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Do Economic Depressions Contribute to CO_2 Emissions? An ARDL Bound Approach

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ABSTRACT

Total carbon dioxide (CO_2) emissions are undoubtedly emitted to the environment, humans, ecosystems, and global economic growth. However, less research has examined the effect of economic depression on carbon dioxide emission (CO_2), especially in Malaysia. Thus, this study intents to examine the impact of the macroeconomic problems, namely unemployment (UNEMP) and the growing number of people: population (POP), on the CO_2 emissions in Malaysia. The study analyzes the data for 28 years, covering the period of 1991–2019, employing a bound ARDL model as an estimation method. The time series data were sourced from the World Bank Development Indicators database. The finding from the study shows that CO_2 emissions, POP, and UNEMP have a long-term cointegration. Under this situation, all variables indicated; UNEMP and POP lead to environmental degradation in Malaysia in the long run. The impact of both UNEMP and POP on CO_2 emissions is positive. Moreover, it is also found that the damage of economic depression will take only around 1 year and a month on CO_2 emissions. Thus, based on this novel finding, a comprehensive set of economic policies is required to ensure our economy is in good condition and hence suggested for maintaining the environmental quality.

Keywords: CO_2 Emissions, Economic Depression, Climate Change; ARDL Bound Test, Malaysia
JEL Classification: F43, F47, Q52, Q58, Q28

1. INTRODUCTION

Humanity's topmost challenges are sustainable economic development and environmental degradation. Environmental degradation is considered the hallmark of industrialization and a significant driver of economic development. Various studies have focused on environmental issues and restraining severe global warming, which may lead to a serious matter. In Malaysia, National Policy on climate change has been enforced to provide a framework that could guide all government agencies, industries, communities, and other stakeholders to face challenges in climate change scenarios (Rambeli-Ramli et al., 2018). The policy has been imposed to ensure climate-resilient development to fulfill national aspirations for the sustainability of its environment.

However, the world economy is complex and uncertain, and Malaysia is one of the countries exposed to world uncertainty. Despite seeking modernity, economic growth, full employment, and sustainable inflation, a country could not avoid an economic depression-only times matter. For example, during Covid 19, due to health restrictions by the government, people were asked to stay at home. The company could not operate normally; no workers were allowed to work, then the economy became gloomier. Due to no production and the company's costing survival, all the variable costs need to be cut. Like it or not, the workers should be free with or without compensation (Nursyazwani, 2020). The unemployment percentage was uproaring and created an economic depression. Thus, does this depression harms the environment? Or, in other words, does this situation contributes to more CO_2 emission?

Thus, this study examines the impact of selected macroeconomic problems, namely unemployment (UNEMP) and population (POP), on the level of CO_2 emission in Malaysia. Among the factors analyzed, UNEMP and POP are the factors that are rarely involved in the analysis of CO_2 emissions, especially in Malaysia. As unemployment is a common macroeconomic issue, this study would contribute new findings regarding the economic depression on CO_2 emission in Malaysia, especially regarding the short-term aid, the stimulus package, and long-term aid, fiscal and monetary policies involved.

The remainder of the paper is organized as follows. Section 2 discusses the related literature and provides a brief significance regarding variables involved in the CO_2 emission analysis in Malaysia. Section 3 highlights the research method. Section 4 discusses the findings and the final section concludes the paper.

2. LITERATURE REVIEW

The association between unemployment due to economic depression and the environment (CO_2 emissions) has drawn attention, but few have addressed it, particularly in Malaysia. Anthropogenic CO_2 emissions are believed to co-exist with socio-economic activities and macroeconomic problems. As one of the macro problems, unemployment occurs due to low economic growth, and a population without job opportunities due to a low gross domestic product could lead to a critical issue in unemployment. Does this issue contribute to CO_2 emissions? Therefore, it is necessary to justify the fact behind these common senses.

