Journal of Economics and Sustainable Development www.iiste.org
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.5, No.27, 2014

The possibility of environmental Kuznets curve for CO_2 emission

Abdolmajid Ahangari[1], and Mahvash Moradi[2]
[1] Department of Economics, Chamran University, Ahvaz, Iran
[2] Ph.D. student, Department of Economics, Chamran University, Ahvaz, Iran
Corresponding author: moradi.mahvash67@gmail.com

Abstract
Considerable interest has focused on the possible existence of an environmental Kuznets curve. The environmental Kuznets curve hypothesis admits the existence of an inverted U-shaped relationship between economic growth, generally approximated by GDP per capita, and environmental degradation. Despite the abundance of empirical literature on the environmental Kuznets curve, so far little study has been dealt with the relationship among developing Asian countries. Hence, we have therefore tried to extract this curve for these countries by focusing on the CO_2 emission as an indicator of environmental degradation. For this aim, we have applied the econometric techniques of panel data over the period ranging from 1990 to 2011. By estimating a quadratic relationship between per capita income and pollution and by employing GLS method, we are able to deduce a U-shaped relation between income and CO_2 emission.
Keywords: Environmental Kuznets curve, growth, CO_2 emission

1. Introduction

Policymakers have recently shown considerable interest in the relationship between per capita income and pollution. Indeed the shape of this relationship played a substantial role in the debate over ratifying the analysis by Grossman and Krueger (1993). That analysis showed, levels of sulfur dioxide first rose with a country's per capita GDP, but later fell as income increased further, with the turning point falling between $4,000 and $5,000 (in 1985 US$). After that many studies suggested the presence of an inverted U-shaped relationship between per capita GDP and pollution, with pollution first increasing with income but later decreasing. This inverted U-shaped relationship is now often referred to as an Environmental Kuznets Curve (EKC).

Based on economic theory, two dominant explanations have been put forth to explain the relationship. The first is that Kuznets behavior is an income effect because the environment is a luxury good. Early in the economic development process individuals are unwilling to trade consumption for investment in environmental protection, as a result environmental quality declines. Once individuals reach a given level of consumption, known in the EKC literature as the "income turning point", they begin to demand increasing investments in an improved environment. Thus after the turning point, environmental quality indicators begin to demonstrate decreases in pollution and environmental degradation.

The other common explanation is that, the EKC is an expression of the "stages of economic growth" economies pass through as they make a transition from agriculturally based to industrial and then post-industrial service based economies. The transition from agricultural to industrial economies results in increasing environmental degradation as mass production and consumption grow in the economy. The transition from industrial to service based economy is assumed to result in decreasing degradation due to the lower impact of service industries. A slightly modified view is the idea that economies pass through technological life cycles, moving from smokestack technology to high technology (Moomaw and Unruh, 1997).

Evidence of the existence of the EKC is far from clear-cut (e.g. List and Gallet 1999, Heerink et al. 2001, Bruvoll and Medin 2003, Jha and Murthy 2003, Paudel et al. 2005, Azomahou et al. 2006, Deacon and Norman 2006, Merlevede et al. 2006, Paudel and Schafer 2009, Carson 2010). Each of these explanations yields a different policy implication. The pollution exporting hypothesis of Suri and Chapman (1998) implies that international trade and capital controls may be necessary. The political economic model of Jones and Manuelli (1995) suggests that developing countries, unable to enact efficient policies, could benefit from international assistance setting up effective environmental institutions. The various dynamic models with multiple equilibrium all imply that any government policy which speeds the transition from one equilibrium to another (i.e. encourages growth) would be beneficial for the environment. In so doing, this paper tries to supply a complete picture of EKC by a panel data on selected Asian countries during the period of 1990 to 2011.

The setup of this paper is as follow: Second section as usual refers to some previous related literature. Section 3 is used to provide a look at Conceptual background of the EKC. In section 4, model, variables and data are introduced. Section 5 describes econometric analyses and results. Section 6 concludes and recommends policy.

2. Literature Review

The seminal valuable effort on growth and pollution can be attributed to Grossman and Krueger's pioneering study, which shaped the foundation for large body of research. This work constituted the starting point of what is called the Environmental Kuznets Curve literature. They proposed a model that suggests a country's pollution concentrations rise with development and industrialization up to a turning point, after which they fall again as the country uses its increased affluence to reduce pollution concentrations.

