Volume 5 No. 1
June 2008
ISSN 1675-7017

Social and Management Research Journal

Research Management Institute

SOCIAL AND MANAGEMENT RESEARCH JOURNAL

Social and Management Research Journal is jointly published by Research Management Institute (RMI) and University Publication Centre (UPENA), Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

SOCIAL AND MANAGEMENT RESEARCH JOURNAL

Vol. 5 No. 1 June 2008 ISSN 1675-7017

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Air Pollutants in Malaysia: The Contribution of Economic Growth Towards It

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ABSTRACT

It is possible to distinguish three main channels whereby income growth affects the quality of the environment as first suggested by Grossman (1995). These are (1) scale effect, (2) composition effect and (3) technological progress. A recent research criticism by Cole (2003 and 2004) of the environmental Kuznets curve (EKC) hypothesis is based on the occurrence of foreign direct investment and international trade. In the previous EKC literature, EKC is always estimated in the form of a single equation. However, since both income and environmental quality are endogenous variables in which they impact upon each other, the estimation of single equation relationships where simultaneity exists will produce biased and inconsistent estimates. The general objective of this study is to measure the relationship between economic growth and different indicators of air pollution in Malaysia. Air pollution indicators were assessed on a number of measures: Carbon Monoxide (CO), Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Ozone (O_3) and Particulate Matter (PM_{10}). The income level per capita GDP (Gross Domestic Product) were measured from the year 1996 to 2006 quarterly. This study contributes to the available literature by Hung et al (2004) AND Shen (2006), This study also estimates population density as an endogenous

ISSN 1675-7017

variable. It formulates a four-equation simultaneous model for empirical research. It tests for exogeneity using the Hausman test and estimates the simultaneity model using the two-stages least squares method. The EKC hypothesis is supported in the cases of SO_2 and PM_{10} and there are several differences found between single polynomial equation estimators commonly used in EKC literatures and simultaneous equation estimators.

Keywords: *Air pollutants, Economic Growth, Malaysia, Environmental Kuznets Curve*

Introduction

Income affects pollution and pollution affects income. Estimating the relationship only by a single polynomial equation might probably produce biased and inconsistent estimates since the economic growth and the environmental quality are jointly determined. According to Shen (2006), it is therefore more appropriate to use simultaneous equation model for the estimation. In this study, based on EKC empirical literature, the first equation (pollution equation) is a commonly used polynomial equation. Contributing to the available literature by Shen(2006), this study adds two extra important variables which are the secondary industry share and the government pollution abatement expense into pollution equation to explain the impacts of industrial structure and environmental policy on pollution in Malaysia. Being different from the study by Shen (2006), this study adds variables such as the number of motor vehicles to explain the impact of it on pollution in Malaysia. This study also estimates population as an endogenous variable being affected by pollution through impacts on health. According to Lopez (1994) and de Bruyn (2000), pollution may directly reduce output and productivity of man-made capital and labor in which it act as a negative externality. To control the feedback impact of pollution on income, the second equation that is the income equation is introduced to manipulate the pollutant emission on input in an extended Codd-Douglas production function. Due to pollution abatement expense and the emission level being jointly determined, a third equation (abatement equation) is introduced to explain abatement expense. Since adding population density into pollution equation may cause another source of simultaneous error in the model, in which population density and the emission level are jointly determined, a fourth equation (population density) is also introduced to explain the effects of pollution on population density. This study is consequently to test the significant difference between single polynomial equation estimators and simultaneous equations estimators after the simultaneous equations model is constructed.

Literature Review

Based on the study by Panayotou (1998) in relation to environmental impact indicator to a measure of income per capita, empirical models of environment and growth consist usually of reduced form single-equation specifications. Income distribution, population density, institutional variables, openness to trade and geographical are examples of variables controlled in different studies. In income and environmental degradation, the functional specification is usually quadratic; log quadratic or cubic. A number of critical surveys of the EKC literature have been published on the subject. Mariano et al. (1998) hypothesize that more equitable distributions of power tend, ceteris paribus, to result in better environmental quality. Their regression results are in general, consistent with the hypothesis. Recent critiques by Kristin (2006) stated that there is no single EKC that fits all pollutants for all places at all times. It seems to work best for local air pollutants such as oxides, nitrogen, sulfur dioxide, and particulate matter. Income growth without institutional matters is not enough. Whether improvements materialize depends on government policies, social institutions and the completeness and functioning of markets need to look for structural explanations and the completeness and functioning of markets need to look for structural explanation of the EKC.

