Co_2, Quality of Life and Economic Growth in Asian 8

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Abstract

The purpose of the study is to examine the relationship between CO_2 on quality of life and on economic growth in ASEAN 8. Pollution may directly decrease output and quality of life by decreasing productivity of man-made capital and labor. The income levels per capita gross domestic product per capita were measured from the year 1965 to 2010. This study formulates a three equation simultaneous model for empirical research. For panel data, the Hausman specification test is the classical test of whether the fixed or random effects model should be used. In the pollution indicator emissions CO_2 in ASEAN 8, the Environmental Kuznets Curve relationship is found.

Keywords: Economic Growth; Environmental Kuznets Curve; Hausman Test; Simultaneity, Endogeneity

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1.0 Introduction

In Asia, pollutants effect the economic growth. There is a proof of global nature of air pollution and its effects on Earth's surface. Over a broad region of Asia, from India to China and Indonesia, the evidence showed that emissions of pollutants were becoming entrained in the monsoon circulation and transported into the lower stratosphere (Insciences 2010). This study attempts to examine the relationship between environmental degradation to economic growth in Asean 8 countries by using the Environmental Kuznets Curve analysis. The focus on environmental degradation is on air pollution measures Carbon Monoxide (CO_2). The primary human source of carbon dioxide (CO2) in the atmosphere is from the burning of fossil fuels for energy production and transport. (Greenpeace, 2009).

The general objective of the study is to examine the relationship between CO_2 on quality of life and economic growth in Asean 8 and to make improvements in the EKC model through an extension and introduction of simultaneity of variables. Pollution may directly decrease output and quality of life by decreasing productivity of man-made capital and labor. Here pollution plays as a negative externality. Due to health problems there are losses of labor day; due to polluted air or water there are deteriorations in the quality of industrial equipment. Secondly, the firm’s production costs are increased when firms abate pollution emissions.

2.0 Literature Review

The first to model the relationship between environmental quality and economic growth was Grossman and Krueger (1991). At higher levels of income they found that it has reduced with per capita GDP. For these two indicators of environmental quality these determinations were depicted statistically evidence for the existence of an EKC relationship. Shafik et al (1992) tested the relationship between various key indicators of environmental quality and economic growth and found a systematically significant relationship between income and all indicators of environmental quality. The EKC development has been searched further by Hettige et al (1992). The existence of an EKC relationship for toxic intensity per unit of GDP found in the outcomes of the study. Suri and Chapman (1998) found that as incomes increase and development precedes the world-wide diffusion of manufacturing lends to environmental betterments. A study by Goklany (2001) found that open developing economies improve their environments. This argument has been remarked also by Grossman and Krueger (1991). Managi (2006) stated that economic growth and the decrease of environmental degradation are compatible in accordance to the Environmental Kuznets Curve (EKC) hypothesis. Markandya et al (2006) studied the association between per capita GDP and sulfur emissions for twelve Western European countries. The study found an inverted U-shaped relationship between income and pollution. Based on the EKC hypothesis, Song et al (2008) investigated the relationship between economic growth and environmental pollution in China. The findings indicate that although there is an inverse N-shaped relationship for waste water in terms of coefficient estimates, all pollutants are inverse U-shaped.

3.0 Theoretical Framework and Model Specifications

Air pollution was measured in terms of Carbon Monoxide (CO_2). The income levels Gross

Domestic Product per capita was measured for the period 1965 to 2006. Income influences environmental quality both directly and indirectly because pollution is the by-product of industrialization and growth (Hung and Shaw, 2004). In order to estimate the relationship between air pollution and GDP per capita in Asean 8 countries this study also applies the simultaneity model of income and the environment in line with its structural relationship. For capturing this simultaneous relationship three equations have been formulated in this study. These are i) pollution equation, ii) income equation and iii) population density equation. By using simultaneous approach and additional variables in these equations the present study therefore has developed an improved model to study the relationship more closely to conclude if it follows the Environmental Kuznets Curve (EKC) in Asean 8 countries. Air pollution has been treated as a function of economic growth (Y) and population density (PD). Constituents of air pollution considered are Carbon Monoxide. Therefore it forms the following model:

$$CO = f\,(Y, PD)$$

In this model, pollution and population density have been assumed to have any simultaneous effect. Equations of the model are:

