyse the significant impact of urbanisation on $CO_2$ emissions in Malaysia
- To analyse the significant impact of trade openness on $CO_2$ emissions in Malaysia

- To analyse the significant impact of FDI on $CO_2$ emissions in Malaysia

We know that urbanisation, trade openness and FDI in Malaysia have been increasing day by day, which ultimately has an impact on $CO_2$ emissions in Malaysia. The scope of this study revolves around the concept of controlling $CO_2$ emissions by reviewing the activities related to urbanisation, trade openness and FDI (Gollin, Jedwab, & Vollrath, 2016). This study provides the complete details about urbanisation, trade openness and FDI and their direct and indirect impacts on $CO_2$ emissions. This study also provides the ways to control $CO_2$ emissions in order to control global warming. It also assists the government of Malaysia to develop policies and investments in favour of the control activities related to $CO_2$ emissions (Green & Stern, 2017).

## Literature Review

### *Treadmill of Production Theory*

Treadmill of production theory, introduced by Allan Schnaiberg, revolves around the idea that all the negative changes in the environment are actually due to the economic development and growth. We know that the overall economy is expanding day by day and is also using many of the naturally occurring resources, which results in the pollution in the air and water due to economic activities (Hodges & McKinney, 2018). In a growing economy, the production or manufacturing of various products uses natural resources in the development process and as a result produces waste, which actually increases the amount of pollution in the environment. This pollution has adverse impacts and causes the degradation of the environment. The founder of the treadmill of production theory suggests that the countries or regions where the economy is facing expansion are actually in a severe conflict with nature (Hugo, 2017). This is because of the fact that with the increasing expansion of the economy in any country, the need for natural resources is also increasing accordingly. The word 'treadmill' in the name of theory describes this increase in the need of resources. Similarly, with this increase of use of resources and increased production, the processes used in it ultimately excrete very dangerous waste in the atmosphere, which adds to the pollution (L. Jiang & O'Neill, 2017; Jin, Garcia, & Salomon, 2016; Kirkby, 2018). This theory also suggests the idea that with the use of the latest technology, the efficiency can be increased, which may result in a decrease in the use of natural resources but at the same time, due to efficiency, the overall increase in production still demands more and more natural resources. In addition, this theory also gives an idea that the relationship between degradation of environment and increase in economic growth remains constant or may also increase with the passage of time (Kottaridi, Louloudi, & Karkalakos, 2019). To put it in a nutshell, this theory basically discusses the fact that to increase the capital and economy in any country, more and more natural resources are used and as a result of more production, more waste is added into the atmosphere, resulting in harm to the environment.

The concepts of urbanisation, trade openness and FDI can be discussed in light of this theory (Lajunen & Lipman, 2016).

***Impact of Urbanisation on $CO_2$ Emissions in Malaysia***

Increase in population or urbanisation refers to the many changes of rural environment to urban environment. Studies have shown that urbanisation has a direct or positive impact on $CO_2$ emissions in most countries. This impact depends mostly on the extent of urbanisation and also on the financial condition of the country. In other words, the countries with lower income or underdeveloped countries face this issue on a relatively greater scale as compared to developed countries (Le, Chang, & Park, 2016). Many studies have discussed the impact of variables such as increases in population, urbanisation, demographics etc. on $CO_2$ emissions and have found out that the impact of population and urbanisation on $CO_2$ emissions is almost the same. However, demographics have not shown any significant impact on $CO_2$ emissions (Lee, Hong, & Makino, 2016). We know that urbanisation involves many changes such as in modes of transportation, changes in the building of houses, conversion of greenery into industrial areas etc. All these factors add to the $CO_2$ emissions in the atmosphere. The modern means of transport add to air pollution by the excretion of several harmful chemicals, especially $CO_2$, in the environment (Li, Zhang, Zhou, & Yao, 2017). Similarly, when greenery is replaced with industries and other buildings, this, on one hand, decreases the natural resources in the environment and the industries also add to air and water pollution by secreting different wastes that are obviously harmful for the environment. Among these wastes, $CO_2$ is most important (Matter et al., 2016; Milner, Tingley, Xu, & Chilton, 2019; Musil, 2017). We know that plants and trees take up $CO_2$ during the process of photosynthesis, but as urbanisation also decreases the amount of greenery from the environment, the $CO_2$ is not consumed and taken up from the atmosphere. This $CO_2$ has a lot of harmful impacts on the environment, as it is an important kind of greenhouse gas that adversely affects the atmosphere. So from this discussion we can conclude that urbanisation has a significant impact on $CO_2$ emissions in Malaysia (Musila & Yiheyis, 2015). We can formulate the following hypothesis:

H 1: Urbanisation has a significant impact on $CO_2$ emissions in Malaysia.

