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An Investigation on Environmental Kuznet's Curve Hypothesis in Upper Middle Income Countries: Does an Inverted 'U' Shaped Exist for CO_2 Emissions?

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Abstract

The environmental Kuznets curve (EKC) hypothesis introduced by Simon Kuznet in 1955 is a theory that discussed the relationship between economic growth and environmental degradation. It simply described how in early stage of development of a nation (low per capita income) could generally increase the environmental degradation, and later shrink after its per-capita income exceeds a certain level forming an inverted 'U'- shaped curve popularly known as the EKC curve. This study attempts to verify the EKC curve for the upper middle-income countries as well as to determine the factors contributing to the increase in the level of their Carbon Dioxide (CO2) emissions. The results show that Gross Domestic Product (GDP) and energy consumption have a negative and positive significant effect on the level of CO2 emission in these countries, respectively. The EKC curve portrays an inverted 'U'- shaped curve as hypothesized and the turning point is computed to be 8.6 implying that their carbon emission will start to decrease after this point. An important implication of this study is that energy consumption proven to be harmful to the environment in these nations but not economic development. Hence, policy should focus on how to consume energy efficiently so as to control the level of carbon emission so as to ensure sustainable growth in the long run.

Keywords: environmental kuznet's curve, co2 emission, upper middle income nations, inverted 'u' shape

Introduction

The upper middle-income countries are categorized by the World Bank as countries with Gross National Income (GNI) per capita between USD$4,036 to USD$12,475. These upper middle-income countries have successfully transformed their economy from primarily being in the agricultural sector to a more energy-led industrial based economy. Although growth has shown a positive outcome for the

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countries' economy, it does however simultaneously portray potential negative contribution in the form of a high level of carbon dioxide emissions.

The contribution of upper middle-income countries to the world carbon emission has increased persistently throughout the years. The CO_2 emission that based on fossil fuel contributes more than 60% of the greenhouse effect of which the major source comes from energy consumed for industrial activities and transport industry in particular for the purpose of economic growth and development. Referring to Figure 1, the World Bank (2018) report clearly shows that the upper middle-income countries stated the second largest contributor to the world's carbon emissions after lower middle-income country. Most of them are still in their transition stages, thus to become a developed country, attempts to move away from low levels of economic activity to achieve higher levels of economic activity are much needed.

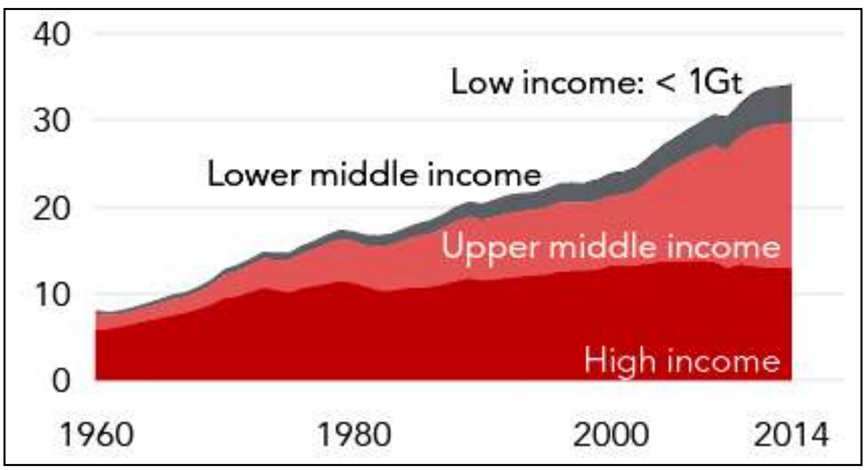

Figure 1. Annual CO2 Emissions (Gt) by Income Group, 1960-2014
(Source: Carbon Dioxide Information Analysis Center. World Development Indicators)

Economic activity measured by GDP is essential to reduce poverty, increases productive capacity, and improves living standards of a nation. Leading the world's economic growth in 2018 is China, an upper middle-income country with expected growth of 6.6 per cent, followed by others such as Kazakhstan, Mexico, Malaysia and Russia (World Bank, 2018b). However, increased economic growth also comes with increased environmental degradation as many past researchers

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have proven (Ang, 2007; Halicioglu, 2009; Zhang and Cheng, 2009; Nasir and Rehman, 2011).