After that, the World Development Report (1992) studied to emphasize this issue. As shown in the report (World Bank, 1992, Figure 4 p. 11), some indicators of environmental degradation (e.g. carbon dioxide emissions and municipal solid wastes) increase with income, which implies that they worsen with economic growth. Other indicators (such as the lack of safe water and urban sanitation) fall as income rises, indicating that, in these cases growth can improve environmental quality. Finally, many indicators (e.g. sulfur dioxide and nitrous oxide emissions) show an inverted-U relationship with income, so that environmental degradation gets worse in the early stages of growth, but eventually reaches a peak and starts declining as income passes a threshold level.

After that up to now, investigating the relationship between income and generating pollution became focal points of interest. Shafik and Bandyopadhyay (1992) estimated EKC for ten different indicators using three different functional forms. Lack of clean water and lack of urban sanitation were found to decline uniformly with increasing income, and over time. Both deforestation regressions showed no relation between income and deforestation. River quality tended to worsen with increasing income. Local air pollutant concentrations, however, conformed to the EKC hypothesis with turning points between $3000 and $4000. Finally, both municipal waste and carbon emissions per capita increased unambiguously with rising income.

Selden and Song (1994) estimated EKC for four emission series: SO_2, NOx, SPM and CO_2 using longitudinal data from World Resources. The data are primarily from developed countries. This study showed that the turning point for emissions was likely to be higher than that for ambient concentrations. In the initial stages of economic development urban and industrial development tends to become more concentrated in a smaller number of cities which also have rising central population densities with the reverse happening in the later stages of development. So it is possible for peak ambient pollution concentrations to fall as income rises even if total national emissions are rising.

Roberts and Grimes (1997) have questioned the existence of an EKC for indicators that seem to follow this pattern. They observe the relationship between per capita GDP and carbon intensity changed from linear in 1965 to an inverted-U in 1990. They argued that the Kuznets-type curve which is observed for carbon intensity today is the result of environmental improvement in developed countries in these last decades and not of individual countries passing through stages of development. The data set shows that carbon intensity fell steadily among high income countries in the period 1965-90, but increased among middle and low-income nations, with a marked increment in the latter group.

Dijkgraaf and Vollebergh (1998) estimated a carbon EKC for a panel data set of OECD countries finding an inverted-U shape EKC in the sample as a whole. The turning point is at only 54% of maximal GDP in the sample. A study by Schmalensee et al. (1998) also implies a within sample turning point for carbon for high-income countries. All these studies suggest that the differences in turning points that have been found for different pollutants may be due to the different samples used.

Stokey (1998) described a static model with a choice of production technologies with varying degrees of pollution. Her critical assumption is that below a threshold level of economic activity, only the dirtiest technology can be used. With economic growth, pollution increases linearly with income until the threshold is passed and cleaner technologies can be used. The resulting pollution-income path is therefore inverse-V-shaped, with a sharp peak at the point where a continuum of cleaner technologies becomes available.

Perman and Stern (2003) tried to validate the environmental Kuznets curve by using panel data approach to cointegration and confirmed the long run equilibrium stable relation between sulfur emissions and economic growth but failed to support the existence of the EKC. Similarly, Asici (2011) investigated causal relationship between economic growth and environmental degradation for the low, middle and high income countries. They applied fixed effect and fixed effect instrumental variables regression and concluded that positive effect of income on environment degradation is stronger in middle income countries as compared to low and high income economies. Moreover, in high income countries, the effect is not only negative but also statistically insignificant. Thus, the results do not provide support for EKC hypothesis.

Thompson (2014) looks for evidence of an environmental Kuznets curve for water pollution in countries that share major rivers as their border and countries that do not share a river. The data in this paper consist of a panel of 21 years and 30 countries, seven of which are border countries. The turning point for the border countries is much lower than that for the other subset. A t-test comparing group means for income and biochemical oxygen demand levels for both subsets finds no statistical difference for either variable, implying that countries sharing a river may be able to enforce environmental regulations more effectively than countries not sharing a river.

