EJEM
Econ. J. Emerg. Mark.

ECONOMIC JOURNAL OF
EMERGING MARKETS
Available at http://jurnal.uii.ac.id/index.php/jep

Developing an empirical Environmental Kuznets Curve

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Article Info

Article history:
Received : 5 January 2015
Accepted : 3 March 2015
Published : 1 April 2015

Keywords:
Environmental Kuznets Curve, pollution, per capita income, fixed effect model

JEL Classification:
A53, N5, Q50

DOI:
http://dx.doi.org/10.20885/ejem.vol7.iss1.art5

Abstract
This study aims to develop a model of Environmental Kuznets Curve (EKC) that relates between environmental pollution level and the prosperity level in Tangerang City. The method uses two models of pooled data regression technique namely, Random Effect Model (REM), and Fixed Effects Model (FEM) both quadratic and cubic. The period of observation is 2002-2012. The results suggest that relationship between per capita income and the level of environment quality, reflected as the BOD concentration (Oxygen Biological damage) and COD (Chemical Oxygen Damage) can be explained by the quadratic FEM model and follow the EKC hypothesis even though the turning point is not identified.

Abstrak
Tujuan penelitian adalah memodelkan kurva lingkungan Kuznet (*Environmental Kuznets Curve* atau EKC) yang menghubungkan antara tingkat pencemaran lingkunganyang dicerminkan oleh konsentrasi *Biologycal Oxygen Damage* (BOD) dan *Chemical Oxygen Damage* (COD) dengan tingkat kesejahteraan di Tangerang yang dicerminkan oleh pendapatan per kapita. Metode penelitian yang digunakan adalah estimasi model panel data yaitu *Random Effect Model* (REM), dan *Fixed Effect Model* (FEM) dengan menggunakan persamaan kuadrat maupun kubik. Periode penelitian adalah mulai 2002 sampai dengan 2012. Hasil penelitian menunjukkan hubungan antara konsentrasi BOD dan COD dengan pendapatan per kapita sesuai dengan hipotesis EKC. Model yang paling baik adalah model FEM kuadrat dengan titik baliknya tidak terindentifikasi.

Introduction

Natural resources are very important for human life because without it human resources will be difficult to survive. God creates the nature is to be used for as much as possible for human wealth in appropriate manner. Exploitation of natural resources without any conservation efforts will lead to disaster for human life.

Human always need of a healthy and comfortable environment. However, many studies reveal that the more developed is a country the worse is the environmental damage. Pollutions may cause to physical damages, psychological and human behavior disorders. Pollution also affects economic development of a country. The common problems faced by developing countries are the depletion and destruction of natural resources, environmental degradation, and negative social and economic effects. The environmental damages are caused by industrialization, transportation, population, poverty, traffic congestion, soil erosion and the exploitation of natural resources. Environmental degradation can be likened to a kidney malfunction (Fauzi, 2013). At entire life the human should be routinely perform "dialysis" that is costly. The patients also can not enjoy a normal life. This shows the importance of maintaining and preserving the environment.

Many studies have examined the problems of environmental degradation. One of them is environmental Kuznets curve (EKC). The initial point of the curve shows that along with the increase in per capita income will be followed by an increase in pollutants up to the point where higher incomes have a higher pollutant or turning point. Further the per capita income will continue to rise but it is followed by the decreasing pollutants. So that researchers previously thought that the economic growth is like a medical panacea to the environmental problems.

Bartz and Kelly (2004) states that economic growth is a function of population and per-capita consumption. The implication of that economic growth is the increase in the supply and demand of goods and services. However, as any successful economic development it is accompanied by various problems. The question that arises is whether the process of environmental degradation along with economic development can be avoided. Based on Iwami (2001) the EKC assumes that up to a certain turning point, per capita income growth goes hand in hand with environmental degradation. Furthermore, beyond the threshold point, an inverse relationship with income growth is accompanied by a decrease in environmental degradation. However, Richmond and Kaufmann (2006) finds that for non-OECD nations, there is no turning point between income and air pollution.

EKC is a hypothetical relationship between the various indicators of environmental degradation and income per capita. In the early stages of economic growth, the pollution increase, but beyond a certain level of per capita income, which will vary for different indicators, the trend reversed. It results in high levels of income growth leading to environmental improvements. This implies that the environmental impact indicator is an inverted U-shaped function of income per capita (Grossman and Krueger, 1991).