***Impact of Trade Openness on $CO_2$ Emission in Malaysia***

Trade openness that is increasing in the culture of trade across countries has become an important point of discussion now-a-days in several contexts. When the impact of trade openness was studied with regard to pollution, environmental degradation and especially $CO_2$ emissions, there were mixed views about this concept (OECD, 2016). Basically trade openness has not been considered as an important indicator of $CO_2$ emissions. The study involving the impact of trade openness on

$CO_2$ emissions firstly divided its areas or countries of study into different parts based on their financial and economic conditions. They were divided into developed, developing and underdeveloped countries and then the study was done in each of these portions separately to study the impact of trade openness in these countries (Ouyang & Lin, 2015). Some studies gave the result of a negative relationship between trade openness and $CO_2$ emissions i.e. when the trade openness increases, $CO_2$ emissions decrease. But other studies showed that trade openness increases $CO_2$ emissions in underdeveloped countries while it has opposite impact in developed countries (Shahbaz, Loganathan, Sbia, & Afza, 2015). The decrease in $CO_2$ emissions due to trade openness is that, because of international trade, countries become economically efficient and use products and manufacturing processes that are environmentally friendly and thus reduce $CO_2$ emissions. So these studies show that there are mixed views and mixed results in countries with different economic and financial conditions (Shahbaz, Nasreen, Ahmed, & Hammoudeh, 2017). Y. Jiang (2015) found a positive relationship between regional openness and pollution emissions in China. So from the above discussion, it can be said that trade openness has a significant impact on $CO_2$ emissions, which can also be studied using the treadmill theory of production. We can therefore develop the following hypothesis:

H 2: Trade openness has a significant impact on $CO_2$ emissions in Malaysia

***Impact of Inward Foreign Direct Investment on $CO_2$ Emissions in Malaysia***

Foreign direct investment has gained a huge importance in the last few decades in underdeveloped and developing countries. FDI acts as an important indicator of economic growth and development for any country. FDI not only increases the capital in the country but also transfers the latest technology and skills in order to increase productivity and improve the economy of that particular country (Shahzad, Kumar, Zakaria, & Hurr, 2017). Due to these benefits, underdeveloped and developing countries make efforts to attract most of the FDI to their countries. There are mixed views about the impact of FDI on $CO_2$ emissions or environmental degradation in general. Most of the studies suggest that FDI improves the environmental condition of the investment receiving country. This is because of the fact that FDI transfers the latest technology equipment in under developed and developing countries (Smith, 2019). This latest technology increases the efficiency of production and also decreases the amount of wastes, specifically $CO_2$, from the equipment. When most of the industries and businesses use such technology, it will have a major effect in the form of reduction of $CO_2$ emissions. Still, the studies relating FDI with $CO_2$ emissions are ambiguous and cannot give concrete and precise information for policy formation (Tang & Tan, 2015; Tingley, Xu, Chilton, & Milner, 2015). This is because of the fact that different types of countries i.e. developed, developing and underdeveloped and different types of industries show different results in the context of the impact of FDI on $CO_2$ emissions (Uddin, Chowdhury, Zafar,

Shafique, & Liu, 2019). Y. Jiang (2015) found a positive impact of FDI on the pollution emissions in China. Naz et al. (2019) also found that FDI inflows increase the CO2 emissions in the country. Acharyya (2009) investigated the effect of FDI inflows on CO2 emissions and found a positive and long-term relationship between both of them. Similarly, a positive relationship was found between FDI and pollution by Hoffmann, Lee, Ramasamy, and Yeung (2005). In spite of the fact that the relation of FDI and $CO_2$ emissions is difficult to study, it is very clear that both of these variables are not independent from each other. So it can be concluded from the above discussion that foreign direct investment has a significant impact on $CO_2$ emissions and environmental degradation in Malaysia (Zhou & Wang, 2016). This can be studied using the treadmill theory of production. We can generate the following hypothesis:

H 3: Foreign direct investment has a significant impact on $CO_2$ emissions in Malaysia

## Methodology

### *Sample and Data Collection*

The present research investigates the impact of urbanisation, trade openness and IFDI on CO2 emissions in Malaysia, therefore, the population of this research encompasses the observations about these variables in Malaysia. For this study, the purposive sampling technique was used to decide the sample observations through which the data for last 30 years concerning the studied variables was collected for Malaysia. The present study relied on the secondary data because the historical data for the last 30 years was needed for the study. This time series data was collected from archival materials and the database of the 'World bank group' and then data was analysed through EViews by applying ARDL modelling.