3. CONCEPTUAL BACKGROUND OF THE EKC

As Grossman (1995) suggested, it is possible to distinguish three main channels whereby income growth affects the quality of the environment. In the first place, growth exhibits a scale effect on the environment: a larger scale of economic activity leads per se to increased environmental degradation. This occurs because increasing output requires that more inputs and thus more natural resources are used up in the production process. In addition, more output also implies increased wastes and emissions as by-product of the economic activity, which contributes to worsen the environmental quality. In the second place, income growth can have a positive impact on the environment through a composition effect: as income grows, the structure of the economy tends to change, gradually increasing the share of cleaner activities in the gross domestic product. In fact, as Panayotou (1993) has pointed out, environmental degradation tends to increase as the structure of the economy changes from rural to urban, from agricultural to industrial, but it starts falling with the second structural change from energy intensive heavy industry to services and technology-intensive industry. Finally, technological progress often occurs with economic growth since a wealthier country can afford to spend more on research and development. This generally leads to the substitution of obsolete and dirty technologies with cleaner ones, which also improves the quality of the environment. This is known as the technique effect of growth on the environment.

An inverted-U relationship between environmental degradation and per capita income suggests that the negative impact on the environment of the scale effect tends to prevail in the initial stages of growth, but that it will eventually be outweighed by the positive impact of the composition and technique effects that tend to lower the emission level.

4. MODEL, VARIABLES AND DATA

Most of the EKC analyses use panel data (Stern, 1998). For their estimation, a statistical quadratic function is employed, in which the chosen environmental degradation indicator is modeled as an inverted U-shaped function of per capita income, and thus the logarithm of the dependent variable is associated to the square of the income log. Using this methodology, the regression model assumes the following static form:

$$\ln CO_{2i,t} = \alpha_i + \gamma_t + \beta_1 \ln GDP_{i,t} + \beta_2 \ln GDP^2_{i,t} + \varepsilon_{i,t} \quad (1)$$

where CO_2 refers to environmental degradation, GDP represents the income per capita and ln indicates natural logarithms. Variables are expressed across a series of countries (i = 1, …, N) and time periods (t = 1, …,T). The first two terms on the right hand side are the intercept parameters, which change among the various countries i and years t. They allow for specific effects across countries (α_i) and through time (γ_t) with the aim to register common stochastic shocks. Random disturbances ε_{it} are assumed to be independent across countries, with variances that may differ across each of these.

To estimate the effect of GDP on environmental quality, we observe its impact on CO_2 emissions. We choose the CO_2 for many reasons. First, CO_2 is produced at important levels by manufacturing industries. Second, CO_2 is currently the most popular pollutant since it is the main greenhouse gas that is behind the principal concern of environmentalists and politicians, namely global warming. Finally, CO_2 has available detailed data of its emissions by activity, for a large panel of developed, emerging, transition and developing countries from 1960 to today (BenKheder, 2010). With all these characteristics, CO_2 as a proxy of environmental pollution is well-adapted to our study.

We collected data for 22 years, 1990 to 2011 from the World Bank. The sample of this study comprises five developing countries with middle income (Based on the report of World Bank), namely; China, Iran, Malaysia, Thailand and Turkey. Our choice of which countries to include is dependent on data availability, the amount of CO_2 that emit to air.

5. ECONOMETRIC ANALYSIS AND RESULTS

The analyses start by testing the stability of the available data using the panel unit root test. The Levin, Lin and Chu (LLC), Im, Pesaran and Sin (IPS), ADF- Fisher and PP-Fisher tests are used which provide the best results in efficient testing power. The reported probability of all statistics and a 5% significance level are used for making a decision on whether to reject the null hypothesis or not. The results indicate that, probabilities are greater than the significance level which leads to a failure to reject the null hypothesis of existence of a unit root in the series, and the data are stationary after the first difference for all unit root tests. These results confirm that when the stationary of all data is detected the model meets the requirement to proceed with the panel cointegration test. The Pedroni cointegration test is used in order to test whether the dependent variable and the independent variables exhibit fundamental long-run relationships with each other. The results for the Pedroni test show that the values of statistics are under the 5% critical value. Therefore, we reject the null hypothesis of there being no cointegration vector found in the long run. This indicates that at least one cointegrationng vector exists that offers a stable relationship among variables (Tables 1 and 2).