The relationship between a number of air and water pollutants in Malaysia and per capita income has been examined by Vincent (1997) from the late 70s to the early 90s. The study emerged from a single-country study and had two main conclusions. First, for the income environment relationship in single countries, cross-country analysis may fail to predict. Second, none of the pollutants examined by Vincent showed an inverted-U relationship with income. The effects of the spatial intensity of economic activity and income on the atmospheric concentration of sulfur dioxide have been explored by Kaufmann et al (1998). An inverted U-shaped relation between the SO_2 concentration and spatial intensity of economic activity can be seen from the results. The study also shows that there is a U-shaped relation between atmospheric concentration of SO_2 and income. From this point of view, it suggests that instead of income, the spatial intensity of economic activity provides the impetus for policies and technologies that reduce SO_2 emissions.

Based on the study by Stern et al (1996), Cole (2003 and 2004), Suri and Chapman (1998), Arrow et al (1995) and Rothman (1998), the environmental Kuznets curve hypothesis is based on the occurrence of international trade and foreign direct investment. This is one of the most damaging criticism of the environmental Kuznets curve hypothesis. According to Anton et al (2005), the argument asserts that the downturn in emissions at higher levels of per capita income can be explained, at least to some extent, by the relocation of "dirty" industries from developed to developing countries, and the tendency among developed countries to import pollution-intensive goods from developing countries rather than produce them at home. As has been shown in the study by Suri and Chapman (1998), Ekins (1997) and Stern et al (1996), this is a more appropriate measure for global environmental impact.

Methodology

The data for the study comprise external information from The Department of Environment (DOE) in Malaysia, Department of Statistics in Malaysia, University library, British Council, National library and Memorial library. Sources such as books, newspapers, journals and internet that are relevant to the research topic are also used. To examine the relationship between air pollution and economic growth, the study estimates several equations that relate the level of pollution in a location to a flexible function of the current and GDP per capita in the country and to other covariates. Air pollution indicators were assessed on a number of measures: Carbon Monoxide (CO), Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Ozone (O_3) and Suspended Particulate Matter (SPM). The income levels GDP (Gross Domestic Product) per capita were measured from year 1996 to 2006 quarterly.

Results and Discussions

A study by Shen (2006) is limited to income per capita and government pollution abatement expenses as endogenous variables. In actual fact, population density is also endogenous to the system, being affected by pollution through impacts on health. According to Lopez (1994) and de Bruyn (2000), pollution may act as a negative externality in which it directly reduces output and productivity of man-made capital and labor. Therefore, a three simultaneous equations method might produce bias and inconsistent estimates. This study formulates four simultaneous equations model that can be as Equations (1), (2), (3) and (4). To check the statistical significance of the cubic terms of log (per capita GDP) in all pollutants, this study employed a t test. The result shows that all of them are not significantly different from zero even at 100% level as listed as follows:

Table 1: T-test to Check the Statistical Significance of the Cubic Terms of Log (per capite GDP) in all the Pollutants (t statistics in parentheses)

	SO_2	PM_{10}	CO	O_3	NO_2
Intercept	-3.2237	4.8169	0.6700	-2.1992	-3.6389
$(\log(\text{per capita GDP}))^3$	-2.1665	0.2305	0.0142	-0.1549	0.0383
	(-4.3830)	(1.2227)	(0.0303)	(-0.9194)	(0.0902)
Adjusted R-square	0.2975	0.0114	-0.0238	-0.0036	-0.0236

Therefore, this study omit the cubic terms in Equation (1).

