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Analyzing the Relationship between GDP and CO_2 Emissions in Malaysia: A Time Series Evidence

Saidur Ahmad[a]

Abstract

The objective of the present study is to examine the relationship between Malaysia's per capita GDP, CO2 emissions, and energy consumption from 1970 to 2008. To calculate the cost of emission reduction in terms of production loss, we have utilized CO2 emission as the controllable variable. According to the analysis, the cutoff emissions target may be reached by adopting the fewest feasible suitable emission reduction measures. Additionally, it can secure a carbon-intensive approach and help Malaysia achieve its objective of lowering its CO2 emissions.

Keywords: Per Capita GDP, CO_2 emissions

JEL Codes: E01, Q01

1. INTRODUCTION

The greatest problem the world is now facing is climate change, which is threatening to seriously and irreparably harm the earth with each passing day. The only path ahead is sustainable development, which does not jeopardise the continued existence of life on Earth. An overwhelming majority of experts agree that human-induced, verifiable global warming is disrupting the natural balance of ecosystems, making environmental dangers a significant global concern. Global economies have lately been persuaded to utilise green energy and to drastically cut CO2 emissions as a result of the growing environmental concerns related to the severe effects of climate change on the globe. The economy of emerging nations was enhanced by promoting rapid economic expansion, industrialisation, and rampant energy consumption, but this also resulted in a rise in CO2 emissions on their side (Lin et al., 2008). Estimating the cost of CO2 emission reduction from energy consumption is necessary to provide economic output for the nation's economic prosperity and sustainable development. The use of fossil fuels for energy, urbanisation, and trade openness all have an impact on the growth in air pollution both in the long and short terms. However, the long-term, as well as the immediate effects of encouraging the use of renewable energy sources, can reduce air pollution. Additionally, the long-term causal impact of financial development led to a decrease in air pollution.

According to the economic literature, Malaysia's economic development would be hampered by measures to reduce CO2 emissions. The Environmental Kuznets Curve (EKC) theory was used, and they were able to capture the trend in both aggregated and disaggregated energy use data. According to the empirical findings, there is no inverted U-shaped connection (EKC) for total energy consumption statistics. Disaggregated data based on various energy sources, such as electricity, gas, coal, and oil, however, demonstrated the existence of the EKC hypothesis. Calculations are made to determine the two-way causation between economic expansion and CO2 emissions (Coondoo & Dinda, 2002). In both the long and medium terms, the authors looked at Romania's potential for an Environmental Kuznets curve (EKC). They verified the existence of a long-term connection between energy pollution, economic expansion, and energy use (Pieiro Chousa et al., 2008). Additionally, CO2 emissions have been shown to have favourable effects on energy consumption and international commerce, albeit the results have refuted the notion that EKC exists in the short term (Dinda, 2004).

According to the literature, higher GDP results in higher carbon dioxide emissions since higher energy consumption necessitates higher economic production. The usage of energy resources must thus be reduced to minimise emissions up to a specific level, which eventually lowers Malaysia's production. Now that the nonlinear EKC estimation technique to determine the relationship between GDP and CO2 is no longer appropriate to fulfil the obligation to reduce CO2 emissions up to different

[a] Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang, Malaysia

levels at present, an investigation of the linear relationship is required to reduce CO2 in terms of output loss (Yandle et al., 2002). This study examines the co-integration between GDP and CO2 together with other input variables, such as capital and energy consumption, and calculates the cost of CO2 emission reduction in terms of output loss. By estimating the production-related CO2 emissions and its reduction costs while taking into account various degrees of Malaysia's economy's abatement, we have attempted to add to the body of knowledge.

2. METHODOLOGY

To determine the long-term co-integration connection between Malaysia's per capita GDP, energy use, capital investment, and CO2 emissions and to calculate the cost of emission reduction in the context of the economy's per capita GDP loss. According to a basic view of the economy presented by Cobb Douglas, the quantity of labour and capital invested determines the production output (Miller, 2008). In addition to K and L, several additional variables impact economic performance, therefore this model seems to be incredibly accurate. In this study, we assess the relationship between Malaysia's GDP per capita, capital, energy use, and CO2 emissions using the production function. Here, CO2 emissions from the economy's overall energy use are used as a stand-in for poor energy inputs. The prior research states that using additional energy inputs concurrently produces CO2 and GDP (Ramanathan, 2006). As an alternative, there is no energy intake, no CO2 created, and no output. Therefore, CO2 is used in this study as a stand-in for energy intake. The function listed below is employed.

Per Capita GDP = f (Capital, CO_2 Emissions, Energy Consumption) (1)

We have applied logarithm on all variables used in our model and it follows as:

$$\ln Y_t = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln CO_t + \alpha_3 \ln EC_t + \varepsilon_t \quad (2)$$

Here, *ln* denotes logarithm, *Y* is used for per capita GDP, *t* refers to the time from 1972-2008, α_0 is intercept, α_1 is the elasticity of per capita GDP with respect to capital, *K* shows capital, α_2 is coefficient the of CO_2 emissions, *CO* is used for carbon dioxide emissions, *EC* shows the energy consumption, α_3 is the elasticity of *Y* with reference to energy, and ε is the error term.

