Simultaneity of Water Pollution and Economic Growth in Malaysia

Halimahton Borhan*
Universiti Teknologi MARA

Elsadig Musa Ahmed**
Multimedia University

Abstract: The objective of the study is to examine the relationship between economic growth and different indicators of water pollution in Malaysia and to improve on the Environmental Kuznets Curve model by using an extended simultaneity model. This study formulates four simultaneous equations with population density as one of the endogenous variables. Water pollution indicators were assessed based on the level of BOD, cadmium and arsenic. The period of study is 1996 to 2006. This study extended the model of Shen (2006) by including variables such as the number of university graduates, local labour, foreign labour, foreign direct investment and government spending. Differences were found between the single polynomial equation model and the simultaneous equations model. Our study confirms that there is a simultaneous relationship between pollutants and economic growth in Malaysia and that it follows the concept of the Environmental Kuznets Curve. The Environmental Kuznets Curve is therefore relevant for water pollutants in Malaysia.

Keywords: Economic growth, Environmental Kuznets Curve, Malaysia, simultaneity, water pollution.
JEL classification: C39, Q51, Q53

1. Introduction

Costantini (2006) studied the relationship between the environment and GDP and found that the variables involved could be simultaneously related. This is supported by Coondoo and Dinda (2002) who tested the causality between income and CO_2 emission and found that a simultaneous relationship does occur. A study by Sahabat Alam Malaysia (SAM) (2001) stated that the rapid growth prior to the economic crisis and the present economic recovery, whilst raising the GDP and incomes, has taken a toll on the environment. Uncontrolled growth with scant regard for ecological principles continues to be the order of the day. Thus, during the Seventh Malaysia Plan period, to ensure balanced and sustainable development, the environmental and natural resource issues continued to be addressed. The relevant institutional, legislative and regulatory mechanisms were strengthened and efforts to integrate environmental considerations into development planning were intensified. A market-based approach to address environmental and resource issues was introduced

* Faculty Business Management, Universiti Teknologi MARA, 75300 Melaka, Malaysia. Email: *hali@bdrmelaka.uitm.edu.my, halimahton2001@yahoo.com* (corresponding author)
** Faculty of Business and Law, Multimedia University, 75450 Melaka, Malaysia. Email: *asadiq29@hotmail.com; elsadigmusa@mmu.edu.my*

and the use of cleaner technologies was promoted. To foster an environment-friendly society, awareness campaigns and environmental education were also launched. During the Eighth Malaysia Plan period, emphasis was placed on addressing environmental and resource management issues in an integrated and holistic manner. In order to ensure sustainable and resilient development, steps were taken to identify prudent, cost-effective and appropriate management approaches that yielded multiple benefits. Efforts are being continued to address air pollution, mitigate degradation of rivers, improve marine and groundwater quality, as well as deal with waste in a comprehensive manner (Malaysia 2001).

Zaharaton (2004) stated that rapid development has created gaps in the prevention of pollution and that a highly dense population in urban centres has converted rivers into open sewers. Cities are well known for being polluters of the aquatic environment with sewage and municipal wastewater, industrial effluent and polluted urban runoff. Similarly, the farming communities pollute the aquatic environment with irrigation returns that contain fertilisers, pesticides and animal wastes. River water quality is also degraded by sediments from land clearance and solid wastes. Water pollution disrupts water supply services, affects human health and destroys aquatic lives and habitat. Based on the above statements, it is necessary for this study to examine the relationship between pollution and economic growth in Malaysia by taking into account the Environmental Kuznets Curve (EKC) as a theory for this study.

The objective of the study is to examine the relationship between economic growth and different indicators of water pollution in Malaysia and to improve the EKC model through the use of a simultaneity model. This study contributes to the literature by extending the model of Hung and Shaw (2004) by including variables such as the number of university graduates, foreign direct investment, fixed capital investment, secondary industry share, and government pollution abatement expense. This approach also modifies the model of Shen (2006). Shen (2006) formulated three simultaneous equations but this study formulates four simultaneous equations by estimating population density as one of the endogenous variables. Population density is also taken as endogenous to the system, since health can be affected by pollution which causes diseses such as lung cancer etc. Empirically, this study uses government pollution abatement expenses and population density as endogenous variables to estimate EKC as compared to Vincent (1997).

This study used quarterly data from 1996 to 2006. Aggressive development in Malaysia took place in the 1990s and pollution became a serious problem in 1997 (Elsadig 2008). Given this scenario, this study shows the real impact of economic growth on pollution during this prime time of Malaysia's economic development.