At the core of this relationship between economic development and environmental degradation says (Kuznets, 1955), lies the observed inverted-U relationship known as the Environmental Kuznets Curve (EKC). The concept of EKC as a phenomenon was much discussed in the 1990s when the issue of the relationship between environmental quality and economic development was being debated (Mohapatra and Giri, 2008). However, Dinda (2005) pointed out that most of the 1990s empirical studies were mainly motivated to find the cause of environmental problems and introduce policy suggestions. While, Munasinghe (1999) claimed that the EKC approach is crucial to help the developing countries learn from the experiences of the industrialized nations; thereby avoiding going through the same stages of growth that involve relatively high levels of environmental harm. Despite the fact that the developed countries were historically responsible for the largest share of emissions, the share is expected to fall continuously in the coming years as shown in Figure 1 earlier.

To consider the policy implications of the CO_2 emission in these nations, it is of essential to consider three factors that could intensify the carbon emissions besides economic growth i.e. energy consumption, foreign direct investment (FDI) and urbanization. Basically, the objectives of this study are: i) to determine the factors contributing to the increase in the carbon emission and; ii) to verify the EKC curve for the upper middle-income countries' economy. Based on a 5-year time period data of seventeen upper middle-income countries, a panel data analysis is then applied.

Method

Econometric Modeling

The basic model for the EKC hypothesis equation was presented as:

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$$E_{it} = \alpha + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \varepsilon_{it}$$

(1)

Where E denoted environmental quality, Y and Y^2 were the income level and its squared respectively, $i = 1,\ldots N$ denoted individual economic units, $t = 1,\ldots T$ denoted time period and ε is an error term. The hypothesis would exhibit a meaningful relationship if the coefficient values are $\beta_1 > 0$ and $\beta_2 < 0$ ~ and if the turning point $-\beta_1/2\beta_2$, gave a practically low value. When the coefficient values of the income level were positive and its squared to be negative, the EKC curve became an inverted U-shaped (Bartoszczuk, Ma, and Nakamori, 2002).

Based on equation (1), this study applied the short-panel balanced data for seventeen countries with a limited five-year period. Using the three competing econometric formulations namely pooled model, random effect model and fixed effect model would provide more information, more variability, more robust analysis and efficiency among the changes in the variables over time. The notation for the empirical model for this study could be written as:

$$CO_{2it} = \alpha + \beta_1 GDP_{it} + \beta_2 GDP_{it}^2 + \beta_\kappa X_{it} + \varepsilon_{it} \quad (2)$$

Where CO_2 denoted carbon dioxide emission, GDP was the gross domestic product of each country and X was the three explanatory variables i.e. energy consumption (EGC), foreign direct investment (FDI) and urbanization (URB). These variables were assumed to be strictly exogenous where each did not depend on the current, past and future error term, ε_{it}. Besides, it also assumed that the error term was normally distributed with (0,~ σ_ε^2) with zero mean and constant variance. It simply meant the characteristics of the explanatory variables at any time period the error term would have zero expectation.

The first technique was to run the basic pooled OLS model of which the pooled entity (countries) was assumed to be almost similar or homogenous. In this model,

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the regression analysis assumed both intercept and slope were the same across units and time. Thus, the empirical equation was presented as:

$$lnCO_{2it} = \alpha + \beta_1 lnGDP_{it} + \beta_2 lnGDP_{it}^2 + \beta_3 lnEGC_{it} + \beta_4 lnFDI_{it} + \beta_5 lnURB_{it} + \varepsilon_{it} \quad (3)$$

Where: $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5 > 0$; i = 17 nations and t = 5 years (2010-2014).

However, within the context of panel data, there were two kinds of variation i.e. between cross-section units and within time-series units. Between variance referred to the variability across the unit of observations or cross sectional variations whereas within variance captures how much the overall variance was due to variability within economic units i.e. the time series variations. These variations could be observed with the random and fixed effect models.