$$\log P_t = \alpha_0 + \alpha_1 \log Y_t + \alpha_2 (\log Y_t)^2 + \alpha_2 \log abate_t + \alpha_4 \log ind_t + \alpha_5 \log PD_t + \alpha_6 \log MV_t + \alpha_6 T_2 + \alpha_7 T_3 + \alpha_8 T_4 + e_t \quad (1)$$

$$\log Y_t = \beta_0 + \beta_1 \log P_t + \beta_3 \log L_t + \beta_3 \log G_t + \beta_4 \log FDI_t + \beta_5 \log K_t + \beta_6 T_2 + \beta_7 T_3 + \beta_8 T_4 + €_t \quad (2)$$

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

$$\log PD_t = \pi_0 + \pi_1 \log P + \pi_2 T_2 + \pi_3 T_3 + \pi_4 T_4 + \pm_t$$

Equation (1) represents the pollution equation, where

P_t represents air pollution for the year t;

Y_t represents GDP per capita for year t;

T represents time-specific effects as a dummy variables in which T2, T3 and T4 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 for the first quarter (Gujarati 2006). The robust estimates of heteroscedasticity are presented in Table 2 to Table 7 as white.

Table 2: Regression Results: Estimated Results for Air Pollutants [Eq. (1)] (t statistics in parentheses)

	Single polynomial equation		Simultaneous equations	
	SO_2	PM_{10}	SO_2	PM_{10}
Intercept	-1.2275	32.7656	35.9016	-38.7897
log(per capita GDP)	-3.7999	5.85024	42.9406	0.8475
	(-0.1879)	(0.5735)	(0.8740)	(0.0357)
			White -0.5743	White::-0.6724
(log(per capita GDP))^2	2.3309	-3.5264	-25.4814	1.0320
	(0.1858)	(-0.5573)	(-0.7266)	(0.0608)
			White -0.9920	White -0.7065
log(abatement expense)	-0.1369	0.0463	-0.1188	-0.0942
	(-0.6737)	(0.4515)	(-0.2045)	(-0.3352)
			White 0.5147	White 0.8774
log(secondary industry share)	0.4694	0.6430	-0.4451	-0.4521
	(0.1191)	(0.3234)	(-0.0465)	(-0.0978)
			White 0.8517	White -0.0057

continued

Table 2 – *continued*

log(population density)	-1.7638 (-0.0792)	-5.6603 (-0.5036)	-11.934 (-0.1846) White -1.5122	7.5338 (0.2409) White 0.48179
log(motor vehicles)	-2.5934 (-0.2073)	2.7052 (0.4286)	3.7483 (0.1030) White -1.4451	-4.6099 (-0.2619) White 0.3112
Time trend, T2	0.2296 (0.8470)	0.1142 (0.8349)	0.2897 (0.4257) White -0.6453	-0.0183 (-0.0555) White 0.2320
Time trend, T3	0.2890 (0.5086)	0.2811 (0.9806)	0.4642 (0.2920) White -0.6284	-0.0171 (-0.0223) White 0.3091
Time trend, T4	0.2890 (0.1282)	0.0111 (0.0270)	0.3965 (0.1708) White -0.4526	-0.4267 (-0.3801) White 0.2726
Adjusted R-square	0.7254	0.3241	0.6793	0.2746
Hausman Test for exogeneity (F-statistic)	-	-	10.6449	3.1999
Turning Point	(0.8151)	0.8295	0.8426	-
BG LM test			0.0015	0.2018
Ramsey Reset test			1.2197	3.1111
Chow test			3.3831	2.3953

Table 3: Regression Results: Estimated Results for Air and Water Pollutants [Eq. (1)] (t statistics in parentheses)