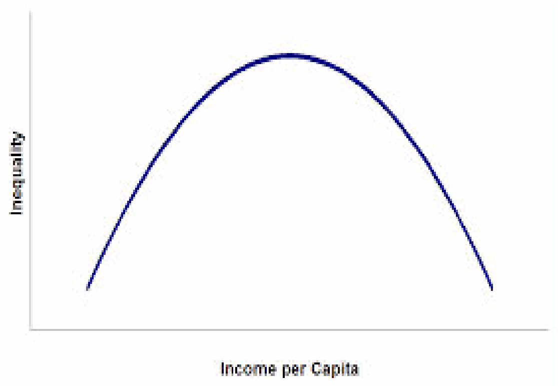


Figure 1: Environmental Kuznets Curve

Panayotou (2003) describes the linkages between the stages of economic development and environmental degradation of EKC curve that is divided into three stages, as shown in Figure 1. In the first phase, the economic development will be followed by increased damage to the environment so called as pre-industrial economics. The second stage is known as industrial economics, and the third phase is known as post-industrial economics (service economy). Industrialization started from small industry and then move into heavy industry. This movement will increase the use of natural resources, and increasing environmental degradation. After that point the industrialization would expand its role in the formation of more stable gross domestic product. The presence of foreign investment has led to the transformation of the economy from agriculture to industry. Increasing the role of the industrial sector in the economy of a country will result in increased pollution in the country. In the next phase of economic transformation will occur in the form of a movement from the industrial sector to the service sector. This movement will be followed by a decrease in pollution in line with increasing per capita income. Besides the increasing demand for environmental quality products go hand in hand with the increase in welfare. In turn, the increase in income will be followed by an increase in the ability of the people to pay for environmental damages caused by economic activity. So according to Andreoni and Levinson (2004), at this stage is also characterized by the emergence of community willingness to forego the consumption of other goods for the sake of protection of the environment.

The EKC is known as the first theory which describe how the relationship between the rate of economic growth with environmental degradation of an economy. According to this theory, when the income of a country is still relatively low, then government attention will be focused only on how to increase state revenues, either through production or investments that lead to higher revenues with disregard the issues of environmental quality. As a result, revenue growth will be followed by a rise in pollution levels and then decline along with the further economic growth. This theory was developed on the basis of the demand for environmental quality that is improving social supervision and regulation of government so that people would be better off (Mason and Swanson, 2003).

Hutabarat (2010) describes the relationship between air pollution problems with an economic growth rate. In the early stages of industrial development of developing countries, they increase the output in order to improve the social welfare. As industrialization increased the air pollution increased as well. A country that experiences the increased economic growth will have the ability to control such pollution. After the state is able to manage in developing methods and procedures to control pollution, the pollution levels can be controlled and could even be lowered along with economic growth. The country power will also be used to improve the air quality. In the end the state will develop environmentally friendly technologies so that pollution can be reduced.

The main source of the economy of the city of Tangerang comes from the manufacturing sector amounted to 58.45%, followed by trade, hotels and restaurants. Both sectors are composing almost 85% of economic activity and it is certainly providing a major contribution to the local revenue. Approximately 75% of the workforce in the city of Tangerang is in the industrial sector, trade and services. Economic growth has led to environmental degradation as a result of industrial and household activities. The problem in this case is not to build or not to build the industry to improve the welfare of the society, but how to build the industry and at the same time it also improve the environmental quality and human being. Industrial activities are not only exploiting the environment, but it also how to preserve it. There is no purpose other than conducting environmentally sound industrial development.

Based on the description above, this research generally aims to develop a mathematical model of EKC to build the alternative policies in order to control environmental pollution in the city of Tangerang. Development of alternative policies based on the existence of two conflicting choices on how to increase development through public welfare, as reflected by per capita income, and environmental quality are reflected by the BOD concentration (Oxygen Biological Damage) and COD (Chemical Oxygen Damage) by modeling a Kuznets curve which relates between the incomes of the population and environmental quality in the city of Tangerang.

Research Method

The EKC model is determined using quadratic and cubic panel data estimation. The general model of panel data is:

$$BOD = \alpha_0 + \sum_{k=1}^{m} \alpha_k Inc + \alpha_{m+1} Popden_{it} + \varepsilon_{it} \quad (1)$$

Where:

BOD is the concentration of *Biological Oxygen Damage* (mg/L).

Inc is per capita income (rupiah).

Popden is population density (people/km^2).

ε is error terms.

i is the i-th observation.
t is time period (2001,2002,….,2012).
m is equal 2 if a quadratic model, and equal 3 if a cubical model.