Basically both econometric models merely allowed heterogeneity or individuality among the countries by allowing them to have their own intercept values, while restricting the slope to be homogenous. To accommodate such heterogeneity, the error term ε_{it}, was decomposed into two independent components depicted by the equation as:

$$\varepsilon_{it} = \lambda_i + \mu_{it} \quad (4)$$

λ_i was termed as individual specific effect meaning each country may have a unique characteristic such as in this case different factor endowments or culture. On the other hand, μ_{it} was a normal error term denoting the remainder disturbance. Subsequently the random effects' equation would be:

$$lnCO_{2it} = \alpha + \beta_1 lnGDP_{it} + \beta_2 lnGDP_{it}^2 + \beta_3 lnEGC_{it} + \beta_4 lnFDI_{it} + lnURB_{it} + \lambda_i + \mu_{it}$$

(5)

Where λ_i became part of the error term and would be appropriate if observations were representative of a sample rather than the whole population. To compute the

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analysis for random effects, a crucial assumption to ensure consistency was to assume $E(x_{kit}\lambda_i) = 0$ for all k, t, i depicting that λ_i was uncorrelated with x_{it}. It meant the individual specific constant terms were randomly distributed across cross-sectional units.

On the other hand, the fixed effect model assumed each individual specific effect to have intercepts that might vary across countries. In econometric terms it was when Cov $(\lambda_i x_{it}) \neq 0$ or λ_i was correlated with x_{it} meaning it relied on the time series variations but was the most flexible in that it allowed endogeneity of regressors. Hence, the equation was:

$$lnCO_{2it} = (\beta + \lambda_i) + \beta_1 lnGDP_{it} + \beta_2 lnGDP_{it}^2 + \beta_3 lnEGC_{it} + \beta_4 lnFDI_{it} + \beta_5 lnURB_{it} + \mu_{it}$$

(6)

$(\beta + \lambda_i)$ means λ became part of constant but still varies by individual units.

The appropriate test to discriminate between the pooled model and the random effect model was to utilize the Breusch-Pagan Lagrangian Multiplier (BP-LM) test. The hypothesis for the test was:

$H_0: \sigma^2_\lambda = 0$ versus $H_A: \sigma^2_\lambda > 0$ (7)

To choose whether the random or fixed effects models provided better analysis, the statistical test would be the Hausman test that based on the hypothesis:

$H_0: Cov(\lambda_i x_{it}) = 0$ (Random) versus $H_A: Cov(\lambda_i x_{it}) \neq 0$ (Fixed) (8)

Rejection of the null hypothesis would mean the fixed effects model was the appropriate method to explain the analysis.

Data Sources

The data gathered involves 17 selected upper middle-income countries namely Bulgaria, Belarus, China, Croatia, Ecuador, Iraq, Kazakhstan, Lebanon, Malaysia, Mexico, Panama, Peru, Romania, Russian Federation, Thailand, Turkey, and

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http://proceedings.itltrisakti.ac.id/index.php/atlr

Turkmenistan ranging from the period of 2010 to 2014 (5 years) which gave a total of 85 observations. These data were gathered from the World Bank 2017. Since each data had different unit of measurement, the data were transformed into natural logarithm that help to reduce the variability within the variables so as to provide a reliable empirical analysis.

Discussion and Result

The discussion begins with a preliminary study on descriptive analysis to examine the characteristics of each variable to test the data goodness-fit measure. Referring to Table 1, the value of the mean and the median show the central tendency where both values are close, showing that the distribution is approximately symmetrical. The value of standard deviation indicates less dispersion of data whereas the probability values of the Jarque-Bera statistics (Gujarati & Porter, 2009) are insignificant at 5% level of significance implying that the data are normally distributed.