2. Literature Review

Based on the study by Panayotou (1998) that related an environmental impact indicator to a measure of income per capita, empirical models of environment and growth consist usually of reduced form single-equation specifications. The key criticism of the hypothesis of Torras and Boyce (1998) is that a more equitable distribution of power tends, *ceteris paribus*, to result in better environmental quality. Their regression results generally are consistent with this hypothesis. Recent critiques by Kiesel (2006) state that there is no single EKC that fits all pollutants for all places at all times. Based on the study by Stern *et al.* (1998), Cole

(2003; 2004), Suri and Chapman (1998), Arrow *et al.* (1995) and Rothman (1998), the EKC hypothesis is based on the occurrence of international trade and foreign direct investment. This is one of the most damaging criticisms of the hypothesis. The relationship between air and water pollutants in Malaysia and per capita income was examined by Vincent (1997) from the late 1970s to the early 1990s. This single-country study prossed two main conclusions. First, the income-environment relationship for a single country may not be relevant for cross-country analysis. Second, none of the pollutants examined by Vincent show an inverted-U relationship with income. Costantini and Martini (2010), who estimated the environment and GDP relationship, pointed out that the simultaneity of variables involved was rarely considered. It has always been postulated that the state of the environment has no impact on the economic growth process from the EKC hypothesis since it is derived from a model that considers only pure economic growth. Shen (2006) and He (2006), tested for this bi-directional causality in a simultaneous system function for China. Coondoo and Dinda (2002) tested the causality process between income and CO_2 emission and showed that there is a simultaneous relationship between these variables. Stern (1998) concluded that presupposing a unidirectional type of causality from economy to environment is inappropriate. Based on the study by Shen (2006), in the real world, pollutant emission may reduce production either through the loss of workdays due to health constraints or the restriction of environmental inputs supply via environmental degradation caused by pollution. Due to this, estimating the relationship using only a single polynomial equation might probably produce biased and inconsistent estimates as economic growth and environmental quality are jointly determined. In conclusion, a simultaneous equations model is more appropriate for estimating the relationship between water pollution and economic growth. Based on the discussion above, this study formulates four equations using a simultaneous model method and adds some important variables to the model.

3. Methodology

This study gathered information mainly from the Department of Environment (DOE) Malaysia, and the Department of Statistics, Malaysia. To study the relationship between water pollution and economic growth, several equations that are related to the level of pollution, GDP per capita and other covariates were estimated. Several indicators were used to measure water pollutants: biochemical oxygen demand (BOD), cadmium (CD) and arsenic (AS). Quarterly data from year 1996 to 2006 were used in the analysis.

The conceptual framework can be represented as follows:

$$log\ P_t = \alpha_{0} + \alpha_1\ Iog\ Y_t + \alpha_2 (IogY_t)^2 + \alpha_3\ log\ abate_t + \alpha_4\ log\ ind_t + \alpha_5\ log\ PD_t + \alpha_6 T_2 + \alpha_7 T_3 + \alpha_8 T_4 + e_t \quad (1)$$

$$Iog\ Y_t = \beta_0 + \beta_1\ Iog\ P_t + \beta_2\ Iog\ LL_t + \beta_3\ Iog\ FL_t + \beta_4\ Iog\ U_t + \beta_5\ Iog\ G_t + \beta_6 log\ FDI_t + \beta_7\ log\ K_t + \beta_8\ T_2 + \beta_9\ T_3 + \beta_{10}\ T_4 + \bullet_t \quad (2)$$

$$log\ abate_t = \lambda_0 + \lambda_1\ log\ K_t + \lambda_2 log\ ind_t + \lambda_3 log\ P_t + \lambda_4\ T_2 + \lambda_5 T_3 + \lambda_6 T_4 + v_t \quad (3)$$

$$log\ PD_t = \Pi_0 + \Pi_1 logP_t + \Pi_2 T_2 + \Pi_3 T_3 + \Pi_4 T_4 + v_t \quad (4)$$

where
P_t = water pollution
Y_t = GDP per capita with secondary industry share deducted
$abate_t$ = government abatement expenses
ind_t = secondary industry share
PD_t = population density
LL_t = local labour
FL_t = foreign labour
U_t = number of university graduates
G_t = government spending
FDI_t = foreign direct investment
K_t = physical capital

T represents a dummy variables in which T_2, T_3 and T_4 are dummies for the second, third and fourth quarter of each year taking a value of 1 for the relevant quarter and a value of 0 otherwise (Gujarati 2006). This dummy variable may represent the effects of technological changes and changes in government regulatory policies in different quarters. Income (Y_t) represents the aggregate effects of those direct and indirect driving forces on pollution. If the coefficient of the log Y_t term is positive and its squared term is negative, respectively, then the EKC hypothesis holds.