### *Variables Definition and Measurement*

Following are the variables included in the present research:

***Dependent variables.*** The dependent variable of this research is 'CO2 emissions'. The annual data of the CO2 emissions of Malaysia for last 30 years was available on the database of 'World Bank Group' so, the secondary data of the dependent variables was collected from the archives of the 'World Bank group'.

***Independent variables.*** There are three independent variables involved in the current study, the impact of which has been analysed on CO2 emissions. These independent variables are trade openness (TO), inward foreign direct investment (IFDI), and urbanisation. The IFDI was measured

by taking the percentage of IFDI in Malaysia. The urbanisation was measured by taking the percentage of the total population of Malaysia living in urban areas. The trade openness was measured by taking the proportion of total trade in the overall GDP of Malaysia.

***Control Variables.*** The two control variables that have been included in this research are Population Growth (PG) and Renewable energy consumption (REC). The data about both these variables for Malaysia was available on the database of the World bank group so, the 30 years of data about the PG and REC was extracted from there.

### *Modelling and Methodological Framework*

To see the impact of urbanisation, trade openness, and IFDI on CO2 emissions,the time series ARDL modelling was adopted, in which the 30 years of data was collected and analysed for Malaysia, because the purpose of the study was to assess the impact of urbanisation, IFDI and trade openness on the CO2 emissions of Malaysia in last 30 years.

### *Time Series ARDL Approach*

The time series ARDL approach is an important approach through which the lag can be identified at which the independent variable significantly influences the dependent variables. Through this approach, the impact of urbanisation, trade openness and IFDI on CO2 emissions was analysed and the lags were identified at which these relationships are significant. The regression equation which has been tested in the current study through time series analysis is as follows:

$$CO2_t = \beta_0 + \beta_1 \text{Urbanisation}_{t-1} + \beta_2 \text{IFDI}_{t-1} + \beta_3 \text{TO}_{t-1} + \beta_4 \text{PG}_{t-1} + \beta_5 \text{REC}_{t-1} + u_{it} \quad (1)$$

In equation 1, CO2 is CO2 emissions, IFDI is inward FDI, PG is population growth, REC is renewable energy consumption, TO is trade openness and $u_{it}$ is the error.

### *Unit Root Test*

The unit root test is a test through which the stationery of the data is checked. This test becomes particularly important when the study includes the macroeconomic variables. The unit root test is an important condition which should be fulfilled before applying the time series ARDL modelling in the data. This test is very important because the order of integration needs to be defined before checking the co-integration in the data. Therefore, the ADF Fisher Chi-square (ADF Fisher) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests were used to check the stationery of the data. The test of KPSS was performed by applying the Bartlett Kernel estimation method and the

Newey–west bandwidth. The following equation represents the unit root test performed in this study.

$$\Delta Y_1 = \beta_1 + \beta_2 \, t + \alpha Y_{t-l} + \sum_{t=1}^{m} \rho_i \, \Delta Y_{t-i} + \mu_t \qquad (2)$$

In equation 2, "$\Delta Y_{t-i}$" is a term of lag difference while the "$\beta_1$" is a constant term. The term "t" is the time trend. In a unit root test, the "$\mu_t$" is made serially independent through inclusion of lag difference terms. Following are the null and alternative hypothesis tested in the unit root test:

$$H_o: \boldsymbol{\alpha = 0}$$
$$H_1: \boldsymbol{\alpha \neq 0}$$

## Findings

The secondary data collected in this study was subjected to analysis through EViews 10 in which the descriptive statistics, unit root test, co-integration test, and ARDL modelling were applied in order to assess the relationships.

### *Descriptive test*

This test was adopted to check the normality and acceptability of the current data. The results of the descriptive statistics have been provided in Table 1.

