

Air Pollution, Economic Growth, and the European Union Enlargement

Ismail Onur Baycan¹

¹ Department of Economics, Anadolu University, Turkey

Correspondence: Ismail Onur Baycan, Department of Economics, Faculty of Economics and Administrative Sciences, 26470 Eskisehir, Turkey. Tel: 90-222-335-0580. E-mail: iobaycan@anadolu.edu.tr

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Abstract

This study examines the Environmental Kuznets Curve (EKC) hypothesis between the levels of air pollution and per capita income growth, considering the largest enlargement of the European Union (EU). Four different measures of environmental quality, SPM, NO_x, SO₂, and CO₂, are employed for three different country groups: the core fifteen countries of the EU before its largest enlargement, the twenty five EU countries after the enlargement, and the new ten countries that became the members of the EU after this enlargement process. The results present a statistically significant U-shaped EKC relationship between each of the air pollutants and per capita income growth for the core fifteen EU member countries and the twenty-five countries after the enlargement. These findings imply that beyond a certain level of GDP, a further rise in income can only be reached at the cost of environmental degradation. For the third country group of the study, the countries that joined the EU after its largest enlargement, there is no statistically significant evidence for the existence of an EKC in any type.

Keywords: environmental kuznets curve, economic growth, air quality, EU enlargement

1. Introduction

The relationship between the environmental degradation and per capita income levels has been highly debated by the resource and environmental economists during the last two decades. Examination of the environmental Kuznets Curve (EKC) is widely utilized to analyze this relationship. According to the EKC argument, little weight is given to environmental concerns in a developing economy, which raises environmental pollution byproducts. As a country reaches higher income levels, people get more concerned about environment, and therefore environmental policies become more stringent. Therefore, the interests give greater weight to a clean environment by reducing and reversing the environmental pollution trend. This implies an inverted-U-shaped EKC relationship between the per capita emissions of pollution and per capita levels of income.

On the other hand, some studies, such as, Dinda et al. (2000), Kaufmann et al. (1998), Sengupta (1997), Shafik (1994), and Grossman and Krueger (1995) suggest a U-shaped EKC relationship, especially for more industrialized country groups. According to this view, the differences in economic growth dynamics of more developed countries compared to the developing ones, as well as the differences in their sectoral compositions causes this U-shaped EKC relationship. These studies argue that a threshold level is already passed for these industrialized countries and additional rise in per capita income cannot be reached without environmental degradation.

This study examines the EKC relationship between the levels of air pollution and per capita income growth considering the largest enlargement of the European Union (EU) in 2004. This enlargement increased the number of member countries from fifteen to twenty five, and as being the largest enlargement of the EU, this enlargement affects the environmental conditions both in the new and old members of the union. The study examines whether this enlargement process affects the EKC relationship between air quality and per capita income growth in the EU.

The remainder of the study is structured as follows. Section 2 reviews the empirical literature. Section describes the employed methodology. Section 4 introduces the data set used in the study. Section 5 and presents the empirical results. Section 6 concludes.

2. Literature Review

The previous empirical studies that focus on the existence of the EKC for different country groups provide mixed results. The first group of studies gives evidence for the existence of the EKC. Grossman and Krueger (1991) focus on the potential environmental impacts of North American Free Trade Agreement (NAFTA) and, for the first time, provide evidence for the existence of an EKC relationship. They use the pollutants of SO₂, dark matter (fine smoke), and Suspended Particulate Matter (SPM). Selden and Song (1993), Shafik (1994), Grossman and Krueger (1995), Panayotou (1997), Torras and Boyce (1998), Kaufmann et al. (1998), and Stern and Common (2001) are other studies that give evidence for the existence of an EKC relationship.

A second group of studies document empirical evidence in favor of a U-shaped EKC. This is also known as reverse or inverse EKC. This group of studies suggests that more industrialized countries have already crossed a threshold point, and therefore an additional rise in per capita income cannot be achieved without environmental degradation. They emphasize that, different economic growth dynamics of more industrialized economies and differences in their sectoral compositions cause this U-shaped EKC relationship. Stern and Common (2001) investigate the EKC relationship for sulfur emissions from 1960 to 1990 for 73 countries. They run regressions for the OECD and non-OECD countries. They use fixed and random effects estimates together with time and country effects to estimate the model. Their findings document a U-shaped EKC relationship. Kaufmann et al. (1998) uses panel data for a group of 23 countries for the time period between 1974 and 1989. They show the existence of U-shaped EKC relationship between concentration of Sulfur Dioxide and income. Millimet, List, and Stengos (2003) use semi-parametric models that document U-shaped curves with lower turning points using U.S. state-level panel data on nitrogen oxide and sulfur dioxide emissions. Dinda et al. (2000) also finds a U-shaped EKC in the case of suspended particulate matter, using the World Bank cross-country panel data on environment. Shafik (1994), Sengupta (1997), Grossman and Krueger (1995) also suggest the existence of a reverse EKC relationship between per capita income and environmental degradation.