This study uses individual country data and both the single equation method and a simultaneous equation method with a structure of four equations. The single equation method involves the use of OLS for estimation. The exogeneity of the log form of per capita GDP and its quadratic term, per capita government pollution abatement expenses and population density in Equation (1) was tested in this study. The single polynomial equation estimation may generate inconsistent forecasts if an explanatory variable is endogenous. Therefore, the use of Instrument Variable (IV) and two-stage least square (2SLS) methods are essential. To assure exogeneity, this study employed the Hausman specification test. The 2SLS method should be employed to estimate these simultaneous equations whenever the Hausman specification test rejects the hypothesis that per capita GDP, its quadratic term, per capita pollution abatement expenses, and population density are exogenous.

4. Results and Discussion

Shen (2006) regarded income per capita and government pollution abatement expenses as endogenous variables. In actual fact, population density is also endogenous to the system, given the impacts of pollutants on health. Based on the study by Lopez (1994) and de Bruyn (2000), pollution may act as a negative externality by directly reducing productivity of man-made capital and labour and output. Therefore, a three simultaneous equations method might produce biased and inconsistent estimates. This study uses the four simultaneous equations model given in Equations (1), (2), (3) and (4). To test the stationarity of the data, the conventional Augmented Dickey-Fuller (ADF) unit root test and Phillips-Perron (PP) unit root test were employed. Table 1 presents the results of unit root test at level and first difference for the variables.

The results indicate that all the variables are stationary after the first difference for both ADF and PP unit root test. These results confirm that the variables meet the requirement for panel cointegration test. The Johansen-Juselius test was used to test whether the dependent variable and all the independent variables in all the equations exhibited fundamental long-run relationships among each other. The results for the Johansen-Juselius cointegration test are given in Table 2. The value of trace statistics and max-eigen value for Malaysia were found to be larger than the 5 per cent critical value. Therefore, we rejected the null hypothesis of no cointegrating vector. This indicates that at least one cointegrating vector offers a stable relationship among the variables.

No evidence of multicollinearity was found in this study. The White test was performed but no evidence of heteroscedasticity was found. The error terms for all of the variables in the model have a constant variance. The exogeneity of the log form of per capita GDP, its quadratic term, per capita pollution abatement expenses and population density was tested. By referring to the results of the Hausman test for exogeneity in Tables 3 and 4, the null hypothesis of exogeneity of these variables is statistically rejected in all cases.

Using the 2SLS method for estimating the simultaneous equations model, the result suggests that a simultaneous relationship between per capita income and per capita pollutant emission does exist in Malaysia. Some differences were found by comparing between the the estimates of the single polynomial equation model estimators and the simultaneous equations model.

The result shows that a 1 per cent increase in population density will reduce per capita pollution emission of CD by 89.91 per cent on average. Using the simultaneous equation, the coefficient of population density appeared to be higher, indicating that as population density increases, pollution emissions are reduced further compared to the single polynomial equation. The above discussion shows that before directly estimating the EKC it is necessary to consider the simultaneity between income and pollution.

Based on the estimated results of income and abatement equations in Tables 5 and 6, the following observations are made:

1. Most of the estimated coefficients are significant and consistent with the expected signs. In the income equation, physical capital and foreign labour majority contributed positively to GDP growth.
2. On the other hand, the size of local labour contributed negatively to GDP in the equation. This indicates that foreign labour is one of the determinants of economic growth in Malaysia compared to local labour. Before the Asian financial crisis, Malaysia was in full employment. The tight labour market spread to the manufacturing and services sectors. This attracted the influx of both legal as well as illegal foreign workers with the total number of foreign workers rising from 4 per cent of total employment in 1990 to about 10.7 per cent in 1997 and 9 per cent in 2001. As of July 2004, there were about 1.3 million registered foreign workers, constituting 12 per cent of total employment in the country. As an immediate solution to the problem, foreign workers were allowed to be employed in the plantation, construction and selected services sectors as well as the manufacturing sector. This is to avoid disruption to the economic growth process (Malaysia 2004).