	Single polynomial equation		Simultaneous equations	
	CO	O_3	CO	O_3
Intercept	258.3939	99.2328	225.8859	151.1282
log(per capita GDP)	-1.6608 (-0.0624)	1.0281 (0.1281)	-58.2862 (-0.9130) White -0.2009	7.0663 (0.3633) White 1.4133
(log(per capita GDP))^2	-7.9937 (-0.4839)	-4.1663 (-0.8367)	-58.2862 (-0.9130) White 0.1316	-10.395 (-0.7487) White 1.3841

continued

Table 3 – *continued*

log(abatement expense)	0.1174 (0.4388)	0.0817 (1.0128)	0.1030 (0.1364) White 5.2391	0.1250 (0.543405) White 0.3869
log(secondary industry share)	9.5137 (1.8337)	4.0123 (2.5653)	11.342 (0.9129) White 1.2393	6.2658 (1.6550) White 1.3806
log(population density)	-45.768 (-1.5602)	-18.266 (-2.0656)	-35.563 (-0.4233) White 0.7519	-27.6525 (-1.0801) White -3.6689
log(motor vehicles)	24.4447 (1.4840)	9.3731 (1.8875)	18.0000 (0.3806) White 2.5054	14.8580 (1.0311) White -2.0636
Time trend, T2	0.5583 (1.5644)	0.2424 (2.2525)	0.5091 (0.5758) White 2.5954	0.3389 (1.2579) White -0.6637
Time trend, T3	1.2726 (1.7008)	0.4376 (1.9400)	1.1256 (0.5448) White 2.9544	0.6970 (1.1071) White -0.1734
Time trend, T4	1.6494 (1.5388)	0.4956 (1.5337)	1.3900 (0.4609) White 3.1253	0.8766 (0.9539) White 0.0187
Adjusted R-square	0.2300	0.4680	0.1245	0.3819
Hausman Test for exogeneity (F-statistic)	-	-	1.9333	5.6123
Turning Point	-	0.1234	(1.1700)	0.3399
BG LM test			1.3053	0.1538
Ramsey Reset test			1.9934	0.8964
Chow test			2.8525	0.3188

Table 4: Regression Results: Estimated Results for Air and Water Pollutants [Eq. (1)] (t-statistics in parentheses)

	Single polynomial equation
	NO
Intercept	69.4750
log(per capita GDP)	22.2656 (0.8536) White 0.0187
$(\log(\text{per capita GDP}))^2$	-13.6305 (-0.8424) White -1.4697
log(abatement expense)	0.0590 (0.2252) White 0.8353
log(secondary industry share)	1.8581 (0.3656) White -0.9779
log(population density)	-15.6898 (-0.5460) White 2.6583
log(motor vehicles)	6.7791 (0.4201) White 1.8823
Time trend, T2	0.2140 (0.6121) White 0.8709
Time trend, T3	0.3712 (0.5064) White 0.7388
Time trend, T4	0.5405 (0.5148) White 0.9340
Adjusted R-square	0.0990
Hausman Test for exogeneity (F-statistic)	-
Turning Point	0.8168
BG LM test	0.3182
Ramsey Reset test	11.0181
Chow test	1.7117

Table 5: Estimated Results for Income Equation [Equation (2)] (t statistics in parentheses)

	log (GDP)	log (GDP)	log (GDP)	log (GDP)	log (GDP)
log SO_2	-0.0388 (-2.0681) White 0.3719	-	-	-	-
log PM_{10}	-	0.5294 (1.6813) White -7.4807	-	-	-