**Table 1. Descriptive Statistics**

| Variables | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|
| IFDI | 0.5892 | 0.6013 | 0.7194 | 0.4781 | 0.0311 | 0.5134 | 1.9040 |
| CO2 | 11.499 | 12.591 | 15.578 | 7.5819 | 1.9882 | -0.4921 | 1.8949 |
| TO | 0.7013 | 0.7921 | 1.4244 | 0.3134 | 0.0414 | 0.28490 | 1.2910 |
| PG | 0.6713 | 1.0145 | 2.1849 | -1.2849 | 0.1813 | -0.7145 | 2.0148 |
| REC | 1.5881 | 1.5782 | 2.8813 | 1.1934 | 0.4913 | 0.7513 | 2.0449 |
| Urbanisation | 0.8782 | 0.8882 | 1.2848 | 0.6823 | 0.2949 | 0.4959 | 1.3389 |

The results of the descriptive statistics provided in Table 1 are showing that the data is acceptable and adequate because the mean value of all variables including CO2 emissions, urbanisation, IFDI,

trade openness, REC and PG are falling within the range of minimum value and maximum value, thus revealing that no outlier exists in the data. The standard deviation for all of them is indicating that there is acceptable variation in the data. Furthermore, the normality of the data has been proved by the statistics of skewness and kurtosis, because skewness for CO2 emissions, urbanisation, IFDI, trade openness, REC and PG are all within the range of -1 and +1 and kurtosis for all of them is more than 1 and less than 3. Hence, the current data is normal and is in a position to be used for further analysis.

***Unit Root Test***

Through this test, the stationery of the data was checked for the sake of avoiding any erroneous regression. The approach of time series ARDL allows the approximation of "co-integrating vector" of both series I(1) and I(0). Table 2 and Table 3 provide the summary for the unit root test applied in this study.

**Table 2. Unit Root Test at the Levels of the Variables**

| Variables | ADF (null: variables has a unit root) | | KPSS (null: variable is stationery) | |
|---|---|---|---|---|
| | Test Statistic | Critical value at .05 level | Test Statistic | Critical value at .05 level |
| IFDI | -0.13 | -2.93* | 0.81 | 0.51** |
| CO2 | 0.38 | | 0.89 | |
| TO | 1.10 | | 0.86 | |
| PG | 1.19 | | 0.81 | |
| REC | 1.11 | | 0.51 | |
| Urbanisation | 1.09 | | 0.48 | |

**Table 3. Unit Root Test at First Differences of Variables**

| Variables | ADF (null: variables has a unit root) | | KPSS (null: variable is stationery) | |
|---|---|---|---|---|
| | Test Statistic | Critical value at .05 level | Test Statistic | Critical value at .05 level |
| IFDI | -6.38 | -2.80 | 0.07 | 0.41 |
| CO2 | -7.12 | | 0.13 | |
| TO | -6.12 | | 0.07 | |
| PG | -6.21 | | 0.13 | |
| REC | -5.37 | | 0.15 | |
| Urbanisation | -6.10 | | 0.07 | |

The unit root test for all variables at level and at first difference (given in Tables 2 and 3) is showing that series CO2 emissions, urbanisation, REC, PG, trade openness and IFDI are I(1). Both tests are providing the same results so, the condition for ARDL modelling is fulfilled.

***Co-integration Test***

After checking the stationery of the data, the co-integration test was performed. If the CO2 emissions, urbanisation, REC, PG, trade openness and IFDI are stationery, then they must be co-integrated. In order to check this co-integration, the indicators of F-statistics, Akaike information criteria (AIC), or Schwarz information criteria (SIC) were considered. The null hypothesis in this test was 'there is no co-integration' while the alternative hypothesis was 'there is co-integration in the data'.

**Table 4. Co-integration Test**

| Lag | Intercept | | | Intercept and trend | | |
|---|---|---|---|---|---|---|
| | AIC | SIC | F | AIC | SIC | F |
| 1 | -2.099 | -1.490 | 3.52 | -2.016 | -1.512 | 3.10 |
| 2 | -2.157 | -1.312 | 4.08 | -2.024 | -1.301 | 3.12 |
| 3 | -2.109 | -1.310 | 2.67 | -1.866 | -1.289 | 2.07 |
| 4 | -2.067 | -1.213 | 3.54 | -1.882 | -1.201 | 2.91 |
| 5 | -2.112 | -1.412 | 3.58 | -2.023 | -1.377 | 3.04 |
| **6** | **-3.013** | **-1.699** | **5.85*** | **-3.042** | **-1.781** | **5.53**** |
| 7 | -2.173 | -1.411 | 0.84 | -2.672 | -1.367 | 0.69 |