Table 1. Unit root tests

	ADF Unit Root Test				PP Unit Root Test			
	Level		First difference		Level		First difference	
	No trend	With trend	No trend	With trend	No trend	With trend	No trend	With trend
log CD	-2.234202 (9)	-2.345440 (9)	-6.327609 (9)***	-6.304085 (9)***	-2.356296 (9)	-2.400681 (9)	-6.327609 (9)***	-6.304005 (9)***
log AS	-2.175750 (9)	-2.322282 (9)	-6.036648 (9)***	-6.036398 (9)***	-2.921410 (9)	-2.892191 (9)	-6.326172 (9)***	-6.309360 (9)***
log BOD	-1.842629 (9)	-1.834360 (9)	-6.455297 (9)***	-6.329694 (9)***	-2.969561 (9)	-2.928118 (9)	-6.328089 (9)***	-6.275852 (9)***
Iog Y	0.757598 (9)	-2.853589 (9)	-3.915734 (9)**	-3.725282 (9)**	-1.362388 (9)	-2.907823 (9)	-8.735985 (9)***	-10.24569 (9)***
(IogY)^2	0.310197 (9)	-3.123059 (9)	-3.031751 (9)*	-3.754207 (9)**	-0.518526 (9)	-2.501426 (9)	-8.122268 (9)***	-10.04410 (9)***
log abate	-2.015850 (9)	-2.290658 (9)	-6.333842 (9)***	-6.255791 (9)***	-2.135208 (9)	-2.462740 (9)	-6.333842 (9)***	-6.255791 (9)***
log ind	-0.371258 (9)	-2.303392 (9)	-3.727737 (9)**	-3.937671 (9)**	-1.448366 (9)	-2.541586 (9)	-6.111009 (9)***	-6.600924 (9)***
log PD	-1.260739 (9)	-1.166623 (9)	-6.258719 (9)***	-6.391704 (9)***	-1.287638 (9)	-1.166623 (9)	-6.258712 (9)***	-6.391182 (9)***
Iog LL	-3.099550 (9)	-3.066653 (9)	-3.502253 (9)*	-3.480910 (9)*	-2.063053 (9)	-3.145758 (9)	-11.42271 (9)***	-11.38037 (9)***
Iog FL	-1.159852 (9)	-1.868702 (9)	-6.390896 (9)***	-6.311989 (9)***	-1.197366 (9)	-1.988914 (9)	-6.390457 (9)***	-6.311030 (9)***
Iog U	-1.914255 (9)	-1.358463 (9)	-4.176085 (9)**	-4.662198 (9)**	-1.944014 (9)	-1.118418 (9)	-8.462281 (9)***	-12.82495 (9)***
Iog G	0.525781 (9)	-2.745544 (9)	-25.24130 (9)***	-25.36087(9)***	-2.341175 (9)	-2.013106 (9)	-19.88884 (9)***	-20.01382 (9)***
log FDI	-1.913368 (9)	-4.062863 (9)	-11.04183 (9)***	-11.03195 (9)***	-2.735569 (9)	-4.081312 (9)	-15.17223 (9)***	-26.67061 (9)***
log K	-2.897551 (9)	-2.913068 (9)	-5.625608 (9)***	-5.592981 (9)***	-2.141588 (9)	-2.376980 (9)	-6.505356 (9)***	-6.684979 (9)***

Notes: Lag length selected by using Schwarz Info Criterion. A maximum of 9 lags are used for Malaysia as listed above. The null hypothesis is that the series is non-stationary, or contains unit root. Figures within parentheses indicate the number of lag structures for ADF Test and lag truncation selected automatically by Newey and West Bandwidth using Barlett Kernal Spectral estimation method for PP Test. All variables are transformed by taking their natural logarithm. *** represents $P<0.01$; **, $P<0.05$; *, $P<0.1$.

Table 2. Cointegration test

	Lag	Hypothesis	Eigen value	Trace statistic	Critical value (5%)	Max-Eigen value	Critical value (5%)
Equation (1)(CD)	6	None	0.801423**	203.1275	139.2753	66.27964**	49.58633
		At most 1	0.688264**	136.8479	107.3466	47.78960**	43.41977
		At most 2	0.576941**	89.05828	79.34145	35.27001	37.16359
Equation (1)(AS)	10	None	0.727401**	187.4027	139.2753	53.28985**	49.58633
		At most 1	0.690019**	134.1129	107.3466	48.02102**	43.41977
		At most 2	0.557347**	86.09184	79.34145	33.41377	37.16359
Equation (1)(BOD)	7	None	0.721782**	199.5809	139.2753	52.45341**	49.58633
		At most 1	0.696693**	147.1275	107.3466	48.91334**	43.41977
		At most 2	0.625356**	98.21412	79.34145	40.25290**	37.16359
Equation (2)	8	None	0.990556**	506.3845	197.3709	191.1582**	58.43354
		At most 1	0.947049**	315.2263	159.5297	120.4741**	52.36261
		At most 2	0.720726**	194.7521	125.6154	52.29808**	46.23142
Equation (3)	11	None	0.936251**	375.1082	197.3709	112.8649**	58.43354
		At most 1	0.831848**	262.2433	159.5297	73.09836**	52.36261
		At most 2	0.784367**	189.1449	125.6154	62.90136**	46.23142
Equation (4)	5	None	0.862026**	267.4853	159.5297	81.20840**	52.36261
		At most 1	0.821104**	186.2769	125.6154	70.55902**	46.23142
		At most 2	0.674025**	115.7179	95.75366	45.95826**	40.07757

Notes: ** denotes rejection of the hypothesis at 5%. The optimum lag length was selected once all the residuals were free from autocorrelation. Note that r indicates the number of cointegrating vectors where 'None' represents r=0, 'at most 1' represents $r \leq 1$, and 'at most 2' represents $r \leq 2$.