The hypothesis of this study is the higher is the per capita income, the higher is the concentration of BOD and COD up to at a certain income level. Then the concentration of BOD and COD will decrease in line with the further increase in per capita income thus forming an inverted U-shaped Kuznet curve. The second hypothesis is the positive effect of the population density on the concentrations of BOD and COD due to increased human activities. These activities, in turn, will pollute the water reflected by the concentration of BOD and COD. Therefore coefficient of *Inc* is expected to have a positive direction and expected Inc2 variable coefficients are negative, so that it will form an inverted U curve. Meanwhile, Popden variable coefficient is expected to be positive. Kuznets curve shape is then determined by the value of the coefficients α1, α2, and α3. The possible shape of the curve of the model analysis is given in Table 1.

The turning point is obtained by the first derivation of the equation that is equal to zero. The quadratic equation and cubic equation is as follow, respectively:

$$BOD = \alpha_0 + \alpha_1 Inc_{it} + \alpha_2 Inc + \alpha_2 Popden_{it} + \varepsilon_{it} \quad (2)$$

$$BOD = \alpha_0 + \alpha_1 Inc_{it} + \alpha_2 Inc + \alpha_3 Inc + \alpha_4 Popden_{it} + \varepsilon_{it} \quad (3)$$

The first derivations of those equation are:

$$\text{Quadratic: } \square BOD/\square Inc = \alpha_1 + 2\,\alpha_2\, Inc \quad (4)$$

$$\text{Cubic: } \square BOD/\square Inc = \alpha_1 + 2\,\alpha_2\, Inc2 + \alpha_3\, Inc^2 \quad (5)$$

By equalizing the equation (4) dan (5) to zero it will be obtained:

$$\text{Quadratic: } Inc = \frac{-\alpha 1}{2\alpha 2} \quad (6)$$

$$\text{Cubic: } Inc = \frac{-2\alpha 2 \mp \sqrt{4\alpha_2^2 - 12\alpha 3\alpha 1}}{6\alpha 3} \quad (7)$$

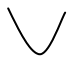
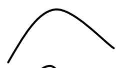
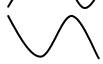
The effect of income change with respect to the BOD concentration can be calculated using elasticity as follow:

$$e_{BOD,Inc} = = \frac{\%\Delta BOD}{\%\Delta Inc} \quad (8)$$

$$e_{BOD,Inc} = = \frac{\partial BOD}{\partial Inc} \cdot \frac{Inc}{Bod} \quad (9)$$

To access the effect of per capita income and population density on the COD concentration can be applied by using those equations (1) – (9) but with changing the dependent variable by COD.

Tabel 1: The Possibility of the Curve Shape

Shape	α_1	α_2	α_3	Diagram
Monotonically positive linear	0	0	> 0	
Monotonically negative linear	0	0	< 0	
U-shaped	< 0	> 0	0	
Inverted U-shaped	> 0	< 0	0	
N-shaped	> 0	< 0	> 0	
Tilted-S shaped	< 0	> 0	< 0	

Source : De Bryuyn, Van Den Bergh, Opschoor (1998)

The method used is the regression of data panel. The data panel is a combination of cross section and time series data. Panel data are also often called pooled data, micro panel data, or longitudinal data. The data used is the balance panel, which means that each variable has the same number of observations during the period of 2001-2012. The models of data panel are divided into three types: Pooled Least Square (PLS), Random Effects Model (REM), and Fixed Effects Model (FEM). PLS method assuming all of the explanatory variables is non-stochastic variables. PLS estimation usually generates a significant value R^2, but the Durbin-Watson statistic is lower so that there is a possibility of autocorrelation. Durbin-Watson value is also associated with a lower specification error. The main problem PLS model is a model ignores the heterogeneity that may occur between individuals. The result is thatthe error term can be ass o-ciated with the explanatory variables resulting a bias. In fact, one important assumption in the classical linear regression is no correlation between the explanatory variables with the error term.

To obtain the coefficient parameters that accommodate the heterogeneity, this study will adopt Fixed Effect Model (FEM) and Random Effects Model (REM). FEM assumes that the intercept may differ between individuals but it allows being same over time. Meanwhile, the coefficient parameter or slope is assumed to be equal across time and individuals. To allow the intercepts vary between individuals, it will be conducted using a dummy. The estimation results indicate that the coefficient intercept of FEM is significant so that the heterogeneity problem has been resolved. Therefore, it can be said that the model FEM is better than the PLS model. However, the dummy technique used by FEM models results in lower degrees of freedom. In this case, this method fails to accommodate the explanatory variables which may not differ all the time because it has the same value. Therefore, the dummy variable indicates a lack of knowledge about good model.