Economic depression is a severe and prolonged turmoil in the economy. The extreme recession could last around three or more years and slow real economic growth by at least 10% (Daniel, 2021). In contrast, depressions are less frequent than milder recessions and tend to be accompanied by high unemployment and low inflation (Barro and Ursúa, 2009). Is unemployment harming CO_2 emissions make sense? Duarte et al. (2016) and Xin et al. (2022) disclosed that people tend to have a low quality of health and damage the environment due to being jobless or not having a stable income. Those who generate a high income have opportunities to fulfill their desires and improve their lifestyle and environment (Xin et al., 2022). This has been seconded by Mulderij et al. (2021), who documented that people with high incomes spend huge amounts on maintaining their health and lifestyle. Xin et al. (2022) revealed that unemployment significantly and positively influences CO_2 emissions in China. Due to financial burdens, green product and service usage decreased, mitigating environmental quality. Meyer (2016) also supported that unemployment and the environment significantly correlate due to time and income restraints. However, Mulderij et al. (2021) concluded that the unemployment and the environment nexus were still indecisive.

Besides unemployment, a larger population also tends to contribute to higher CO_2 emissions. Population refers to the number of people or inhabitants in a country or region (Merriam-Webster, 2022). In other words, people are endogenous to environmental degradation. The increase in the population has reflected the CO_2 emissions, where urban areas suffer from higher pollution compared to rural areas (Gebre and Gebremedhin, 2019). Carlino et al. (2007) showed that a city with double-developed employment density would contribute 20 percent of CO_2 emissions. A city with a double-developed employment density leads to higher production and various intermediaries (Rahman et al., 2020). Rahman and Kashem (2017), and Owusu-Agyei et al. (2012), who work on the bidirectional panel causal link between GDP and population density, found a significant and positive impact of population growth on CO_2 emissions.

Given these facts, the findings from previous studies may or may not reflect the reality of the nexus between economic depression and CO_2. Few previous studies alert the depression related to environmental concerns, despite the global calls for a green economy and environment, especially in Malaysia. Thus, this study is motivated to examine the nexus of unemployment and population issues to the environmental performance of CO_2 due to the economic depression.

3. METHODOLOGY

3.1. Model Specification

This study adopts the investigation of autoregressive distributed lag (ARDL) bound testing by Pesaran et al. (2001) due to its provision of long-term relationships and dynamic interaction among a series of interests. Bound testing is appealing to utilize due to its attractive features:

1. This approach allows having a different integrated level, e.g., level I(0) or I(1).
2. In this approach, the empirical evidence is efficient and consistent in the small sample.
3. It involves a single-equation setup, thus making it easy to implement and interpret.
4. It allows to assign of different lag lengths from different variables as they enter the model.

In order to examine the impact of UNEMP and POP on CO_2 emissions in Malaysia, the following model is considered:

$$CO_2 = f\left(UNEMP, POP\right) \tag{1}$$

Where CO_2 represents CO_2 emissions, UNEMP is unemployment, and POP represents the population. Regarding empirical and theoretical literature, UNEMP boosts CO_2 due to a country's depression. POP is also estimated as positively related to CO_2 once they reach high. Estimation of Equation (1) yields only long-run estimates. Thus, this study also employs an error-correction model in an attempt to analyze the short-term effect. An econometric approach that yields the long-run and the short-run effects in one step is that of Pesaran et al. (2001) as follows:

$$lnCO_{2t} = \beta_0 + \beta_1 lnUNEMP_t + \beta_2 lnPOP_t + \varepsilon_t \tag{2}$$

All the study variables are transformed to their logged shape (ln). The parameters in Eq. (2), β1, β2 are the long-run elasticity coefficient of carbon dioxide emissions (CO_2) from unemployment

Table 1: Stationary tests

Variables	ADF		PP	
	Level	1 differences	Level	1 differences
LCO_2				
Intercept	−2.106	−5.465***	−2.160	−5.465***
Intercept and trend	−2.166	−5.366***	−2.227	−5.366***
LUNEMP				
Intercept	−2.754	−4.875***	−2.344	−5.024***
Intercept and trend	−2.681	−4.935***	−2.217	−4.909***
LPOP				
Intercept	1.812	−3.976***	−12.408***	−0.493
Intercept and trend	−5.770***	−0.867	−0.002	−2.152

*,**, ***Imply 10%, 5%, and 1% level of significance respectively. ADF: Augmented Dickey-Fuller, PP: Phillips-Perron