3. The contribution of human capital in production is not significant in the model although labour is an important factor in production. This indicates that the economic development in Malaysia relied primarily on capital-intensive industries. The evidence can be seen in the income equation where there is a positive significant relationship between physical capital and economic growth. This is true as economic growth in Malaysia was stimulated by investment, with capital accumulation contributing more than 50 per cent to productivity growth (Wahab, 2002).

4. The indicator of pollutant emissions, BOD, is significant and negatively related to the GDP. The other pollutant emissions are not significant. This is consistent with the theory that as pollution level increases, income decreases. Thus, this study can conclude that there is a small significant impact of water pollutants on income in Malaysia particularly where BOD is concerned. It could be due to BOD being the main contributor of pollutants in Malaysia; the pollutant mainly originates from industrial activities.

Table 3. Estimated results for water pollutants - Equation (1)

Independent variables	Dependent variable Single polynomial equation		Dependent variable Simultaneous equations	
	CD	BOD	CD	BOD
Intercept	-2.3819	-12.2719	448.3516	-37.8905
log (per capita GDP)	56.8715 (1.7646)	1.3886 (2.1332)	115.3773 (1.6287)	1.9976 (1.1883)
(log (per capita	-34.6931 (-1.0156)	-0.5949 (-0.8622)	-110.8392 (-1.0302)	-0.0974 (-0.0382)
log (abatement expense)	0.6352 (1.4971)	-0.0264 (-3.0847)	1.6025 (0.8312)	-0.0682 (-1.4914)
log (secondary industry share)	-4.6362 (-1.1254)	-0.2929 (-3.5196)	-1.6773 (-0.1248)	-0.6255 (-1.9617)
log (population density)	-5.8386 (-0.1311)	2.8061 (3.1185)	-89.9059 (-0.4425)	7.4004 (1.5348)
Time trend, T_2	-0.3917 (-0.6862)	-0.0311 (-2.6952)	0.3999 (0.1898)	-0.0801 (-1.6034)
Time trend, T_3	-1.0139 (-0.8725)	-0.0751 (-3.2009)	0.8763 (0.1757)	-0.1909 (-1.6129)
Time trend, T_4	-1.2386 (-0.7490)	-0.1079 (-3.2292)	1.5932 (0.2180)	-0.2757 (-1.6000)
Adjusted R-square	0.4794	0.1433	0.3212	-0.5419
Hausman Test for exogeneity (F-statistic)	-	-	8.3368	6.7598
Turning point of EKC	0.8196	1.1671	0.5205	10.2546

Note: *t*-statistics are in parentheses

Table 4. Estimated results for water pollutants - Equation (1)

Independent variables	Dependent variable Single polynomial equation AS	Dependent variable Simultaneous equations AS
Intercept	-235.8941	-108.3967
log (per capita GDP)	19.2564 (0.5744)	58.8377 (0.8744)
(log (per capita GDP))^2	4.0732 (0.1146)	-39.9935 (-0.3914)
log (abatement expense)	0.0899 (0.2036)	0.4445 (0.2427)
log (secondary industry share)	-6.7912 (-1.5846)	-6.8833 (-0.5393)
log (population density)	38.9377 (0.8402)	14.0882 (0.0730)
Time trend, T_2	-0.5795 (-0.9759)	-0.3789 (-0.1894)
Time trend, T_3	-1.5189 (-1.2565)	-1.0299 (-0.2174)
Time trend, T_4	-2.1299 (-1.2381)	-1.3651 (-0.1967)
Adjusted R-square	0.1292	0.0533
Hausman Test for exogeneity (F-statistic)	-	2.3141
Turning point of EKC	(2.3638)	0.7356

Note: *t*-statistics are in parentheses

Table 5. Estimated results for income - Equation (2)

	Dependent variable	Dependent variable	Dependent variable
Independent variables	log (GDP)	log (GDP)	log (GDP)
Intercept	4.6668	-0.2576	5.8712
log CD	0.0360 (1.1702)		
log AS		0.0088 (0.4787)	
log BOD			-1.2260 (-3.0148)
log(local labor)	-0.0809 (-0.0765)	-1.0587 (-2.5338)	-0.2495 (-0.4525)
log (foreign labor)	0.4727 (1.2519)	0.1382 (0.7378)	0.1590 (1.3370)
log(physical capital)	0.0527 (0.6550)	0.1352 (5.5978)	0.1263 (4.5170)
log(govt. spending)	0.0583 (0.4087)	0.1881 (2.7842)	0.3039 (6.3773)
log (foreign direct investment)	0.0364 (1.8717)	0.0199 (1.9362)	0.0086 (1.1705)
log (university students)	0.3335 (1.4562)	0.1441 (1.0822)	0.0548 (0.7039)
Time trend, T_2	0.0090 (0.1778)	-0.0387 (-1.8721)	-0.0623 (-4.4185)
Time trend, T_3	0.0355 (0.4935)	-0.0324 (-1.0753)	-0.0658 (-3.49016)
Time trend, T_4	0.05781 (0.5558)	-0.0390 (-0.8462)	-0.0921 (-3.3283)
Adjusted R-square	0.8208	0.9128	0.8758