To overcome that problem, then the approach used is a method that can accommodate the time difference and the individual through disturbance component error by REM method. Therefore, the error component consists of two parts, namely: individual specific error and time error. The combined error is not correlated with the explanatory variables.

From the above it is known that the PLS model is less reliable so a panel regression data will be carried out on the model of FEM and REM. To determine the best model among both models is performed by using Haussman test.

H_0: REM is better than FEM
H_1: FEM is better than REM

Hausman statistic test is significant if the probability is less than significant level so that Ho is rejected. It means that FEM model is better than REM. To see the significance of the variables will be conducted at the level of alpha 5% with the following hypotheses.

H_o: $\alpha_i = 0$ (the variable does not affect BOD)
H_1: $\alpha_i \neq 0$ (the variable does affect BOD)
The null hypothesis (H_o) is rejected if the value $|t_{stat}| > t_{\alpha/2df = n - k - 1}$

Where, n is number of observations
k: the number of variables

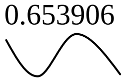
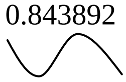
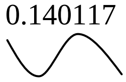
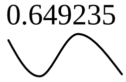
The number of observation in this study exceeds 30 so that when $|t_{stat}|$ value> 1.96 then the null hypothesis is rejected or the independent variable is significantly affecting the dependent variable.

Result and Discussion

Mathematical model of the relationship between the concentration of BOD and COD to the per capita income

To evaluate the relationship between the variables BOD and COD as a representation of environmental quality with a per capita income is estimated using panel data. The regression model used is Random Effects Model (REM) and Fixed Effects Model (FEM) both in quadratic or cubic. The regression estimation is shown in Table 2. The complete results will be shown in detail in the next section. Overall, the results of the panel data regression indicate good results if it is evaluated from the value of significance and the direction of the coefficients. As explained earlier when | t-stat | > 1.96, then these variables have a significant effect. In Table 2, the variables that have a significant effect on the level of α = 5% indicated with an asteric (*). For the quadratic model, all variable income (Inc and Inc2) are significant at the 5% significance level and the coefficient has a sign as expected. The signs of Inc variable are expected to be positive and it is expected negative for variable Inc2 so it will form inverted U-shaped Kuznet-curve. Both models of FEM and REM indicate to be inverted U Kuznet curve.

Table2: Estimation Results for BOD and COD

	Model	**BOD**		**COD**	
		REM	**FEM**	**REM**	**FEM**
Quadratic	Inc_{it}	-4.75×10^{5}*	1.15×10^{5}*	-1.49×10^{5}*	1.82×10^{6}*
		(-8.737957)	(1.668120)	(-0.884589)	(1.273169)
	Inc_{it}^{2}	1.34×10^{12}*	-4.07×10^{-12}*	7.02×10^{13}*	-6.33×10^{12}*
		(3.862314)	(-1.845854)	(0.801599)	(-1.384892)
	Popden	0.000969	-0.001225	0.000240	-0.001346
		(2.476604)	(-0.532325)	(0.366274)	(0.281801)
	Intercept	27.75068	-80.39885	144.6398	-143.706
		(0.191027)	(-0.083199)	(0.579253)	(-0.713611)
	Haussman Test	0	[0,0000]		[0,0000]
	Turning point	0	0	0	0
	R-Square	0.753971	0.826581	0.045326	0.648764
	Curve				
Cubic	Inc_{it}	-1.15×10^{6}	6.08×10^{6}	1.60×10^{6}	3.56×10^{6}
		(-3.298371)	(-1.488606)	(-2.319763)	(0.398077)
	Inc_{it}^{2}	8.21×10^{12}	4.64×10^{11}*	1.54×10^{11}	-1.85×10^{11}*
		(2.444100)	(1.644047)	(2.321908)	(-0.299295)
	Inc_{it}^{3}	-2.20×10^{19}	-1.18×10^{-18}*	-4.72×10^{19}	2.84×10^{19}*
		(-2.122149)	(-1.793265)	(-2.296038)	(0.197196)
	Popden	0.001265	-0.000445	0.000894	0.001159
		(3.438019)	(-0.196688)	(1.226955)	(0.234181)
	Intercept	120.7258	2730.950	337.8840	-2107.746
		(0.946150)	(1.497146)	(1.347742)	(-0.528401)
	Haussman Test	0	[0,0000]	0	[0,0000]
	Turning point	NotDefined	Not Defined	Not Defined	Not Defined
	R-Square	0.653906	0.843892	0.140117	0.649235
	Curve				

Note: The ( ) explains the statistic t and the [ ] explains the probability, the * means significant at 5% level of significance

Based on the table above, the REM and FEM models either quadratic or cubic have the ability to explain the relationship between BOD and COD with a per capita income.