A last group of studies argue that emissions of the pollutants are an increasing monotonic function of income, and therefore either an original or inverse EKC relationship cannot exist. Harbaugh et al. (2002) investigate the EKC relationship using three common air pollutants, namely, sulfur dioxide, smoke, and suspended particulates. Their results show no empirical evidence for the existence of EKC in cities world-wide. Caviglia-Harris et al. (2008), and Harbaugh et al. (2002) also find no evidence that supports the existence of EKC between economic growth and environmental quality degradation.

3. Empirical Model

To examine the EKC relationship, the study analyzes the relationship between four different air pollutants and per capita income growth. The analysis rests on three different country groups. These country groups are the core fifteen countries of the EU before its largest enlargement, the twenty five EU countries after the enlargement, and the new ten countries that became the members of the EU after the enlargement process.

The estimated EKC specification is as follows:

$$m_{it} = \beta_0 + \beta_1 y_{it} + \beta_2 y_{it}^2 + \beta_3 d_{it} + \varepsilon_{it} \quad (1)$$

where i is the country index, t is a time index and ε is a disturbance term with zero mean and a finite variance. The dependent variable, m_{it} stands for the measure of per capita emissions for each of the pollutants. The variable y_{it} stands for per capita GDP. d_{it} stands for the population density, which allows to distinguish the effects of urbanization.

The study excludes all explanatory variables other than per capita GDP and population density. The reason for doing that is to get rid of the endogenous consequences of growth and other factors. To deal with endogeneity, I omitted the factors such as the level of education, political structure, and composition of output. These factors are closely related with the emission of the pollutants. Because there would exist a systematic relationship among such kind of variables and per capita GDP growth, and as our objective is to assess both the direct and indirect consequences of growth, I exclude these variables from the equation.

The sign requirements for the existence of the EKC is obtained by taking the first order derivatives of per capita emissions (m_{it}) for each of the pollutants and each of the country groups with respect to real gross domestic product per capita (y_{it}). The threshold point where the first-order derivative of y_{it} is equal to zero indicates a critical point, where there is either a minimum or a maximum, that is, whether the model estimation results in a U or an inverted-U shape. For the existence of a maximum or an original Environmental Kuznets Curve, β_1 must be positive while β_2 is negative, and for the existence of a minimum or a reverse Environmental Kuznets Curve, β_1 must be negative, while β_2 must be positive.

4. Data

Our data set consists of longitudinal data and consists of twenty five countries and three different country groups. The sample period starts from 1995 and ends in 2005. All data are drawn from the Eurostat database. Real income (GDP) per capita is constructed in purchasing power standards (PPS). Using the PPS eliminates the differences in price levels between countries. Besides, calculations on a per capita basis allows for a comparison of different economies that are significantly different in absolute sizes. Population density is in terms of inhabitants per km², where the ratio is the mid-year population of a territory to its size. Air pollutants employed in the study are Suspended Particulars (SPM), Oxides of Nitrogen (NO_x), Sulfur Dioxide (SO₂) and Carbon Monoxide (CO₂). The emission of each of those pollutants brings different environmental problems, and cause important adverse health problems.

The extracted data for emissions are in terms of 1000 tons. They are used in per capita measures, obtained by dividing emissions for each country to its population. Because per capita emissions in terms of 1000 tons yield very small numbers, they became problematic in the calculations. Therefore, I multiply them with a scalar value of one million to transfer the level of pollutants into kilograms.

5. Empirical Results

The EKC model is estimated for three country groups and four different pollutants. Descriptive statistics for each group of countries are reported in Table 1. We examine the relationship for the core fifteen countries of the EU before its largest enlargement, the twenty five EU countries after the enlargement, and the new ten countries that became the members of the EU after this enlargement process. First, a Breusch-Pagan/Cook-Weisberg test is employed to detect the existence of any linear form of heteroscedasticity. The results show strong evidence of heteroscedasticity. This result is not surprising considering that we work with different countries for each of the country groups, which means that we deal with different cluster of variances. Because the standard error variances are all a multiplicative function of different variables, standard errors are clustered and weighted for each group in order to deal with heteroscedasticity.

Table 1. Descriptive statistics for EU-15, EU-25, and NEW-10

	<i>Mean</i>			<i>Std.Dev.</i>		
	EU-15	EU-25	NEW-10	EU-15	EU-25	NEW-10
Popd	155.5176	173.4065	200.24	120.1977	238.1314	345.8298
Gdp	22927.88	18314.18	11393.64	7368.353	8394.362	3858.68
Gdpsq	5.80E+08	4.06E+08	1.45E+08	4.64E+08	4.22E+08	9.36E+07
Spm	48421.76	51688.37	56.58828	14745.4	17784.14	20.67662
No _x	29147.7	27129.85	24.10307	8989.84	8577.5	6.923919
so ₂	18655	29341.47	45.37117	13730.98	23610.69	26.18164
co ₂	1.01E+07	9287636	8019091	3823903	3726664	3194390

Both fixed and random effect estimates are obtained from the model. We know that there is a trade off between the fixed and random effect models. The estimates from the fixed effects always give consistent results, but they may not be the most efficient model to run. Random effects, on the other hand, are more efficient estimators. Hausman test is employed to decide for the best estimates. This test verifies a more efficient model against a less efficient but consistent one, to make sure that the more efficient model also gives us consistent results. The favored results are reported in the tables for each of the country groups.