continued

Table 5 – *continued*

log CO	-	-	0.0638 (2.3634) White -5.9402	-	-
log O	-	-	-	0.1498 (3.3953) White 1.1788	-
log NO	-	-	-	-	- 0.0054 (-0.5002) White 2.9097
Intercept	1.1794	-2.7264	1.5622	1.6905	1.4694
log(labor)	0.1249 (0.2777) White -0.3400	-1.4841 (-0.9049) White -0.7206	0.1962 (0.3390) White -1.5634	-0.0824 (-0.1807) White -2.4881	0.1305 (0.2926) White -0.7689
log (physical capital)	0.1050 (4.3315) White -0.6837	-0.0025 (-0.0317) White 1.2032	0.0857 (3.1629) White -6.084	0.0657 (3.0396) White 1.4120	0.0832 (3.8473) White 0.8708
log (govt. spending)	0.2301 (4.8869) White -0.0642	0.2434 (2.8381) White 0.9685	0.3778 (12.409) White -0.6847	0.3595 (2.2576) White -1.2944	0.3110 (3.2466) White -1.2836
log (foreign direct investment)	0.0271 (2.8235) White -1.2900	0.0130 (0.4328) White 0.6567	0.0093 (0.6174) White -1.7885	0.0222 (2.2576) White -0.5408	0.0306 (3.2466) White -1.3531
Time trend, T2	-0.0242 (-1.2548) White -0.6538	-0.0898 (-1.9022) White -0.8473	-0.0795 (-3.7263) White -2.9409	-0.0787 (-4.8956) White -2.5839	-0.0507 (-3.6516) White 0.1037
Time trend, T3	-0.0218 (-0.8612) White -0.4791	-0.1605 (-2.1870) White -1.3872	-0.1034 (-4.0064) White -2.5651	-0.0886 (-5.2106) White -0.4738	-0.0619 (-4.0445) White 1.0834
Time trend, T4	-0.0405 (-1.3187) White -0.0926	-0.0263 (-0.3848) White -1.7022	-0.1387 (-4.3780) White -2.4860	-0.1069 (-5.4385) White -1.0889	-0.0880 (-4.5549) White 1.3232
Adjusted R-square	0.8604	-0.2438	0.7696	0.8582	0.8649
BG LM test	0.6547	0.0499	1.4687	0.0813	1.2635
Ramsey Reset test	3.1996	2.2927	4.0404	2.9095	3.7458
Chow test	2.0281	1.6943	1.9203	1.5702	1.5485

Table 6: Estimated Results for Abatement Equation [Equation (3)]
(t statistics in parentheses)

	log (abatement)	log (abatement)	log (abatement)	log (abatement)	log (abatement)
log SO_2	-2.6438 (-4.1185) White 2.5259	-	-	-	-
log PM_{10}	-	-10.7447 (-1.5412) White -6.5469	-	-	-
log CO	-	-	-2.2608 (-4.2771) White -12.6546	-	-
log O	-	-	-	-5.5186 (-4.4404) White 4.0227	-
log NO	-	-	-	-	-0.4779 (-1.4456) White 21.0735
Intercept	-16.0371	53.8241	0.3901	-13.4207	-2.5059
log (secondary industry share)	-6.2647 (-2.2848) White -0.4186	7.1403 (2.0473) White 1.3618	2.9841 (2.0919) White -0.3692	2.8299 (2.2290) White 1.5950	3.4607 (2.8942) White 0.1432
log (physical capital)	2.9905 (3.0436) White -4.7641	1.6721 (0.9887) White 0.6683	0.4859 (0.6943) White -3.9606	1.0491 (1.5936) White -0.7515	0.3008 (0.4801) White 0.5789
Time trend, T2	0.6815 (1.4827) White -1.5713	0.6281 (0.6566) White -0.2171	0.1990 (0.4486) White -0.1004	0.3407 (0.8463) White -1.0321	-0.1070 (-0.2906) White 0.6979
Time trend, T3	1.0805 (2.0731) White -1.9447	1.9425 (1.1931) White -0.8873	0.3607 (0.7870) White -0.4183	0.0581 (0.1481) White -1.0697	-0.1374 (-0.3684) White 0.4682
Time trend, T4	0.8804 (1.7762) White 0.35200	-1.3694 (-1.2705) White -1.4532	0.0928 (0.2093) White 0.0787	-0.6521 (-1.6473) White -0.7989	-0.1168 (-0.3076) White 0.4022

continued

Table 6 – *continued*

Adjusted R-square	-0.1239	-3.3090	-0.2650	0.0064	0.1075
BG LM test	0.1823	0.5700	1.7000	0.3728	0.2745
Ramsey Reset test	9.6680	2.8543	2.6114	8.5208	5.9729
Chow test	7.1897	1.3739	1.7792	0.7723	1.3173