Note: *t*-statistics are in parentheses

Table 6. Estimated results for abatement - Equation (3)

	Dependent variable	Dependent variable	Dependent variable
Independent variables	log (Abatement)	log (Abatement)	log (Abatement)
Intercept	1.6821	4.2064	-66.4468
log CD	0.7562 (3.5055)		
log AS		1.0049 (3.2497)	
log BOD			17.9747 (1.5004)
log (secondary industry share)	1.1158 (0.7996)	2.7080 (1.9179)	3.7532 (2.8545)
log(physical capital)	-1.7848 (-2.3305)	-1.3337 (-1.7097)	-0.2510 (-0.3861)
T_2	0.1126 (0.2980)	-0.0071 (-0.0167)	-0.1615 (-0.4020)
T_3	0.0289 (0.0766)	-0.1013 (-0.2367)	-0.2358 (-0.5854)
T_4	-0.1247 (-0.3357)	-0.2255 (-0.5301)	-0.2777 (-0.6902)
Adjusted R-square	0.0907	-0.205329	-0.0782

Note: *t*-statistics are in parentheses

5. The coefficients of government expenditure are positive and significant. This indicates that government spending is one of the main determinants of economic growth in Malaysia.
6. Foreign direct investment also has a positive and significant effect on income. The results suggest that foreign direct investment is one of the determinants of increased economic growth in Malaysia. According to Tsen (2006), foreign direct investment (FDI) contributed to a higher percentage of gross fixed capital formation in Malaysia. The contribution of FDI to gross fixed capital formation was 15.1 per cent, 13.9 per cent and

Table 7. Estimated results for population density - Equation (4)

Independent variables	Dependent variable log (pop. density)	Dependent variable log (pop. density)	Dependent variable log (pop. density)
Intercept	4.3619	4.3106	4.4259
log CD	0.0170 (1.1738)		
log AS		0.0071 (0.3196)	
log BOD			-0.0428 (-0.0410)
T_2	0.0054 (0.1558)	0.0054 (0.1544)	0.0054 (0.1546)
T_3	0.0109 (0.3134)	0.0109 (0.3107)	0.0109 (0.3110)
T_4	0.0164 (0.4724)	0.0164 (0.4682)	0.0164 (0.4687)
Adjusted R-square	-0.0784	-0.0976	-0.0954

Note: *t*-statistics are in parentheses

20.1 per cent in 1997, 1998 and 1999 repectively. The stock of FDI in Malaysia has also increased over time from USD10.3 billion in 1990 to USD54.3 billion in 2000. Moreover, FDI has contributed to a higher GDP growth in Malaysia. The stock of FDI as a percentage of GDP in 1985 was 23.7 per cent. The stock of FDI over GDP rose to 24.1 per cent in 1990 and to 65.3 per cent in 1999. Generally, FDI plays an important role in the Malaysian economy.

7. Meanwhile, the number of university graduates is positive and significant in the equation. According to Zin (2005), rapid economic growth has increased the demand for educated labour force resulting in a massive expansion in school enrolment, which led to increasing competitiveness of the educated workers in the labour market, resulting in higher income and higher economic growth.

8. The share of secondary industry and physical capital are the critical determinants of the pollution abatement expenses. According to Shen (2006), the bigger the share of the secondary industry, the higher the need for the pollution abatement expenses. More physical capital leads to more pollution abatement expenses. The results follow the

theory that there is a positive significant relationship between secondary industry share and pollution abatement expenses. It can be seen that most of the coefficients of the physical capital variable are positively related to pollution abatement expenses. Therefore, to maintain long run sustainable growth for the Malaysian economy, more pollution abatement investments are required even though pollution may not be the main contributor to income reduction in Malaysia.

Turning to the equation for population density, the coefficients of the water pollution indicators are negative but not significant. Pollution can affect our health in many ways with both short-term and long-term effects. Examples of short-term effects include irritation to the eyes, nose and throat, and upper respiratory infections such as bronchitis and pneumonia. Long-term health effects can include chronic respiratory diseases, lung cancer, heart diseases, and even damage to the brain, nerves, liver, or kidneys (Earthplatform 2011).