Equation 1: Air Pollution (Pollutants) = f (Income, Population density)

Equation 2: Income (Y) = f (Pollutants, Labour, Government expenditure, Foreign Direct Investment, Fixed capital, Net export)

Equation 3: Population density (PD) = f (Pollutants)

Equations (1), (2), and (3) designate the simultaneous equations for this model.

$$\log CO_{tiQj} = \alpha_0 + \alpha_1 \log Y_{ti} + \alpha_2 (\log Y_{ti})^2 + \alpha_3 (\log Y_{ti})^3 + \alpha_3 \log PD_{ti} + €_{ti} \quad (1)$$

$$\log Y_{tiQj} = \beta_0 + \beta_1 \log CO_{ti} + \beta_2 \log L_{ti} + \beta_3 \log G_{ti} + \beta_4 \log FDI_{ti} + \beta_5 \log K_{ti} + \beta_6 NX_{ti} + €_{ti} \quad (2)$$

$$\log PD_{tiQj} = \lambda_0 + \lambda_1 \log CO_{ti} + \lambda_2 \log Y_{ti} + v_{ti} \quad (3)$$

i: 46 years

t: time

Equation (1) represents the air pollution equation, where

CO_{ti} : air pollutant in year t;

Y_{ti} : GDP per capita in year t;

PD_{ti} : population density in year t;

In the pollution equation, whenever the coefficient of the logY is positive, Y^2 is negative and that of Y^3 is negative; it indicates the existence of the EKC hypothesis.

Equation (2) represents the income equation, where

L_{ti} : labour in year t;

G_{ti} : government expenditure in year t;

FDI_{ti} : foreign direct investment in year t;
K_{ti} : fixed capital investment in year t;
NX : net export in year t;
Equation (3) represents the population density equation

Many scholars in Environmental Kuznets Curve (EKC) studies used linear and quadratic as well as cubic equations (Shafik 1994, Moomaw and Unruh 1997, Wu 1998, Friedl and Getzer 2003). The quadratic equation (Y^2) means at the initial stage of development when GDP increases environmental degradation increases, and later with further increases in GDP environmental degradation decreases. The cubic equation (Y^3) means with further increases in GDP environmental degradation decreases. Therefore for the EKC to exist, in cubic equation, Y must have the positive coefficient, Y^2 must have the negative coefficient and Y^3 must have the negative coefficient. In case of quadratic equation, Y must have the positive coefficient and Y^2 must have the negative coefficient. In order to ascertain the econometric explanation of the model specification, in the simultaneous equation method a Hausman test is used for income endogeneity. Holtz-Eakin and Selden (1995) used this test in their studies.

The analysis starts by testing the existence of multicollinearity and heteroscedasticity in which this study executes the following diagnostic-check:

1. Multicollinearity correlation test will be used in order to test the multicollinearity problem
2. White test will be used in order to test the heteroscedasticity problem

The exogeneity of the log form of per capita GDP, its quadratic term, its cubic term, and per capita population density in Equation (1) is the next issue the study is interested in. The single polynomial equation estimation may generate unfair and not consistent forecasts if an explanatory variable is an endogenous variable. Therefore, this study necessitates an Instrument Variable (IV) method. Thus use of two-stage least square (2SLS) method is essential. Gross Domestic Product used in this study is the total income contributed by all the sectors in Asean 8.

Table 1 shows the expected signs of coefficients of independent variables of the model.

Table 1 Expected Signs of the Explanatory Variables of the Models

Equation (1)		Equation (2)		Equation (3)	
Explanatory variables	Signs	Explanatory variables	Signs	Explanatory variables	Signs
log (per capita GDP)*	+	log (pollutant emission)*	-	log (pollutant emission)	-
(Y)	-	log (labor) (L)	+	log (income)	+
[log (per capita GDP)]²*		log (govt. spending) (G)	+		
(Y^2)	+/-	log (foreign direct	+		
log (population density)*		investment) (FDI)			
(PD)		log (physical capital)* (K)	+		
		log (net export) (NX)	+		

** Are also supported by Shen's study (2006)*

All data used in this study have been taken from the secondary sources. Secondary sources are the Asean 8 Air Quality Data Report 1965 – 2010 and Asean 8 Statistics Data Report.