Mathematical model of BOD

1. Quadratic Model
   a) FEM
   BOD = -80.39885 + 1.15 x $10^{-5}Inc_{it}$ – 4.07 x $10^{-12}Inc_{it}^2$ – $0.001225Popden_{it}$
   b) REM
   BOD = 27.75068 – 4.75x$10^{-5}Inc_{it}$ + 1.34x$10^{-12}Inc_{it}^2$ + $0.000969Popden_{it}$

   Based on the above FEM equation it can be explained that BOD is influenced by income with a coefficient of 1.15x10-5 and negatively affected by squared income (Inc2) of 4.07x10-12. BOD is also negatively affected by population density (Popdenit) amounted to 0.001225.

   Based on the REM model, BOD is adversely affected by per capita income of 4.75x10-5 and positively influenced by squared per capita income (Inc2) of 1.34x10-12. The population density is also positively influencing the BOD of 0.000969.
2. Cubic Model
   a) FEM
   BOD = 2730.950 + 6.08x$10^{-6}Inc_{it}$ + 4.64x$10^{-11}Inc_{it}^2$ – 1.18x$10^{-18}Inc_{it}^3$- $0.000445Popden_{it}$
   b) REM
   BOD = 120.7258 – 1.15 x$10^{-6}Inc_{it}$ + 8.21x$10^{-12}Inc_{it}^2$ – 2.20x$10^{-19}Inc_{it}^3$ + $0.001265Popden_{it}$

Using the cubic FEM model the BOD is influenced by per capita income with a coefficient of 6.0 8x 10^{-6} and positively influenced by squared of per capita income (Inc2) of 4.64x10-11. BOD is also negatively affected by cubic of per capita income (Inc3) of 1.18x10^{-18}, as well as negatively affected by population density (Popden) amounted to 0.000445. The estimation results of the REM model suggests that BOD is negatively affected by per capita income at 1.15 x10^{-6} and positively influenced by squared of per capita income (Inc2) of 8.21x10^{-12}, and influenced by cubic of per capita income (Inc3) of 2.20x10^{-19}. BOD is also positively influenced by population density (Popden) in the amount of 0.001265. To clarify the model of FEM and REM both quadratic and cubic above the study also performed simulation of the effect of per capita income with the interval of Rp. 1,000,000.00 (Table 3).

Table3: Simulation of BOD Model

INC	POPDEN	OBSERVED BOD	BOD SIMULATION			
			QUADRATIC		CUBIC	
			FEM	REM	FEM	REM
4000000	500000	203	512,981	343,691	3151,01	783,146
5000000	600000	189	610,351	405,151	3446,05	1380,98
6000000	700000	151	699,581	469,291	3798,49	2136,41
7000000	800000	127,5	780,671	536,111	4201,25	3048,12
8000000	900000	136	853,621	605,611	4647,25	4114,79
9000000	1000000	108	918,431	677,791	5129,41	5335,1
10000000	1100000	89,5	975,101	752,651	5640,65	6707,73
11000000	1200000	56	1023,63	830,191	6173,89	8231,36
12000000	1300000	21	1064,02	910,411	6722,05	9904,67
13000000	1400000	64	1096,27	993,311	7278,05	11726,3
14000000	1500000	10,5	1120,38	1078,89	7834,81	13695
15000000	1600000	73,5	1136,35	1167,15	8385,25	15809,5
16000000	1700000	102	1144,18	1258,09	8922,29	18068,3
17000000	1800000	96,5	1143,87	1351,71	9438,85	20470,2