Table 2: The autoregressive distributed lag cointegration bound test

Test statistic	Value	Significane (%)	I (0)	I (1)
F-statistic	6.6607	10	2.845	3.623
		5	3.538	4.335
		1	5.155	6.265

Critical values are in Narayan (2005)

Table 3: Long run and bounds estimates using the autoregressive distributed lag approach

Dependent variable: LCO_2			
Variables	Coefficient	SE	t (P)
LUNEMP	1.6380	0.4131	5.3014 (0.0000)
LPOP	5.6380	0.4130	3.9652 (0.0007)
C	−101.9942	20.0773	−5.0801 (0.0000)

The maximum lag length is ARDL (1,2,0) based on the SC. ARDL: Autoregressive distributed lag, SE: Standard error

(UNEMP) and population (POP) for carbon dioxide emissions correspondingly, and ε_t is the error term.

3.2. ARDL Bound Testing Method

The advantage of the autoregressive distributed lag (ARDL) bound method is its availability to investigate the equations when the variables are stationary at a level I(0) and also in first difference I(1) (Pesaran et al., 2001). The cointegration between the variables must be established prior to adopting the ARDL model. Subsequently, ARDL bound test is employed to investigate the presence of cointegration among the variables in short-run and long-run relationships.

The unrestricted or unconstrained error correction models for CO_2 emissions, UNEMP, and POP based on the ARDL model are as follows:

$$\Delta \ln CO2_t = \beta_0 + \sum_{i=1}^{k}\beta_1\,\Delta lnCO2_{t-i} + \sum_{i=1}^{k}\beta_2\,\Delta lnUNEMP_{t-i} + \sum_{i=1}^{k}\beta_3\,\Delta lnPOP_{t-i} + \gamma_1 lnCO2_{t-i} + \gamma_2 lnUNEMP_{t-i} + \gamma_3 lnPOP_{t-1} + \varepsilon_t \quad (3)$$

Where Δ is the first difference operator, β_0 represents the constant term, and ε_t denotes the residual term. The short-run relationship coefficient is denoted by β_1, β_2, and β_3, while the long-run relationship coefficient is denoted by γ_1, γ_2, and γ_3, respectively.

In order to determine whether the series are cointegrated, ordinary least squares (OLS) are applied to estimate Equations (3). The next step is applying the F-test for the lagged levels of the variables to zero. The null and the alternative hypothesis of cointegration for Equations (3) are as follows:

$$H_0: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0$$

$$H_1: \gamma_1 \neq \gamma_2 \neq \gamma_3 \neq \gamma_4 = 0$$

The null rejection means that the series are cointegrated in the long run. The next step is the assessment of the error correction model (ECM), stated as follows:

$$\Delta lnCO2_t = \beta_0 + \sum_{i=1}^{k}\beta_1\,\Delta lnCO2_{t-i} + \sum_{i=1}^{k}\beta_2\,\Delta lnUNEMP_{t-i} + \sum_{i=1}^{k}\beta_3\,\Delta lnGDP_{t-i} + \sum_{i=1}^{k}\beta_4\,\Delta lnPOP_{t-i} + \gamma\, ECM_{t-1} + \varepsilon_t \quad (4)$$

Even though the ARDL cointegration technique does not require unit roots pre-testing, the study still tests unit roots to avoid the presence of an integrated stochastic trend of I(2) in the series (Debele, 2019; Manzoor et al., 2021). The study employs Augmented Dickey-Fuller (ADF) and Philip Perron (PP) for this unit root testing (Table 1).

3.3. Data

This study covers the time series data of 28 years from 1991 to 2019, sourced from the World Development Indicator (WDI) database, The World Bank. This study uses CO_2 per capita emissions as the dependent variable measured by metric tons per capita. The explanatory series consists of unemployment (UNEMP) which uses the percentage of the total labor force, and population (POP), which refers to the total population yearly.