Besides, the sources like books, newspapers,
journals and internet that were relevant to the research topic were used. All the sources have been referred throughout the findings and analysis of the research. All monetary terms with regard to GDP per capita and local government expenditure are deflated by the Consumer Price Index with the base year of 1987.

4.0 Findings and Analysis

In this chapter the empirical model has been analysed and their results have been interpreted and discussed. In selecting the equations of the model, in this analysis we have used both quadratic and cubic equations for the model. Whenever the cubic term is found statistically insignificant it has been dropped from the equation finally selected. To determine the statistical significance of the cubic terms of log (per capita GDP) in all the pollutants, a t test has been applied. Based on the regression test, air pollutant equations cubic terms were found statistically significant. As such the cubic term of log (per capita GDP) for the pollutant was added in the Equation 1.

To determine the existence of multicollinearity correlation test was done. None of the independent variables were found to be correlated with each. If the correlation matrix between one independent variable with other independent variable is greater or equal to 0.9 then only multicollinearity problem occurs. (Wulder, 2005) For estimating the heteroscedasticity, a White test was performed and no heteroscedasticity was found. The error terms for all of the variables in the model have a constant variance or homoscedasticity. The coefficients were not found significant as at 5% level. In respect of the exogeneity of the log form of per capita Gross Domestic Product, its quadratic term, its cubic term, and the population density, the null hypothesis of exogeneity of these variables is statistically rejected, as can be viewed from the outcomes of the Hausman test for exogeneity (Table 2).

Table 2 Estimated Regression Results for Air Pollutants and Income (Eq-1)

	Dependent variables
Independent variables	Simultaneous equations
	CO_2
Intercept	1.680000 (2.424626) **
log Y(per capita GDP)	23141576 (8.070940) *** White 1.3258
log Y^2(per capita GDP)^2	-76.86276 (-7.874545) *** White 1.0583
log Y^3(per capita GDP)^3	-7.120000 (-7.238231) *** White 0.5236
log PD (population density)	5903189. (23.14727)*** White 0.8245
Adjusted R-square	0.837462
Hausman Test for exogeneity for GDP per capita (F-statistic)	68.42580***
Hausman Test for exogeneity for GDP population density (F-statistic)	527.5233***

note: 1. t-statistics in parentheses.
*2. *** represents P<0.01; **, P<0.05; *, P<0.1.*

This means that in the data set of Asean 8, the simultaneous relationship between per capita income and per capita pollutant emission does exist For panel data, in order to examine which model to be used in the regression, the Hausman specification test is the classical test of whether the fixed or random effects model should be used. This study found that fixed effect one way is the model that to be used. Then, this study proceeds with the likelihood ratio test to examine whether the fixed effect or pooled model should be used. Again, this study found that fixed effect one way is the model that to be used. The regression results are as shown in the table below.

Table 3 Estimated Regression Results for Income and Air Pollutant (Eq-2)

	Dependent variable
Independent variables	log Y (GDP)
Intercept	-153371.7 (-23.41941)***
log CO_2	2.270000(12.94762) *** White 0.0587
log L (labor)	0.025132 (27.85949) *** White 0.1569
log K (physical capital)	0.190461 (2.842211) *** White 1.3369
log G (govt spending)	0.155918 (6.703342)*** White 1.0059
log FDI (foreign direct investment)	0.538743 (13.94529) *** White 0.4600
log NX (net export)	0.587113 (8.119697) ***
Adjusted R-square	0.949133

note: 1. t-statistics in parentheses.
*2.*** represents P<0.01; **, P<0.05; *, P<0.1*

Table 4 Estimated Regression Results for Population Density (Eq-3)

	Dependent variable
Independent variable	log PD
Intercept	23060.15 (2.265343)**
log CO_2	-1.250000 (-21.47626) *** White 0.8723
log Y	0.752107 (6.280713)*** White 1.9826
Adjusted R-square	0.856978

note: 1. t-statistics in parentheses
*2. *** represents P<0.01; **, P<0.05; *, P<0.1.*

4.1 Results and Interpretation as shown in Table 2

This estimation was done under simultaneous equation method.