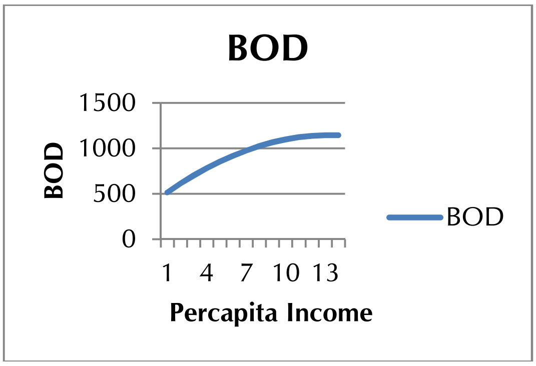


Figure 2: Quadratic FEM Model

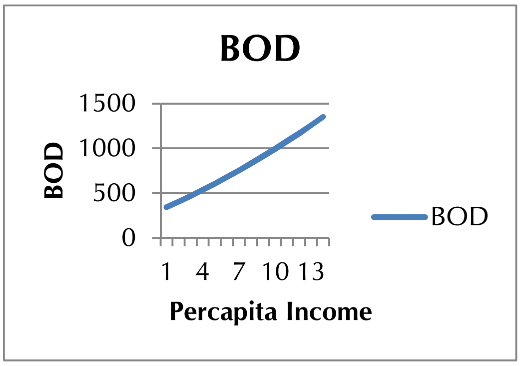


Figure 3: Quadratic REM Model

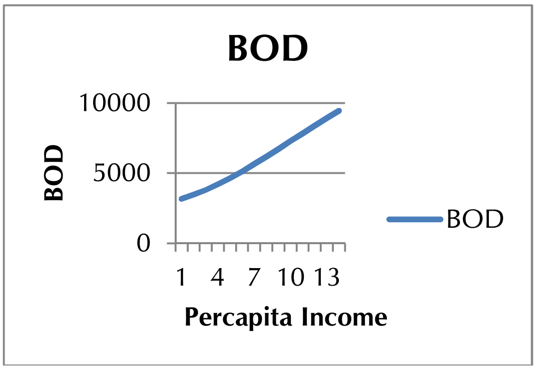


Figure 4: Cubic FEM Model

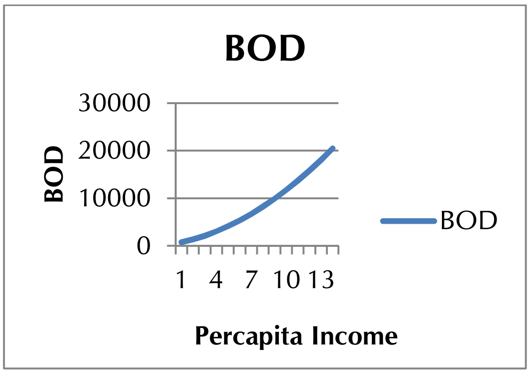


Figure 5: Cubic REM Model

The simulation results then are depicted into diagram to see the shape of each model whether forms the inverted-U Kuznet curve or not.

Mathematical model of COD

1. Quadratic Model
   a) FEM
   COD = -143.706 + 1.82 x $10^{-6}Inc_{it}$ – 6.33 x $10^{-12}Inc_{it}^2$ + $0.001346Popden_{it}$
   b) REM
   COD = 144.6398 – $1.49x10^{-5}Inc_{it}$ + $7.02x10^{-13}Inc_{it}^2$ + $0.000240Popden_{it}$

   Based on the estimation results it can be explained that FEM model of COD is influenced by per capita income with a positive coefficient of 1.82 x 10^{-6} and negatively affected by income squared (Inc_{it2}) at 6 : 33 x 10 - 12. BOD also positively influenced by population density ($Popden_{it}$) of 0.001346. The REM model suggests that COD is negatively affected by per capita income that is equal to 1.49 x 10-5 and positively influenced by squared of per capita income (Inc_2) of 7.02 x 10^{-13}. In addition, COD is also positively influenced by population density (Popden) by 0.000240.

2. Qubic Model
   a) FEM
   COD = -2107.746 + $3.56x10^{-6}Inc_{it}$ – $1.85x10^{-11}Inc_{it}^2$ + $2.84x10^{-19}Inc_{it}^3$ + $0.001159Popden_{it}$
   b) REM
   COD = 337.8840 – 1.60 $x10^{-6}Inc_{it}$ + $1.54x10^{-11}Inc_{it}^2$ – $4.72x10^{-19}Inc_{it}^3$ + $0.000894Popden_{it}$

   Based on the FEM equation above it can be explained that the COD is positively influenced by per capita income with a coefficient of 3.56 x 10^{-6} and negatively affected by squared per capita income (Inc2) of 1.85 x 10^{-11} and also positively influenced by cubic per capita income (Inc3) of 2.84 x 10^{-19}. COD is also positively influenced by population density (Popden) amounted to 0.001159.

REM model suggests that COD is negatively affected by per capita income up to 1.60 x 10^{-6} and positively influenced by squared of per capita income (Inc2) of 1.54 x 10^{-11}, and also negatively influenced by cubic per capita income (Inc3) of 4.72 x 10^{-19}. COD is also positively influenced by population density (Popden) by 0.000894. The simulation results for per capita income of COD model with the interval of Rp. 1,000,000.00 is presented in Table 4.