4. RESULTS AND DISCUSSION

As mentioned, this study utilizes an ARDL estimator to explore the economic depression impact on CO_2 emissions in Malaysia. To

Table 4: Log-linear short-run estimates and error correction model

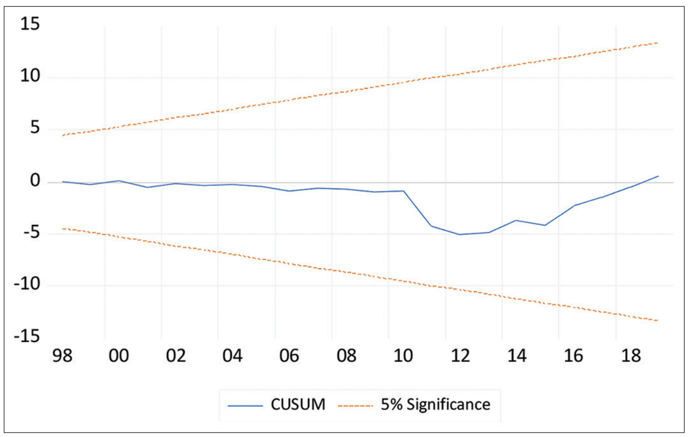
Variable	DLUNEMP	DLPOP	DLPOP (−1)	ECT (−1)
Coefficient	1.1096*** (0.0016)	395.9614*** (0.0000)	−214.1653*** (0.0014)	−0.9315*** (0.0001)
R-squared	0.6383			
Adjusted *R*-squared	0.5725			
F-statistic	9.7053			
Probability (*F*-statistic)	0.0001			
DW statistic	2.0137			

*,**, ***Imply 10%, 5%, and 1% level of significance respectively. ECT: Error correction term

Table 5: Diagnostic test for error correction term-based autoregressive distributed lag model

Test statistic	Obs* *R*-squared	Probability values
Serial correlation (lag 2)	2.0685	0.3555
Serial correlation (lag 4)	3.1303	0.5363
CUSUM	Stable	

Figure 1: A plot of the cumulative sum of recursive residuals



prove it, firstly, we have to test whether the series is stationary in level I(0) or the first difference I(1). The augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) stationary tests are employed for this purpose. Both the null hypothesis in the ADF and PP stationary tests indicate that the series is not stationary.

The results for each series are shown in Table 1 by using, with intercept, and with intercept and trend. Accordingly, the null of having a unit root is rejected for CO_2 and UNEMP based on the ADF and PP tests in the first-order integrated, I(1). However, POP rejected the null hypothesis in level I(0) for the ADF test, with intercept and trend, and the null hypothesis in level I(0) for the PP test, with intercept.

4.1. Bounds Cointegration Test

The results of the bounds cointegration test are shown in Table 2. The respective calculated F-statistic is 6.6607 is greater than the critical value of the finite sample, n = 27, of all significance levels. Therefore, the null hypothesis of no cointegration is rejected. Consequently, there is a stable long-run cointegration among the set of variables.

4.2. Log-linear Long Run Coefficient

Driven by an assumption that the model of the study, CO_2 emissions as the predicted variable, we have estimated a log-linear long-run for Malaysia. The assessed log-linear long-run coefficient is found from the subsequent estimations of ARDL given in Table 3 below. Table 3 shows that the coefficient for the UNEMP variable is positive and significant at 5%. The coefficient of UNEMP identifies that, with every 1% increase in UNEMP, the CO_2 emissions tend to increase by 1.6%. In other words, the country's environment is polluted by 1.6% due to the loss of occupation. This empirical evidence confirms that UNEMP positively affects Malaysia's environmental cases. These findings are consistent with the prior study by Xin et al. (2022), which finds that unemployment contributes to more carbon emissions.

Meanwhile, the POP is elastic, positive, and statistically significant at the 5% significance level. In particular, a 1% increase in POP leads to a 5.9% increase in CO_2. This show that there is evidence that an increase in POP will significantly affect environmental degradation. Thus, it confirms the work of Martínez-Zarzoso et al. (2007) that pollution is a matter of human hands. It could also be justified that education is one of the tools that could counter this problem to alert this situation from worsening.