Table 7: Estimated Results for Population Density Equation [Equation (4)] (t statistics in parentheses)

	log (pop. density)	log (pop. density)	log (pop. density)	log (pop. density)	log (pop. density)
log SO_2	-0.1555 (-10.322) White 1.9694	-	-	-	-
log PM_{10}	-	0.1773 (0.7841) White 1.64851	-	-	-
log CO	-	-	-0.1333 (-2.2483) White -2.2335	-	-
log O	-	-	-	-0.5277 (-3.2464) White 1.4047	-
log NO	-	-	-	-	-0.2701 (-2.6148) White 1.3579
Intercept	3.5433	3.4031	4.3409	3.0510	3.2449
Time trend, T2	0.0451 (2.1702) White -0.3818	-0.0133 (-0.3041) White -0.3034	0.0287 (0.7240) White -0.2616	0.0612 (1.4442) White -0.6163	0.0583 (1.0625) White 0.2753
Time trend, T3	0.0624 (2.9669) White -0.7650	-0.0306 (-0.4748) White 0.8113	0.0459 (1.1109) White -0.0851	0.0411 (1.0317) White -0.6423	0.0753 (1.3296) White 0.1548

continued

Table 7 – *continued*

Time trend, T4	0.0409 (1.9854) White 1.0419	0.0312 (0.7544) White -1.4018	0.0344 (0.8802) White -0.3013	-0.0276 (-0.6736) White -1.0935	0.0905 (1.5508) White -0.4858
Adjusted R-square	0.6272	-0.2084	-0.3050	-0.3382	-1.3225
BG LM test	3.3559	260.2505	113.0735	60.8522	91.7600
Ramsey Reset test	15.7326	-	-	-	-
Chow test	11.5322	18.8541	21.1165	17.9965	16.9976

There are some indicators of pollutants that show that heteroscedasticity found in which the error terms for some of the variables in the model do not have a constant variance. White test is significant at 5% level of significance for some of the pollutant indicators. Due to only minor indicators that show significant at 5% level of significance, this study can proceed without dropping any of the variables. Breusch-Godfrey Serial Correlation LM test has been used in the study to show that the error terms are not correlated to each other. Autocorrelation is found in air pollutant equation for CO and income equations for CO, SO_2 and NO_2 and CO are in abatement equation. Autocorrelation is also found in population density equation. This study proceeds with the Ramsey Reset test to check whether this model suffer autocorrelation due to specification error. The result in Table 2 to Table 7 shows that NO_2 in pollutant equation, CO and NO_2 in income equation, SO_2, O_3 and NO_2 in abatement equation and SO_2 in population density equation suffers with specification error which means that this study omits certain relevant variables. Due to this study taking eight measures of indicators of pollutants and less than 50% from the measures showing specification error, it can be concluded that this model is not suffering from specification error problems. Therefore, this study can continue without adding any other relevant variables. To further check for parameter instability of the model, this study employs Chow test to determine the existence of structural break. Table 2 to Table 7 shows that most of the indicators in pollution equation except for O and NO_2 in income equation, SO_2 in abatement equation and all indicators of pollution in population density equation suffers with structural break. This indicates that the estimated parameters are not stable during the sample period of 1996 quarter one to 2002 quarter one. Parameter instability may happen when there is a structural change in the relationship between dependent and independent variables. This structural change may be due to external forces such as oil crisis and financial crisis or due to policy changes such as fixed exchange rate to flexible exchange rate. Malaysia suffered with financial crisis in the year 1996 and 1997. Due to only minor indicators of air and water pollutants suffer with this problem; this study does not break the data into pre and post period as mentioned above.

The issue concerns the exogeneity of the log form of per capita Gross Domestic Product, its quadratic term and per capita pollution abatement expense. The null hypothesis of exogeneity of these variables is statistically rejected in all cases except for two of the measure of pollutants that is Nitrogen Dioxide and Arsenic from the Hausman test for exogeneity as listed in Table 2 to Table 4. This study is referring to the F test as more than one endogenous regressor is involved (Gujarati, 1995). This study suggests that the simultaneous relationship between per capita income and per capita pollution emission does exist in the data set of Malaysia. This study has found two main significant differences turning to the comparison between the single polynomial equation model estimators and the simultaneous equations model estimators. [Some of the interpretation below is following the study by Shen (2006)]:

Single polynomial equation model:

a. Estimated results suggest that in one pollutants that is SO_2 the expected EKCs are not found to exist.
b. The difference between these two methods is found in the estimated coefficients of several other explanatory variables.
    i. The difference for per capita pollution abatement expense is that its elasticity's in the case PM_{10} on per capita emission in Table 2 is 0.0463 showing that as per capita pollution abatement expense increases by 1 percent per capita emission of PM_{10} increases by 0.0463 percent.
    ii. As can be seen from Table 2, in the case of PM_{10} by using single equation, as abatement expense increase by one percent PM_{10} increase by 0.0463 percent. There is no significant impact of per capita pollution abatement expense on per capita emissions. Policy makers do not have any incentive to invest on pollution abatement in order to reduce pollutant emissions.
    iii. To investigate industrial structural impact from two sources:
        1. Direct impact measured by the coefficient in Equation (1):
        In the case of O_3, the direct impact indicates that a 1% increase in the secondary industry share causes an increase of 4.0123% in per capita emission (Table 3).
        2. Indirect impact measured by the coefficient of the secondary industry share in Equation (3) multiplying the coefficient of per capita pollution abatement expense in Equation (1):
        In the case of O_3, the indirect impact via pollution abatement expense shows that a 1% increase in the secondary industry share causes an increase of 2.8299% of per capita pollution abatement expense (Table 6), and a 1% increase in pollution abatement

expense increases per capita emission by 0.0817% (table 3), therefore there is an increase of 0.2312% (2.8299*0.0817) of per capita emission.

3. Net impact should be calculated as the net values of these two impacts:
   In the case of O_3, the net impact is that a 1% increase in the secondary industry share cause a net increase of 4.2435% (4.0123 + 0.2312) in per capita emission which is 0.6 times smaller of that one estimated in simultaneous equation.

c. For the remaining variables in Equation (1), it shows that when 1% increases in number of motor vehicle used per capita emission will increase by 9.3731% only. Using the single polynomial equation, the coefficient of motor vehicles turns to be lower in $O_{3.}$

Simultaneous equation model

a. Estimated results suggest that in one pollutants that is SO_2 the expected EKCs are found to exist.
b. The differences between these two methods are found in the estimated coefficients of several other explanatory variables.

   i. Per capita pollution abatement expense elasticity's in the case of PM_{10} on per capita emission turns out to be a negative relationship as per capita pollution abatement expense increase by one percent per capita emission of PM_{10} decrease by 0.0942 percent due to the two stages least square method. This follows the economic theory that as per capita abatement expense increases, per capita emissions decreases.
   ii. Using the two stage least square method PM_{10} decreases by 0.0942 percent when there is an increase by one percent per capita emission. This evidence is significant to give the policy makers a higher incentive to invest more on pollution abatement in order to reduce pollutant emission.
   iii. To investigate industrial structural impact by two sources:

      1. Direct impact measured by the coefficient in Equation (1):
         In the case of O_3, the direct impact indicates that a 1% increase in the secondary industry share causes an increase of 6.2658% in per capita emission (Table 3).
      2. Indirect impact measured by the coefficient of the secondary industry share in equation (3) multiplying the coefficient of per capita pollution abatement expense in Equation(1):
         In the case of O_3, the indirect impact via pollution abatement expense shows that a 1% increase in the secondary industry share causes an increase of 2.8299% of per capita pollution abatement

expense (Table 6), and a 1% increase in pollution abatement expense increases per capita emission by 0.1250% (table 3), therefore, an increase of 0.3537% (2.8299*0.1250) of per capita emission.

3. Net impact should be calculated as the net values of these two impacts:
In the case of O_3, the net impact is that 1% increase in the secondary industry share causes a net increase of 6.6195% (6.2658 + 0.3537) in per capita emission which is 1.6 times larger of that one estimated in single polynomial equation. This results shows that secondary industry share is one of the main contributors of pollutants in Malaysia. This is true as Malaysia has undergone a major structural transformation moving from agriculture to manufacturing-based economy. Increasing transportation activities arising from rapid industrial growth and urbanization are the main contributing factors to the persistently prevailing problem of air pollution in the world today (Mahathir, 1996). Industrial zone such as Shah Alam in Malaysia is now one of the most highly polluted areas in the country.

c. For the remaining variables in Equation (1), by applying the two stages least square method, the coefficient of motor vehicles turns to be higher in O_3. It shows that when 1% increases in number of motor vehicles used per capita emission will increase by 14.8580%. This indicates that other main sources of pollution in Malaysia come from transportation.