Table 1: Results for LLC, IPS, ADF and PP

Variable	LLC	IPS	ADF	PP
CO_2	-6.3284 (0.0000)	-6.2563 (0.0000)	53.2694 (0.0000)	55.1165 (0.0000)
GDP	-2.5194 (0.0059)	-2.3736 (0.0088)	32.5217 (0.0003)	32.2870 (0.000)
GDP^2	-6.2104 (0.0000)	-5.9310 (0.0000)	51.1354 (0.0000)	68.0438 (0.0000)

Table 2: Results for Pedroni test

Statistic	Within dimension	
	Statistic	Prob.
Panel v-Statistic	1.51	0.006
Panel rho-Statistic	0.67	0.251
Panel pp-Statistic	-3.11	0.0009
Panel ADF-Statistic	-4.40	0.0000
	Between dimension	
	Statistic	Prob.
Group rho-Statistic	0.780	0.7824
Group pp-Statistic	-1.40	0.0008
Group ADF-Statistic	-2.49	0.0063

Next, the study tests for choosing between a fixed effect and a random effect. In order to validate the results, the Hausman specification test is performed which has an asymptotic chi-square distribution. The resulting probability (0.000) is less than critical value of 5% which supports our view on the fixed effect model. In most regressions, the data suffer from heteroscedasticity. Using the Likelihood ratio test, the hypothesis based on the existence of homoscedasticity in variances is rejected and thus, the model has heteroscedasticity. Therefore we decided to use a remedy for this disturbance. We use the traditional GLS method in order to obtain efficient and robust standard results. Table 3 shows the results of the coefficients for each variable.

Table 3: Results for estimation by GLS

Variables	Coef.	Z	P>|z|
GDP	0.0001	5.43	0.000
GDP^2	-0.003	-3.83	0.000
Prob= 0.000		Wald Chi2= 105.81	

From the probability and Wald statistic tests, we can see the model fits well. The results in Table 3 show that the positive coefficient of per capita GDP indicates that carbon dioxide emission increases with per capita GDP. This result suggests that in the selected countries the increase of income is accompanied by an increase of pollution.

In case of pollutant CO_2 the anticipated EKCs is found to exist. The coefficient of GDP is +0.0001 and GDP^2 is -0.003 which follows the EKC theory. This theory shows an inverted-U relationship with income: environmental degradation gets worse in the early stages of growth, but eventually reaches a peak and starts declining as income exceeds a certain level. However, the main conclusion of most literature supply evidence on EKC but policy makers should avoid simplistic recommendations. More specifically, the possibility that environmental degradation may eventually fall as income grows, does not necessarily mean that growth will automatically solve the problems it causes in the early stages of development. Much work remains to be done to get a deeper understanding of the environment-income relationship. In the future, it would therefore be interesting to perform some more studies on this subject.

6. CONCLUSION AND POLICY RECOMMENDATION

In the last few years, several studies have found an inverted-U relationship between per capita income and environmental degradation. This relationship, known as the environmental Kuznets curve, suggests that environmental degradation increases in the early stages of growth, but it eventually decreases as income exceeds a threshold level. Using data from 5 Asian countries, this study contributes to a better understanding of the relationships between CO_2 pollution and per capita GDP. By employing relevant econometrics analyses, our results are consistent with the existence of environmental Kuznets curve.

The acceptance of the EKC hypothesis has important policy implications. First, the relationship implies a certain inevitability of environmental degradation along a country's development path. Second, the normal EKC suggests that, as the development process picks up, when a certain level of per capita income is reached, economic growth helps to undo the damage done in earlier years. If economic growth is good for the environment, policies that stimulate growth (trade liberalization, economic restructuring and price reform) ought to be good for the environment. However, income growth without institutional reform is not likely to be enough.

Better policies, such as the removal of subsidies, and the introduction of more secure property rights over resources, and the imposition of pollution taxes to connect actions taken to prices paid will flatten the EKC and perhaps achieve an earlier turning point. Because market forces will ultimately determine the price of environmental quality, policies that allow market forces to operate are expected to be unambiguously positive. The search for meaningful environmental protection is a search for ways to enhance property rights and markets.

REFERENCE

[1] Asici, A.A., "Economic growth and its impact on environment: A panel data analysis", MPRA paper, 2011, No. 30238.

[2] Azomahou, T., Laisney, F., and Nguyen Van. P., "Economic development and Co2 emissions: A nonparametric panel approach", Journal of Public Economics, 90(6-7), pp. 1347-1363, 2006.

[3] BenKheder, S., "French FDI and pollution emissions: An empirical investigation", 2010, [Online.] In: http://www.cerdi.org/environment-and-natural-resources-management-in-developing-and-transition-economies-program.html.