(1) The anticipated EKCs are found to exist in air pollutants CO_2 (coefficient of log Y is +23141576, log Y^2 is -76.86276 and log Y^3 is -7.12000).

(2) Positive significant relationship for the population density with CO_2 (coefficient of 5903189, t-statistic = 23.14727). This suggests that the higher the population density in Asean 8, is the greater pollution will be emitted. This is consistent with the expectation.

Contribution of endogenous variables on air pollution:

Income contribution: As income increases by 1%, air pollution indicator CO_2 increases by

23141576%, then decreases by 76.86%, and after that decreases by 7.12%. This is following the theory that as income increases pollution also increases at the early stage and decreases at the latter stage. Population density contribution: Population density contribute to a higher pollution in Asean 8 in which as population density increases pollution also increases for CO_2.

4.2 Results and Interpretation as shown in Table 3

Most of the approximated coefficients are coherent with the anticipated signs and significant. CO_2 indicates negative relationship with income (coefficient of -2.2700) and has a significant effect on income (t-statistic of 12.9476). This suggests that as pollution level increases income reduces and it is coherent with the theory in which quality of life deteriorate due to pollution effect. This indicates that CO_2 is one of the primary contributors of air pollutants that decreases income in Asean 8 and it is primarily arriving from industrial activities. The normal inputs such as labor (coefficient of 0.025132, t-statistic = 27.85949) and physical capital (coefficient of 0.190461, t-statistic = 2.842211) are positively and significantly related to the Gross Domestic Product in the income equation. The share of human capital in production is significant (t-statistic of 27.85949) on income in the model. This shows that labor is an important factor in production. The coefficient of government expenditure shows a positive relationship with income (coefficient of 0.1559) and is highly significant effect on income (t-statistic of 6.7033). Foreign direct investment has a positive relationship with income (coefficient of 0.538743) and has a significant effect on income (t-statistic of 13.94529). Foreign direct investment also has a positive relationship with income (coefficient of 0.5871) and has a significant effect on income (t-statistic of 8.1197). This shows that government spending, foreign direct investment and net export are important factors in increasing the income of Asean 8.

4.3 Results and Interpretation as shown in Table 4

The coefficient of air pollution indicator shows significant effect (t-statistic of 21.4763 for CO_2) on population and it having a negative relationship (coefficient of -1.250000). This indicates that the higher the pollution is the lower the population density. The relationship between income and population density shows a positive relationship (coefficient of 0.7521) and significant effect (t-statistic of 6.2807) of income on population density. This indicates that people with higher income afford to have more family members compared to the lower one.

5.0 Conclusion

The air pollution (CO_2) has been empirically tested for the case of Asean 8 using econometric models and simultaneous equation method. The hypothesis relates to whether CO_2 in Asean 8 do or do not contribute to quality of life and economic growth and do or do not follow EKC theory. In the course of fulfilling the research objectives of this study, various econometric tests have been employed such as Hausman test. In this section, the study summarizes the findings of the objectives as follows. The test shows that there exist simultaneous relationship between CO_2 of air pollution and income. Thus, the two stage least square method will be employed. Thus, the EKC hypothesis is supported by the cases of air pollution CO_2 in Asean

8. Based on the result, CO_2 shows negative significant relationship with income. This is following the theory that as pollution level increases income decreases in which pollution may directly decrease output and quality of life by decreasing productivity of man-made capital and labor. Due to health problems there are losses of labor day; due to polluted air or water there are deteriorations in the quality of industrial equipment. The coefficient of air pollution indicator shows significant effect on population density and it having a negative relationship with population density. This indicates that as pollution increases population density decreases which causes death of human being in Asean 8.

This study recommends for a future studies to include variables such as solid waste treatment, hazardous waste and noise in the city. Moreover, factors such as Gini index of income distribution can be taken into account to measure the equality of income distribution in Asean 8. Hence, in any of these ways a further extension could be established.

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