Table 4: Simulation of COD Model

INC	POPDEN	OBSERVED COD	COD SIMULATION			
			QUADRATIC		CUBIC	
			FEM	REM	FEM	REM
4000000	500000	133,5	435,294	216,272	240,274	994,676
5000000	600000	127,5	514,744	231,69	359,354	1192,28
6000000	700000	119	581,534	248,512	526,634	1406,53
7000000	800000	57,5	635,664	266,738	759,154	1634,59
8000000	900000	86,5	677,134	286,368	1073,95	1873,62
9000000	1000000	109,5	705,944	307,402	1488,07	2120,8
10000000	1100000	97	722,094	329,84	2018,55	2373,28
11000000	1200000	112,5	725,584	353,682	2682,43	2628,25
12000000	1300000	145,6	716,414	378,928	3496,75	2882,87
13000000	1400000	123	694,584	405,578	4478,55	3134,3
14000000	1500000	87,5	660,094	433,632	5644,87	3379,72
15000000	1600000	114,5	612,944	463,09	7012,75	3616,28
16000000	1700000	92,5	553,134	493,952	8599,23	3841,17
17000000	1800000	184,5	480,664	526,218	10421,4	4051,55

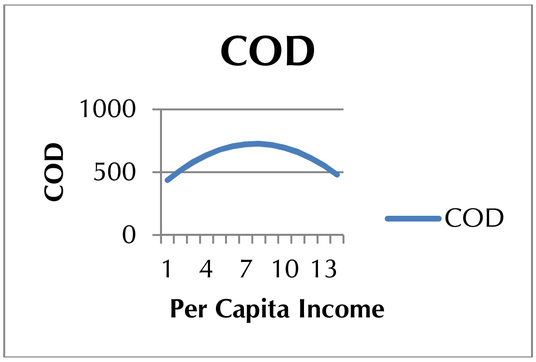


Figure 5: Quadratic FEM Model

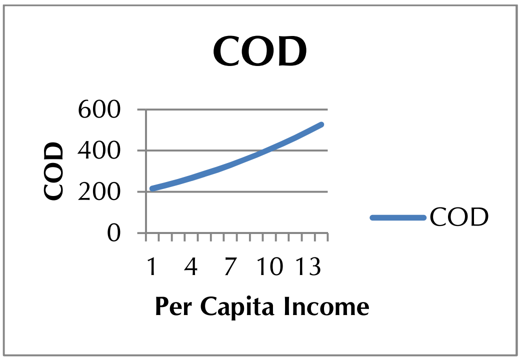


Figure 6: Quadratic REM Model

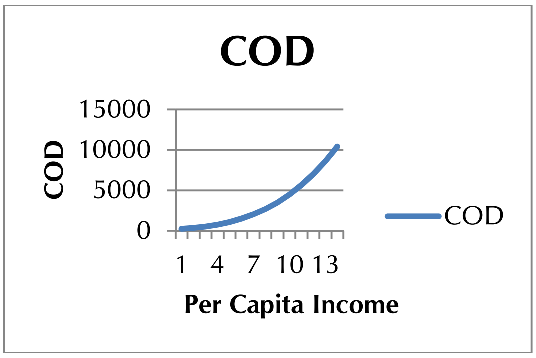


Figure 7: Cubic FEM Model

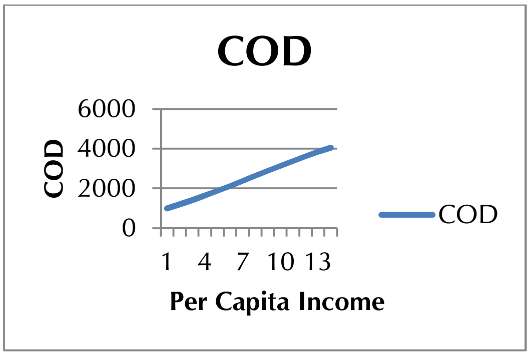


Figure 8: Cubic REM Model

The simulation results then are depicted into diagram to see the shape of each model whether forms the inverted-U Kuznets curve or not.

To determine the best model between FEM and REM is performed using Hausman test. Of the quadratic model both BOD and COD Hausman probability value is 0.0000 or less than 5% significance level. Therefore it rejects the null hypothesis or the model of REM is rejected. However the turning point of quadratic model has not been in identified yet.