The results of Table 4 are revealing that F-statistics is higher at minimum AIC and SIC than the 'upper bound critical value' so, the null hypothesis can be rejected and it is found that there is co-integration in the data. The SIC and AIC at this lag reveal the optimal m. The co-integration test is followed by the long-run ARDL modelling, through which the following equation was tested:

$$\mathrm{CO2}_t = \beta_0 + \sum_{i=0}^{p}\beta_{1i}\mathrm{Urbanisation}_{t-i} + \sum_{i=0}^{q}\beta_{2i}\mathrm{IFDI}_{t-i} + \sum_{i=0}^{r}\beta_{3i}\mathrm{TO}_{t-i} + \sum_{i=0}^{s}\beta_{4i}PG_{t-i} + \sum_{i=0}^{t}\beta_{5i}REC_{t-i} + \epsilon_t \quad (3)$$

After checking the long-run equation, the short-term impact of trade openness, IFDI, and urbanisation on the CO2 emissions was checked through the following equation:

$$CO2_t = \delta_0 + \sum_{i=0}^{p}\delta_{1i}\Delta Urbanization_{t-i} + \sum_{i=0}^{q}\delta_{2i}\Delta IFDI_{t-i} + \sum_{i=0}^{r}\delta_{3i}\Delta TO_{t-i} + \sum_{i=0}^{s}\delta_{4i}\Delta PG_{t-i} + \sum_{i=0}^{t}\delta_{5i}\Delta REC_{t-i} + \lambda ECM_{t-1} + \pi_t \quad (4)$$

In the above equation, ECM is 'coefficient of error correction term' which has been used to estimate the short-term effects of trade openness, IFDI, and urbanisation on CO2 emissions.

***ARDL Model***

The results given in Table 5 depict effects and t-statistics as well as p-values against those effects at level and at first lag.

**Table 5. ARDL Estimation (Dependent variable: CO2 emissions)**

| Variable | Coefficient | Std. Error | t-Statistic | Prob.* |
|---|---|---|---|---|
| IFDI | 0.167144 | 0.1122 | 1.489294 | 0.3891 |
| IFDI(-1) | 0.181455 | 0.0352 | 5.145911 | 0.0004 |
| TO | 0.289256 | 0.1720 | 1.681845 | 0.1939 |
| TO(-1) | 0.29350 | 0.0924 | 3.17484 | 0.0019 |
| Urbanisation | 0.174858 | 0.1713 | 1.020499 | 0.1939 |
| Urbanisation(-1) | 0.20136 | 0.0668 | 3.01040 | 0.0005 |
| REC | -0.38995 | 0.4559 | -0.85534 | 0.4571 |
| REC(-1) | -0.21840 | 0.0752 | -2.902041 | 0.0014 |
| PG | 0.18494 | 0.1241 | 1.489134 | 0.1027 |
| PG(-1) | 0.20013 | 0.1974 | 1.014991 | 0.1848 |
| C | -10.1760 | 5.9132 | -1.720949 | 0.1468 |
| R-squared | 0.782455 | Mean dependent var | | 11.499 |
| Adjusted R-squared | 0.726444 | S.D. dependent var | | 0.0311 |
| S.E. of regression | 0.500134 | Akaike info criterion | | 1.3582 |
| Sum squared resid | 2.169991 | Schwarz criterion | | 1.3891 |
| Log likelihood | -4.64788 | Hannan-Quinn criter. | | 1.1949 |
| F-statistic | 82.92413 | Durbin-Watson stat | | 2.4781 |
| Prob (F-statistic) | 0.000000 | | | |

It can be seen in Table 5 that all independent variables, i.e. trade openness, IFDI and urbanisation have shown a significant positive impact on CO2 emissions at first lag. It means that there is a significant positive impact of all these variables on the CO2 emissions as p-values against them are <0.05 and t-statistics are < t-tabulated. The control variable of PG showed no significant impact on CO2 emissions, while REC showed a negative impact on CO2 emissions at first lag. The long-term and short-term effects of variables found through ARDL modelling have been provided in Table 6.