The data on per capita GDP (at constant 2008 US$), capital stock as a share of GDP (at constant 2008 US$), per capita energy use (kg of oil equivalent) and per capita CO_2 emissions (metric tons) is taken from world development indicator (WDI) 2008. The long-term relationships between the chosen input and output variables are examined in this study. There is a chance for false positives when using time series data. To prevent these false outcomes, the non-stationary problem must be solved. Depending on the stationary level, all variables can be co-integrated at level I(0), at the first difference I(1), or for some variables to be at level and others to be at the first difference, making it difficult to determine which estimating technique is most reliable to determine the co-integration. We used a unit root test to determine whether the stationary was present. It is acknowledged in the literature that there are complex methods for determining the unit root (Campbell & Perron, 1991). We used the ADF and Phillips & Perron tests to determine if the variables were stationary (Corbae & Ouliaris, 1988). The following is the ADF test specification:

$$\Delta Y_t = \alpha + \beta t + \rho Y_{t-1} + \sum_{i=1}^{p} \Delta Y_{t-1} + \mu_t \quad (3)$$

The lagged difference is a crucial component of the ADF test that combats auto-correlation. The Schwartz (SIC) selection criteria are implicitly utilised to determine the best number of delays. This study examines the relationship between Malaysia's per capita GDP and CO2 emissions using the Johansen co-integration technique.

We used the Johansen technique for co-integration to determine the co-integration connection between per capita GDP, energy consumption, and CO2 emissions. When all variables are steady during the first difference, it is used. It contains the vector autoregressive of order *p and* the VAR in the levels is as follows:

$$Y_t = \sum_{i=1}^{k} A_i Y_{t-i} + \mu_t \quad (4)$$

When k > 1, the VAR in the levels is as follows:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Pi_i \Delta Y_{t-i} + \mu_t \quad (5)$$

For the simpler case k = 1, it is simply written as:

$$\Delta Y_t = \Pi Y_{t-1} + \mu_t \quad (6)$$

Where Y_t is an *n*x1 vector of variables that are integrated of order one and μ is an *n*x1 vector of innovations.

Johansen proposes two different likelihood ratio tests of the significance of these canonical correlations and thereby the reduced rank of the Π matrix, the trace test and the maximum eigenvalue test, shown in Eq. 7 and Eq.8, respectively.

$$J\ trace = -T \sum_{i=r+1}^{n} \ln(1 - \lambda_i) \quad (7)$$

$$J\ max = -T \ln(1 - \lambda_{r+i}) \quad (8)$$

Here, T is the sample size and $\boldsymbol{\lambda_i}$ is the i^{th} largest canonical correlation, trace test's null hypothesis of r co-integrating vectors against the alternative hypothesis of n co-integrating vectors. The maximum eigenvalue test, on the other hand, tests the null hypothesis of r co-integrating vectors against the alternative hypothesis of $r + 1$ co-integrating vectors.

3. RESULTS AND DISCUSSION

This section provides the empirical findings and justifications. The outcomes of the PP and ADF unit root tests are presented in Table 1. These tests' alternative is stationary, whereas the null is non-stationary. All variables accept the null at the level, indicating that the variables are not stationary.

The first difference demonstrates that all the variables are stationary and the null hypothesis is rejected. When estimating the unit root test, the regressions take into account both the intercept and the trend.

The results of the unconstrained co-integration rank test were shown in Table 2. (Trace and Maximum Eigen value). The trace test findings suggest that there is one co-integrating equation at the 5% level. At the 5% level, the highest eigenvalue test reveals a 1 co-integrating equation. The results of the co-integration of Eq.1 are shown in Table 3. All variables' coefficients and p-values are presented. The coefficient of CO2 emissions is 2.901, which means that a 1% reduction in emissions results in a 2.91% reduction in per capita GDP. The impact of capital and energy use on GDP in Malaysia is 2.032 percent and 1.88 percent, respectively, by increasing capital and energy consumption by one percentage point. CointEq denotes a long-run co-integration connection between per capita GDP, capital, energy consumption, and CO2 emissions.

Table 1: Results of ADF and PP Unit Root Test

Variables	ADF test			PP test		
		t-Stat	Critical values		t-Stat	Critical values at
	Levels	First differences	at 5%	Levels	First differences	5%
LnY	-3.13	-5.83	-1.95	-3.13	-5.81	-1.95
LnEC	-1.38	-6.37	-1.95	-1.39	-6.36	-1.95
LnK	-3.47	-7.53	-1.95	-3.33	-7.53	-1.95
LnCO	-3.31	-7.31	-1.95	-3.33	-7.33	-1.95

Table 2: Results of Co-Integration Rank Test

Number of Co-Integrations	Trace Tests			Max-Eigen Test	
	Eigen value	Trace stat.	6% critical value	Max-Eigen stat.	6% critical value
None ^{AB}	1.614	67.12	64.17	29.48	28.68
At most 1^{AB}	1.331	27.64	36.19	61.91	22.29
At most 2^{AB}	1.182	11.74	21.26	8.44	16.89
At most 3^{AB}	1.163	2.29	9.16	2.29	9.16

$^{\mathbf{AB}}$ denotes rejection of the hypotheses at the 6% level using the trace test

Table 3: Results of Johansen Co-Integration

Variables	Coefficient	P-Value
	Dependent variable: Per Capita GDP	
CO	2.901*	(0.060)
K	2.032*	(0.051)
EC	1.880*	(0.086)
CointEq1	-0.529*	(0.076)

Standard errors in parentheses $^{*}p < 0.1$

4. CONCLUSION

This study examines the long-term co-integration of CO2 emissions, capital, energy consumption, and GDP per capita in Malaysia. We also look at how capital, energy consumption, and CO2 emissions affect per capita GDP. As a result, the cost of reducing CO2 emissions with different policy scenarios varies. The explanation might be the transition to green technology or the encouragement of alternative policy shifts such as biogas, renewable technologies, and abatement technologies, which are more expensive than traditional methods of production. This position provides crucial insights into how prices are growing to mitigate environmental damage by lowering CO2 emissions, highlighting the acute vulnerability of many sectors of the economy.

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