For cubic BOD and COD models, all income variables are significant both in FEM and REM models . For all models, the coefficients of Inc and Inc2are negative on REM model and positive coefficient of Inc2 on FEM and negative coefficient for Inc3 on all models so that the curves are tilted-S curve. This means that pollution will decline at the beginning of economic growth. After peaking at the first turning point of income, pollution will increase again and decrease after the second turning point. The probability of Hausman test shows the value 0.0000. This value is also smaller than the significance level (5%) so that it can be concluded that FEM is better than REM. However the value of turning point for the model cubic REM was also undefined because the roots of the determinant in the calculation of the turning point are negative.

From the previous test, FEM is the best model among others. The goodness of fit of the model can be reviewed based on the value of R^2. FEM models have higher R^2 value, which is 60.95% for quadratic and 61.01% for cubic.

These models also include variables of population density (Popden) as one of the factors that influence the level of BOD and COD concentration in the river. For quadratic and cubic specification, variable of Popden is significant for FEM models, but it is not significant in the model of REM. Meanwhile, the coefficients are negative for both model, FEM and REM.

From the estimation results it is known that the FEM model is the best model where the variable Popden is negative significant. According to the hypothesis the coefficienct should be positive. The increase in population density will lead to increased concentrations of BOD, which means the river water is more polluted due to increasing human activities. For the FEM model for COD, the coefficient of Popden variable is positive but at certain point falling as Kuznets theory. Possible explanation is that the variable of population density is significantly affecting the increase in the concentration of BOD and COD, but the rules and public concern about the quality of the environment can reduce the concentration. Survey of BOD and COD concentration in 2010 on the river of the city of Tangerang showed that almost 70% waste comes from domestic sources. However, the drainage rules caused the number of total BOD concentration decreased by nearly 50% compared with previous years.

FEM models consist of cubic and quadratic models. For the quadratic FEM model the curve is inverted U-shaped, while the cubic FEM model is tilted-S curve. So the quadratic FEM model fit the Kuznets curve hypothesis in which the pollution will increase at the beginning of economic growth and ultimately decreases along with the increase in per capita income. Meanwhile, cubic FEM model implies that the pollution will decline at the beginning up to the first turning point and then increase up to the second turning point, and finally fall again.

Based on the number of significant variables, all variables of quadratic FEM models are significant while there is one insignificant variable in cubic FEM model. So it can be clearly seen that the FEM model of quadratic is better than cubic FEM model Although it does not differ too significantly, the R^2 of quadratic FEM model is slightly higher (84.61%) than that of cubic FEM model (84.39%). Therefore, the most suitable model to describe the relationship between economic growth and pollution is FEM quadratic model. Based on this model, the elasticity of BOD concentration with respect to per capita income is negative 0.609. It means that every 1% increase of per capita income will reduce the BOD concentration by 0.609%.

The implication of the results above is that environment pollution can be controlled when per capita income is rising and the population is under control. In addition, governments need to improve the quality of public education and regulate the private sectors for preserving the river by processing the pollutant into a tolerable smaller residue before thrown into rivers. Since Tangerang City is as buffer stock city of Jakarta then the economic, cultural and social structure conditions are not much different from Jakarta. Tangerang City residents have relatively high income and higher concerns investment on infrastructure for water resource management, public awareness for the clean environmental and disaster preparedness.

Tangerang City residents are not accustomed to throw garbage into the river because of the value for preserving the river has been internalized into the culture of life. There are some lessons learned for other cities that have characteristics such as Tangerang City: First, strengthening of local government institutions to control the environmental damages. The regulation of water pollution in the Tangerang City was initiated by the people who live near the river to not throw garbage into the river. In addition, the companies were also required to pre-processing the waste before thrown into river. Second, the use of technology is to manage more safely waste discharged. The technology is very important since the amount of waste disposed is not comparable to a natural ability to decompose naturally. Third is the law enforcement. The government should conduct regular supervision and crack down on offenders. Previously at the beginning the Tangerang City was well known as the dirtiest city, but starting in the early 2008's the total waste disposal has decreased 70% compared to the previous years, and the last 3 years in a row the Tangerang City got an Adipura prize.

Conclusion

The best model that can be used to explain the concentration of BOD and COD in relationship with per capita income in the Tangerang City is quadratic FEM model with not defined turning point. However the result still meets the inverted U shaped Kuznets curve or Environmental Kuznets Curve. Based on that model, the elasticity of the BOD concentration with respect to the per capita income is negative 0.609. Environmental Kuznets Curve will be achieved if a per capita income increases with controlled population density, upgrading the community education, government participation to educate the people for always protect the environment and to raise the awareness about preserving the environment and conserving natural resources. Thus, to improve the quality of the environment is closely related to per capita income where the higher is the earnings; the better is the quality of the environment.

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