Tables 2 to 5 report the estimation results for four different pollutants and three different country groups. As discussed earlier, the evidence for the original EKC requires the coefficient β_1 must have a positive and β_2 has a negative sign. For the existence of a U-shaped EKC, β_1 must be negative, while β_2 must have a positive sign. The results for the core fifteen EU member countries and the total twenty-five countries after the enlargement show a statistically significant negative value of β_1 and a statistically significant positive value of β_2 . The results for these country groups suggest a U-shaped relationship between the pollutants of SPM, NO_x, SO₂, and CO₂ and per capita income growth. This implies that beyond a certain level of GDP, a further rise in income can only be reached at the cost of environmental degradation. For the third country group of the study, the countries that

joined the EU after its largest enlargement, there is no statistically significant evidence for the existence of an EKC in any type.

Table 2. EKC model results for SPM

VARIABLES	EU-15 (RE)	EU-25 (FE)	NEW-10(RE)
gdp	-1.994*** (0.241)	-3.071*** (0.277)	-0.00169 (0.00130)
gdpsq	1.17e-05*** (3.84e-06)	2.68e-05*** (4.78e-06)	-7.32e-08 (5.30e-08)
popd	-38.70 (25.22)	-110.4** (49.91)	0.0129 (0.0184)
Constant	93,380*** (5,804)	116,195*** (8,593)	83.89*** (10.74)
Conclusion	Reverse EKC	Reverse EKC	-

Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1.

Table 3. EKC model results for NO_x

VARIABLES	EU-15 (RE)	EU-25 (FE)	NEW- 10(RE)
gdp	-1.081*** (0.165)	-1.001*** (0.126)	0.000404 (0.000477)
gdpsq	8.29e-06*** (2.62e-06)	6.97e-06*** (2.17e-06)	-4.60e-08** (1.94e-08)
popd	-12.57 (14.64)	6.677 (22.67)	0.00400 (0.00492)
Constant	51,081*** (3,581)	41,472*** (3,904)	25.35*** (3.423)
Conclusion	Reverse EKC	Reverse EKC	EKC (insignificant)

Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1.

Table 4. EKC model results for SO₂

VARIABLES	EU-15(RE)	EU-25 (FE)	NEW-10 (RE)
gdp	-2.062*** (0.220)	-3.936*** (0.360)	-0.00350* (0.00182)
gdpsq	1.68e-05*** (3.50e-06)	4.34e-05*** (6.19e-06)	-3.96e-08 (7.42e-08)
popd	-16.91 (22.31)	-121.8* (64.68)	0.0430** (0.0196)
Constant	58,814*** (5,191)	104,955*** (11,136)	82.31*** (13.28)
Conclusion	Reverse EKC	Reverse EKC	-

Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1.

Table 5. EKC model results for CO₂

VARIABLES	EU-15 (RE)	EU-25 (RE)	NEW-10 (RE)
gdp	-102.2** (49.53)	-92.28*** (30.69)	-439.3*** (71.34)
gdpsq	0.00339*** (0.000788)	0.00323*** (0.000535)	0.0182*** (0.00292)
popd	5,491 (4,394)	789.7 (2,099)	1,091 (2,402)
Constant	9.655e+06*** (1.076e+06)	9.532e+06*** (731,218)	1.017e+07*** (1.252e+06)
Conclusion	Reverse EKC	Reverse EKC	Reverse EKC

Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1.

6. Conclusion

This study examines the EKC relationship between the levels of environmental degradation and per capita income growth, considering the largest enlargement of the EU. This enlargement increased the number of member countries from fifteen to twenty five, and as being the largest enlargement of the EU, it affects the environmental conditions both for the new and old members of the union. The study tests whether adding ten new members (Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia) in the 2004 enlargement process affects the relation between different kinds of air pollution and per capita income growth in the EU. The Eurostat cross-country panel data on air quality and per capita real GDP data are employed for the period 1995–2005. Four different measures of air pollutants, namely, SPM, NO_x, SO₂, and CO₂, are utilized. We examine the relationship for three different country groups: the core fifteen countries of the EU before its largest enlargement, the twenty five EU countries after the enlargement, and the new ten countries that became the members of the EU after this enlargement process.

The findings document a statistically significant U-shaped EKC relationship between each of the air pollutants employed in the study and per capita income growth for two of the country groups: The core fifteen EU member countries and the twenty-five countries after the enlargement. These results imply that beyond a certain level of GDP, a further rise in per capita income can only be reached at the cost of environmental degradation. The findings are consistent with the earlier studies that were conducted for different industrialized country groups, which argue that the differences in economic growth dynamics of more developed countries compared to the developing ones, as well as the differences in their sectoral compositions causes this U-shaped EKC relationship. There is no statistically significant evidence for the existence of an either original or inverse EKC relationship for the third country group of the study, which consists of the countries that joined the EU after the enlargement.

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