**Table 6. Estimation of Impacts (Dependent variable: CO2 emissions)**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| | Long Run Equation | | | |
| IFDI | 0.265828 | 0.093311 | 2.84882 | 0.0001 |
| TO | 0.38242 | 0.083529 | 4.57828 | 0.0018 |
| Urbanisation | 0.26921 | 0.075026 | 3.58822 | 0.0001 |
| REC | -0.25710 | 0.086616 | -2.96825 | 0.0049 |
| PG | 0.09572 | 0.086560 | 1.10582 | 0.4592 |
| | Short Run Equation | | | |
| COINTEQ01 | -0.0499 | 0.0445 | -1.12011 | 0.1930 |
| D(IFDI) | 0.19781 | 0.1334 | 1.48193 | 0.1031 |
| D(TO) | 0.1274 | 0.9223 | 0.13813 | 0.2013 |
| D(Urbanisation) | 0.22849 | 0.0784 | 2.91341 | 0.0013 |
| D(REC) | -0.21942 | 0.0572 | -3.83121 | 0.0000 |
| D(PG) | 0.19588 | 0.1810 | 1.08131 | 0.2013 |
| C | -15.50841 | 11.2274 | -1.3813 | 0.1971 |
| ECM | -0.79 | 0.3183 | 2.4813 | 0.0012 |

The results of long-term effects show that trade openness, IFDI, and urbanisation all have significant positive long-term effects on CO2 emissions however, IFDI and trade openness do not have significant short-term impacts on CO2 emissions. The short-term impact of urbanisation on CO2 emissions is significant and positive.

**Discussion**

The current study was about the impact of urbanisation, IFDI, and trade openness on the CO2 emissions of Malaysia. In response to the first hypothesis of the study i.e. 'urbanisation has a significant impact on $CO_2$ emissions in Malaysia', the present study found that there is a significant impact of urbanisation on CO2 emissions. It has been found that the increasing rate of urbanisation adversely affects the environment of the country. These results are consistent with findings of previous studies e.g. Li et al. (2017) and Musila and Yiheyis (2015), which also suggested that urbanisation enhances CO2 emissions in the country. The second hypothesis of this study was

about the impact of trade openness on the CO2 emissions in response to which, the current findings concluded that there is a positive impact of trade openness on the CO2 emissions of the country. It has been suggested through findings that the trade openness enhances the pollution in the country. These results get theoretical support from past literature because a number of previous studies also suggested that trade openness causes the pollution in the country e.g. Y. Jiang (2015) and Shahbaz et al. (2015) showed similar types of findings. In response to the third hypothesis of this study, which was, 'Foreign direct investment has significant impact on $CO_2$ emission in Malaysia', the current study revealed that IFDI positively affects the CO2 emissions in the country because increased IFDI enhances the industrialisation in the country, which ultimately increases the pollution. These findings are also in line with previous studies as Y. Jiang (2015), Naz et al. (2019), Acharyya (2009), and Hoffmann et al. (2005) also suggested that there is a significant positive relationship between IFDI and CO2 emissions. Hence, the results of the present research are sufficiently supported by the previous studies.

## Conclusion

The present research has suggested that urbanisation, trade openness and IFDI adversely affect the environment of Malaysia because these factors enhance the CO2 emissions in the country. This research was carried out with 30 years of data on Malaysia, in which the long-term and short-term impacts of urbanisation, trade openness and IFDI on CO2 emissions have been estimated. All hypotheses of this research have been accepted because significant impacts of urbanisation, trade openness and IFDI have been found in the long-run however, only the short-term impact of urbanisation on the CO2 emissions was supported through findings, while the other two independent variables showed only long-term effects on CO2 emissions.

### *Implications of the Study*

This study can contribute to the literature and practice in a great way because it will enhance the theoretical understanding of the impact of urbanisation, trade openness and IFDI on CO2 emissions, so the literature will be enhanced significantly because the current mixed findings regarding these relationships require empirical findings for clarity of relationships. The strategy makers and policymakers can develop guidelines from this research in understanding how urbanisation, trade openness and IFDI are alarming for pollution in the country so, they can formulate appropriate strategies and policies regarding pollution.

***Limitations and Future Suggestions***

Although the current study is very important due to its implications and contributions, there are some limitations in it that need to be eliminated in future studies. For instance, the current findings are confined to Malaysia, while the impact of IFDI, trade openness, and urbanisation on CO2 emissions may be different in other developing or developed countries, therefore future researchers should conduct cross-national studies to generalise the relationships. Furthermore, the present research has wholly focused on the time series data of Malaysia while future researchers can assess these relationships with the panel data approach by collecting data about different countries so that the understanding about these relationships can be further enhanced.

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