5. Conclusion

The discussion in the first part of the paper indicates that water pollution has an impact on economic growth. The second part has clarified this point by surveying the literature on the impact of water pollution on economic growth in a global perspective, and for Malaysia in particular. It is clear from the existing empirical EKC studies, as mentioned by Shen (2006), pollution is viewed only as the outcome of economic growth although in many theoretical models, pollution is assumed to be both an input and a by-product of economic activities. By taking into consideration government pollution abatement expenses and population density as endogenous variables, there are no empirical studies in Malaysia that estimate the EKC by using a simultaneous equation method with the inclusion of these endogenous variable. To estimate the relationship between per capita income and various environmental indicators, this study formulated a simultaneous equations model for per capita GDP and per capita pollutant emission and extended the model to include variables such as foreign direct investment, secondary industry share, government pollution abatement expenses, government spending, number of university graduates and labour (labour being divided into local labour and foreign labour). This study added population density as an endogenous variable and formulated four simultaneous equations. The model is an improvement compared to the works of Vincent (1997) and Shen (2006).

This study found that there is a simultaneous relationship between pollutants and economic growth in Malaysia for some of the pollutant indicators. In the model, the results of the Hausman test for exogeneity showed that the null hypothesis of exogeneity of these variables is statistically rejected in all cases. The estimated results suggest that in all pollutants, the expected EKCs are found to exist. From the above result, this study confirms the existence of a simultaneous relationship between pollutants and economic growth in Malaysia, following the concept of the EKC. The EKC is therefore relevant for water pollutants in Malaysia. Some conclusions can be drawn from this study:

1. In Malaysia there is an existence of a pattern of “pollute first and control pollution later” since the EKC hypothesis is supported in the cases of some indicators of pollutants. It would have been more prudent for the government to protect the environment through enforcement and implementation of policies. According to Petra (2006), per capita greenhouse gas emission of Malaysia is rising, a clear indication that

enforcement of regulations to abate pollution is not strict. The government also places greater importance on economic growth and industrial production.

2. At an earlier stage of economic development, the turning points of EKC have occurred. A study by O'Connor (1994) stated that there may be four reasons for the "latecomer's advantage" such as increased availability of technology, learning from experience, increased exposure to international environmental pressures and lower unit abatement costs. It can be said that Malaysia has this advantage based on the timing of these turning points. This is true as supported by GTZ (2006) that activities at the international level are based on European standards which include private sector technology transfer between Malaysia and Europe and promotion of the Clean Air Initiative for Asian Cities. This indicates that pertaining to the environment, a part of the Malaysian regulations have been built on the experience of foreign countries. The lowering of the peak in the EKC is a result of the effects of the government's environmental policies.

Although this study has found that economic growth and other variables have a small impact on water pollution, pollution is not the main contributor that reduces income in Malaysia. However, Malaysia still needs to implement policies that can help to overcome the main problem of pollution while sustaining economic growth. Such policies would include the following:

1. In order to combat the effect of climate change, Malaysia will need to implement policies to protect economic growth and development as well as moderate strategies to decrease the emission of greenhouse gases.
2. Rising public awareness of environmental issues in Malaysia should lead to the formulation of more policies and government action on pollution. At lower levels of economic development, growth in public awareness could activate countries to formulate effective air quality management control policies.
3. To facilitate effective enforcement of the 'polluter pay principle', the government should ensure that the cost of compliance is lower than the cost of violating the policy.
4. Advanced and tertiary operation of pollution control is required in order for pollution to be reduced.

This study recommends that future studies should include those variables that are important to residents as the environment exerts a pervasive influence apart from water quality variables such as air pollution, solid waste treatment, hazardous waste and noise in the city. Further, factors such as the GINI index of income distribution can be taken into account to measure the equality of income distribution in a country.

References

Arrow, K., B. Bolin, R. Costanza, P. Dasgupta, C. Folke, C.S. Holling, B.O. Jansson, S. Levin, K.G. Maler, C. Perrings and D. Pimental. 1995. Economic growth, carrying capacity and the environment. *Ecological Economics* **15(2)**: 91-95.

Cole, M.A. 2003. Development, trade, and the environment: how robust is the environmental Kuznets curve? *Environment and Development Economics* **8(4)**: 557-580.

Cole, M.A. 2004. Trade, the pollution-haven hypothesis and the Environmental Kuznets Curve: examining the linkages. *Ecological Economics* **48(1)**: 71-81.

Costantini,V. and C. Martini. 2010. A modified Environmental Kuznets Curve for sustainable development assessment using panel data. *International Journal of Global Environmental Issues* **10(1/2)**: 84-122.

Coondoo, D. and S. Dinda. 2002. Causality between income and emission: a country group-specific econometric analysis. *Ecological Economics* **40**: 351-367.

de Bruyn, S.M. (2000). *Economic Growth and the Environment: An Empirical Analysis*. Dordrecht: Kluwer Academic Publishers.