4.3. Log-linear Error Correction Model (ECM)

Table 4 presents the results of the estimated ECM, and these findings indicate that the coefficient of the CO_2 model is positive and statistically significant at a 5% significance level. The short-run CO_2 states that a total of 1.12% of CO_2 is increased with each 1% rise in UNEMP. The short-run UNEMP coefficient is slightly rigid relative to long-run estimates. In short, the positive effect of UNEMP is less apparent than it is in the long run. The POP in the short run is also positive and significant at the 5% significance level. The short-run POP suggests that a 1% change in POP would result in a rise in a worrisome CO_2 of 396%. That indicates that the positive POP effect is most polluted in the short run. The lag (−1) POP rate, though, in the short run, is found to be significant and negative. The estimated coefficient lag POP is negative and statistically significant at the 1% significance level. In particular, a 1% increase in the lag POP would lead to a 214% decrement in CO_2. The approximate coefficient of the (ECT) error correction term is negative and statistically significant at 1%. The outcome implies that the short-run deviation adjustment procedure is very high. The ECT coefficient −0.9315 defines a rapid adjustment rate at any short-run deviation will take about 1 year and a month. As this is annual data, therefore 0.9315 will be converted to a percentage that will become 1.07 years (1/93.15 *100). It would mean that within a year, if the UNEMP is left ignored, thus, the CO_2 will worsen.

4.4. Diagnostic Test

The results of diagnostic assessments are summarized in Table 5 and Figure 1 below. The evaluated ARDL model is tested on serial correlation problems (as the sample is small, less than 30, thus, this study uses two different lags, 2 and 4, to show the good fit of the sample) and stability of the parameters. Table 5 proves that the assessed ARDL model passed out all the serial correlation tests, which means the model is free of serial correlation that could spoil the result once it appears. The Cumulative Sum (CUSUM) parameter stability test plot in Figure 1 also proves that the estimated parameters are within the upper and lower bounds. This is evidence that the model is stable.

5. CONCLUSION

The study finds evidence of the relationship between CO_2 emissions, UNEMP, and POP in Malaysia from 1991 to 2019. The study employs augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) for its unit root tests. Subsequently, the study performs the autoregressive distributed lag (ARDL) bound method to find the short-run and long-run relationship between all variables. Our results confirmed that there is both a long-run and short-run relationship between the endogenous variable, CO_2 emissions, and exogenous variables, UNEMP and POP.

The long-run analysis shows that a 1% increase in UNEMP or a 1% increase in job loss cases and an increase of 1% in total population lead to an increase in CO_2 emissions by 1.6% and 5.6%, respectively. The results of the short-run estimate that CO_2 emissions from both UNEMP and POP also have a positive and significant relationship with CO_2 emissions. The most exciting outcomes of the short-run analysis show that the ECT was −0.9315, which displays that the deflection of CO_2 emissions from short-run to long-run equilibrium is settled by 93.15% every year. It takes about 1 year and a month to degrade. This reaffirms the earlier findings that the unemployed engage in unproductive activities detrimental to the environment.

COVID-19 teaches us how slow economic growth affects our country's productivity. Based on these results, several main policy initiatives should consider the issue of job opportunities and education in Malaysia. People were unhired, and low purchasing power tended to harm the environment for survival. A short-term fiscal stimulus policy could be the best solution to this issue. The government should reduce its bureaucracy in handling the issue of unemployment, especially on stimulus packages for those affected. Besides fiscal stimulus, monetary stimulus should always be flexible in curbing unemployment. The role of the Central Bank in moderating the issue of loans and fixing the installment amenity should be moderated. They were the "engineer" to give a proper way to lessen the burden of the people during COVID-19.

Finally, promoting environmental and energy-redeeming initiatives will regulate CO_2 emissions and safeguard our ecosystem from pollution, thus saving millions of inhabitants from natural disaster impacts. As the high population is significant to environmental pollution, thus education sector should be the one to have the initiative upholding the new generation on the green and clean protected environment. The current study attempts to justify the structural problems to scrutinize the association between CO_2 emissions and economic depression. The study was limited in the context of Malaysia to the mentioned variables. On the other hand, the results may vary in other developing nations in a similar context. Therefore, it is the government's responsibility to create policies that favor public interests and promote the welfare of the people in the country. The government should focus on increasing sustainable economic growth, price stability, and job creation to reduce economic depression.

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