Table 1. Summary of Descriptive Analysis

	$lnCO_2$	lnFDI	lnGDP	$lnGDP^2$	lnEGC	lnURB
Mean	1.650	1.105	8.941	80.062	7.571	4.173
Median	1.519	1.103	8.979	80.628	7.528	4.237
Maximum	2.750	2.778	9.540	91.003	8.550	4.474
Minimum	0.512	-1.434	8.398	70.530	6.454	3.786
Std. Dev.	0.563	0.788	0.333	5.964	0.568	0.183
Skewness	0.212	-0.298	0.078	0.120	0.054	-0.369
Jarque-Bera	1.833	1.425	5.465	5.370	1.619	5.819
Probability	0.399	0.491	0.065	0.068	0.445	0.055

The next part is to carry out the correlation analysis to ensure the variables are not highly correlated among each other. From Table 2, all variables are not highly correlated so the model does not suffer multicollinearity problem and, consequently appropriate for interpretation purpose.

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Table 2. Correlation Analysis

	lnGDP	lnFDI	lnEGC	lnURB
lnGDP	1.000	0.067	0.273	0.235
lnFDI	0.067	1.000	0.261	-0.015
lnEGC	0.273	0.261	1.000	-0.287
lnURB	0.235	-0.015	-0.287	1.000

The results, firstly, discuss the factors contributing to the increase in the level of CO_2 emission by running the pooled OLS, the random effect and the fixed effect models and then to choose the model that best explain the study. Two specification tests were computed i.e. the Breusch-Pagan LM test to choose between the pooled OLS or the random effect model, and the Hausman test to choose between the random effects model or the fixed effects model. Secondly, based on the chosen model, the EKC hypothesis would be verified by plotting the curve. Summary of respective results is depicted in Tables 3 and 4 respectively.

Table 3. Summary of Results

	Pooled OLS	Random Effect	Fixed Effect
Constant	-1.672	-24.077	-21.977***
lnGDP	-0.904	4.673**	3.891**
lnGDP^2	0.042	-0.267**	-0.226**
lnFDI	0.001	0.004	0.006
lnEGC	0.992***	0.938***	0.954**
lnURB	0.127	-0.419	-0.079
Prob(F-statistic)	0.000	0.000	0.000

Note: ***1% level of significance; **5% level of significance

The results of pooled OLS show only the coefficient of GDP has a negative insignificant relationship with CO_2 emission, while EGC shows a positive significant relationship as expected. FDI and URB though correctly portray a positive relationship, they are not significant. The overall pooled model is statistically significant at 1% level of significance as indicated by the probability F-statistic. The equation for the model is written as follows:

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Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/atlr

$$lnCO_{2it} = -1.672 - 0.904 lnGDP_{it} + 0.042 lnGDP_{it}^2 + 0.992 lnEGC_{it} + 0.001 lnFDI_{it} + 0.126 lnURB_{it} + \varepsilon_{it}$$

(9)

The random effects model assumes that variations across entities are random and uncorrelated with the predictors included in the model. From Table 3, there are three predictors found significant and cause impact on the level of CO_2 emission i.e. GDP, GDP^2 and EGC. Again FDI and URB are not significant even in this model. Overall the random effects model is statistically acceptable at 1% level of significance. The equation could be presented as:

$$lnCO_{2it} = -24.077 + 4.673 lnGDP_{it} - 0.267 lnGDP_{it}^2 + 0.938 lnEGC_{it} + 0.004 lnFDI_{it} - 0.419 lnURB_{it} + \varepsilon_{it}$$

(10)

In contrast with the random effects model, fixed effects model assumes that variations across entities are not random and the predictors are correlated. Table 3 proves that three predictors showed significant impact on CO_2 emission i.e. GDP, GDP^2 and EGC. Similarly FDI and URB are insignificant and this model is statistically acceptable at 1% level of significance. The equation is shown as:

$$lnCO_{2it} = -21.977 + 3.891 lnGDP_{it} - 0.226 lnGDP_{it}^2 + 0.954 lnEGC_{it} + 0.006 lnFDI_{it} - 0.079 lnURB_{it} + \varepsilon_{it}$$

(11)

Table 4: Statistical Tests among the Models

	Pooled OLS versus Random Effect	**Random Effect versus Fixed Effect**	**Selection**
Breusch-Pagan LM Test	143.904***		Random
Hausman Test		1.802	Random

Note: ***1% level of significance; **5% level of significance

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Table 4 shows the results of the statistical test among the models of which the Lagrangian Multiplier (Baltagi, 2008) test is significant at 1% level of significance; hence rejecting the null hypothesis revealing a strong evidence to retain country specific effects. Due to this, the random effect model was chosen to be appropriate description then the pooled OLS. It also identifies that the country specific effects is a random draw that is uncorrelated with the independent variables and the overall error term.