From the above discussion, this study finds that the differences between the single polynomial equation model and the simultaneous equations model do exist, and these differences will certainly lead to different policy implications. Therefore, this study confirms that it is necessary to consider the simultaneity between income and pollution before directly regressing environmental Kuznets curve in future studies.

In addition, most of the estimated coefficients are significant and consistent with the expected signs turning to the estimated results of income and abatement equations in Table 5 and Table 6. The normal inputs such as physical capital and labor majority contribute positively to the Gross Domestic Product in the income equation. The contribution of human capital in production is not significant in the model although labor is an important factor in production. This indicates that the economic development in Malaysia relies primarily on capital capital-intensive industries. This is true as Malaysian economic growth was stimulated by investment, with capital accumulation contributing more than 50% to productivity growth (Wahab, 2002). The two indicators of air pollutant emissions, SO_2 and NO_2 are negatively related to the GDP and only one measure, SO_2 showing significant income. This is consistent with the theory that as pollution level increases, income decreases. Thus, this study can conclude that there is small significant feedback of air and water pollutants on income in Malaysia as SO_2 is the only indicator that shows significant feedback. It could be due to SO_2 is the one of main contributors of air pollutants that reduces income in Malaysia which mainly comes from industrial activities.

The coefficient of government expenditure is positive and highly significant. Foreign direct investment also has a positive significant impact on income. Besides these, secondary industry share and the physical capital are another two critical determinants of the pollution abatement expense, the heavier the weight of the secondary industry is the more pollution abatement expense would be needed. More physical capital leads to more pollution abatement expense available. These evidences from income and abatement equations suggest that still more pollution abatement investment are required to keep sustainable growth in the long run for the Malaysian economy even though pollution is not the main contributor that reduces income in Malaysia. Turning to population density equation, most of the coefficients of air pollution indicators show significantly on population and all of it having a negative relationship except for PM_{10}. This indicates that as pollution emission increases, population density reduces in Malaysia.

Conclusion

The results from this study show that certain measures of air pollutants follow the EKC in which as per capita income rises, pollution increases up to certain level and start decreases as per capita income decreases. It can be said that Malaysia did not achieve economic growth and environmental decreases. It can also be said that Malaysia did not achieve economic growth and environmental protection simultaneously. Practically local governments sought economic development first and then cleaned up later. From abatement equation, it shows generally negative significant relationship between indicators of air pollution in Malaysia the cost of abatement and this is not following the empirical theory. It can be said that again in reality local governments do not seriously enforce regulations to abate pollution and put economic growth and industrial production first. Due to this, this study proposes some policies as discussed below that can be implemented in order to overcome the problems. The starting point for policy recommendations is to offer policies that can help to overcome the problems of the air pollution facing Malaysia. According to Suleyman et al (2007), firstly, policy actions that might be taken against the individual sources of pollution would be ineffective when the actions are concentrated to control only one source of pollution. Secondly, policy measures against pollution may be appropriate and effective, but lack of coordinative actions and holistic actions in implementing the policies might lead to non-improvement in the level of pollution in the country.

Thirdly, it is due to lack of cooperation between the government and private business firms to comply with regulatory policies for pollution. Fourthly, availability of technologies in industries does not necessitate reduction in pollution rather it depends on the appropriateness of those technologies in terms of capacity and up dates; and the compliance of concerned firm industries to install these technologies. This study puts a recommendation for a future studies to include variables such as solid waste treatment, hazardous waste and noise in the city. These variables are important as the environment exerts an all-round influence apart from air pollution and water quality. A further extension could be made in any of these directions. Malaysia needs to embrace, tighten and stringent certain policies although this study found that air pollutants' have a small impact on income and it is not the main contributor that reduces income in Malaysia.

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