Deutsche Gesellschaft fur Techniche Eusammenarbeit (GTZ). 2006. Air pollution control for Malaysian cities: transport and industry. Available at *http://www.gtz.de/en/aktuell/6250.htm* (Accessed 2 January 2007).

Earthplatform. 2011. Pollution. Available at: *http://www.earthplatform.com/c/pollution/air* (Accessed 10 January 2011).

Elsadig, Musa Ahmed. 2008. *Green Productivity: Applications in Malaysia's Manufacturing Sector*, Serdang: Universiti Putra Malaysia Press.

Gujarati, D.N. 2006. *Essential of Econometrics*. 3rd ed. Singapore: McGraw-Hill International Edition.

He, J. 2006. Pollution haven hypothesis and environmental impacts of foreign direct investment: the case of industrial emission of sulphur dioxide (SO_2) in Chinese provinces. *Ecological Economics* **60**: 228-245.

Hung, M.F. and D. Shaw 2004. Economic growth and the Environmental Kuznets Curve in Taiwan: a Simultaneity Model analysis. Available at: *http://www.sinica.edu.tw/econ/dshaw/download/ekc.pdf* (Accessed 19 January 2007).

Kiesel, K. 2006. International Economics and the Environmental Kuznets Curve. Available at: *http://are.berkeley.edu/course/EEP101/* (Accessed 5 June 2007).

Lopez, R. 1994. The environment as a factor of production: the effects of economic growth and trade liberalisation. *Journal of Environmental Economics and Management* **27**: 163-84.

Malaysia 2001. *Eighth Malaysia Plan, 2001-2005*. Kuala Lumpur: Percetakan Nasional Berhad. Available at: *www.epu.jpm.my* (Accessed 11 January 2009)

Malaysia 2004. *Economic Report 2004/2005*. Kuala Lumpur: Percetakan Nasional Berhad. Available*:http://www2.treasury.gov.my/pdf/economy/er/0405/chapter1.pdf* (Accessed 21 May 2008).

O' Connor, D. 1994. *Managing the Environment with Rapid Industrialisation: Lessons from the East Asian Experience*. Paris: OECD.

Panayotou, T. 1998. Economic growth and environment. *Quarterly Journal of Economics, CX*: 353-77.

Petra, Raja Kamarudin. 2006. Malaysia Today Special Report on the NEP. *Available* at*: http://gundohing.blogspot.com/2006_03_15_archive.html (Accessed 14 May 2007).*

Rothman, D.S. 1998. Environmental Kuznets curves - real progress or passing the buck? A case for consumption based approaches. *Ecological Economics* **25(2)**: 177-194

Sahabat Alam Malaysia (SAM). 2001. SAM'S World Environment Day Message: More needs to be done to give priority to protection of the environment. Press release. Available at *http://www.surforever.com/sam/pressrelease/wed.htm* (Accessed 26 February 2009)

Shen, J. 2006. A simultaneous estimation of Environmental Kuznets Curve: evidence from China. *China Economic Review* **17**: 383 – 394

Sinha, D. 1998. Government expenditure and economic growth in Malaysia. *Journal of Economic Development* **23(2)**: 71-80.

Stern, D.I., M.S. Common and E.B. Barbier. 1998. Progress on the Environmental Kuznets Curve. *Environment and Development Economics* **3**: 173-196.

Suri, V. and D. Chapman. 1998. Economic growth, trade, and energy: implications for the Environmental Kuznets Curve. *Ecological Economics* **25**: 195–208.

Torras, M. and J.K. Boyce. 1998. Income, inequality, and pollution: a reassessment of the Environmental Kuznets Curve. *Ecological Economics* **25**: 147–160.

Tsen W.H. 2006. Foreign direct investment in manufacturing industry in Malaysia: an empirical study. *Unitar E-Journal* **2(2)**: 1-38. Available at *http://host.uniroma3.it/docenti/costantini/LMquant_file/Costantini_Martini_2006.pdf*. (Accessed 20 December 2007).

Vincent, J. 1997. Testing for Environmental Kuznets Curves within a developing country. *Environment and Development Economics* **2**: 417-431

Wahab Muhamad. 2002. *Total Factor Productivity Growth: Survey Report*. e-Books on Industry and Services: Asian Productivity Organisation.

Zaharaton binti Raja Zainal Abidin. 2004. IWRM Implementation Realities in Malaysia" Available at *http://www.epu.jpm.my/New%20Folder/speech/kpspeech/IWRM%20Implementation%20Realities%20in%20Malaysia%20Slides.pdf* (Accessed 19 September 2007).

Zin, R.H.M. 2005. Income distribution in East Asian developing countries: recent trends. *Asian-Pacific Economic Literature* **19(2)**: 36-54.