To decide between fixed or random effects, the Hausman test was conducted. Table 4 depicts that the null hypothesis fails to be rejected which means the country specific effects are not correlated with the regressors. Thus, the random effects estimator is consistent implying that it is the appropriate model to explain this analysis.

To test the underlying EKC hypothesis based on the random effects model, the coefficients of GDP and GDP^2 stated; β_1 (3.891) and β_2 (-0.226), respectively, meaning both have satisfy the assumption of $\beta_1 > 0$ and $\beta_2 < 0$. Thus, these values prove the validity of the hypothesis. To calculate the turning point for the 17 upper-middle income countries, substitute the values to the earlier discussed formula i.e.$-\beta_1/2\beta_2$; -3.891/2(-0.226) = 8.608.

The turning point, 8.608 describes that carbon emission will begin to fall once it reaches this point. The diagram is plotted in Figure 2 to define the change at the turning point. It demonstrates in these 17 nations at low levels of growth, CO_2 emission exhibits a sharp increase as GDP per capita gradually rise hence producing an upward sloping curve. However, after reaching the turning point when growth levels are high, the level of CO_2 emission starts to decrease, thus showing a downward sloping curve.

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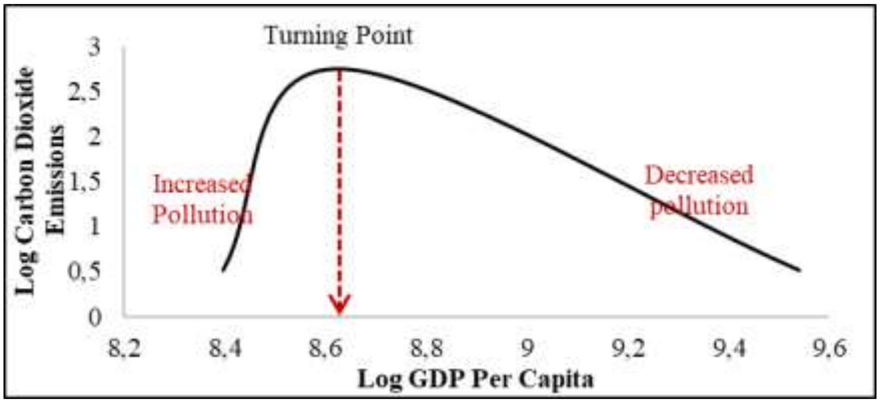

Figure 2. Environmental Kuznet's Curve

Conclusion

This paper examines the relationship between CO_2 emission, GDP, energy consumption, FDI and urbanization using a panel data of 17 countries over the period of 2010-2014. The results suggest that the random effects model is empirically more suitable in explaining the analysis. This model clearly signifies the significant direct relationship of economic growth and energy consumption with CO_2 emissions in these nations. Both GDP and GDP^2 are significant hence, verifying the EKC hypothesis with an inverted 'U'-shaped curve. The results support the existing study by Pao and Tsai (2011), Neequaye and Oladi (2015), and Sapkota and Bastola (2017). Energy consumption indicates that upper middle-income countries consume a lot of energy as they progress to become high-income nations. The results are similar to Soytas and Sari (2009), Jalil (2014) and, Ouyang and Lin (2017). In contrast, the other two variables FDI and urbanization are insignificant.

According to International Energy Association (IEA) 2017 report, the upper-middle income group relies highly on fossil fuel sources to generate energy for consumption and transportation system. Though a vibrant economic development is vital to a nation, protecting the environment for the sake of future generation is a must agenda as well. Innovation and creation of greener technologies should be encouraged to ensure sustainable growth in the long run for both its energy and transport sectors. Thus, the dependency on fossil fuel should be reduced gradually

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http://proceedings.itltrisakti.ac.id/index.php/atlr

and replace with renewable energies such as solar, wind and hydroelectric power so as to mitigate the carbon emission.

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