[4] Bruvoll, A., and Medin, H., "Factors behind the environmental Kuznets curve: A decomposition of the Changes in air pollution", Environmental and Resource Economics, 24(1), pp. 27-48, 2003.

[5] Carson, R.T., "The environmental Kuznets curve: Seeking empirical regularity and theoretical structure", Review of Environmental Economics and Policy, 4(1), pp. 3-23, 2010.

[6] Deacon, R.T., and Norman, C.S., "Does the environmental Kuznets curve describe how individual countries behave?", Land Economics, 82(2), pp. 291-315, 2006.

[7] Dijkgraaf, E., and Vollebergh, H.R.J., "Growth and/or (?) environment: Is there a Kuznets curve for carbon emissions?", Paper presented at the 2nd biennial meeting of the European society for ecological economics, Geneva, 4-7th March, 1998.

[8] Grossman, G.M., "Pollution and growth: What do we know?", In the economics of sustainable development, edited by Goldin I. and Winters L.A., Cambridge University Press, pp.19-45, 1995.

[9] Grossman, G.M., and Krueger, A.B., "Environmental impacts of a North American free trade agreement", National Bureau of Economic Research Working Paper 3914, NBER, Cambridge MA, 1991.

[10] Grossman, G.M., and Kruger, A.B., "Environmental impacts of a North American free trade agreement", In Carber, P.M. (Ed), The Mexico-U.S. Free Trade Agreement, MIT Press, Cambridge, 1993.

[11] Heerink, N., Mulatu, A., and Bulte, E., "Income inequality and the environment: Aggregation bas in environmental Kuznets curves", Ecological Economics, 38(3), pp. 359-367, 2001.

[12] Im, K.S., Pesaran, M.H., and Shin, Y., "Testing for unit roots in heterogeneous panels", Journal of Econometrics, 115, pp. 53-74, 2003.

[13] Jha, R., and Murthy, K.V.B., "An inverse global environmental Kuznets curve", Journal of Comparative Economics, 31(2), pp. 352-368, 2003.

[14] Jones, L.E., and Manuelli, R.E., "A positive model of growth and pollution controls", NBER, Working paper [5205], 1995.

[15] Levin, A., Lin, C.F., and Chu, C., (2002), "Unit root rests in panel data: Asymptotic and finite-sample properties", Journal of Econometrics, 108, pp. 1-24, 2002.
[16] List, J.A., and Gallet, C.A., "The environmental Kuznets curve: Does one size fit all?", Ecological Economics, 31(3), pp. 409-423, 1999.
[17] Merlevede, B., Verbeke, T., and Clercq, M.D., "The EKC for So2: Does firm size matter?", Ecological Economics, 59(4), pp. 451-461, 2006.
[18] Moomaw, W.R., and Unruh, G., "Are environmental Kuznets curves misleading us? The case of CO_2 emissions", Environment and Development Economics, 2(4), pp. 451-463, 1997.
[19] Panayotou, T., "Empirical tests and policy analysis of environmental degradation at different stages of economic development", World Employment Program Research, Working Paper 238, International Labor Office, Geneva, 1993.
[20] Paudel, K.P., and Schafer, M.J., "The environmental Kuznets curve under a new framework: The role of social capital in water pollution", Environmental and Resource Economics, 42(2), pp. 265-278, 2009.
[21] Paudel, K.P., Zapata, H., and Susanto, D., "An empirical test of environmental Kuznets curve for water pollution", Environmental and Resource Economics, 31(3), pp. 325-348, 2005.
[22] Perman, R., and Stern, D. I., "Evidence from panel unit root and cointegration test: That the environmental Kuznets curve does not exist", Australian Journal of Agricultural and Resource Economics, 47, pp. 325-327, 2003.
[23] Roberts, J.T., and Grimes, P.E., "Carbon intensity and economic development 1962-91: A brief exploration of the environmental Kuznets curve", World Development, 25(2), pp. 191-198, 1997.
[24] Schmalensee, R., Stoker, T.M., and Judson, R.A., "World Carbon Dioxide Emissions: 1950–2050", Review of Economics and Statistics, 80(1), pp. 15-27, 1998.
[25] Selden, T.M., and Song, D., "Environmental quality and development: Is there a Kuznets curve for air pollution emissions?", Journal of Environmental Economics and Management 27, pp. 147–162, 1994.
[26] Shafik, N., and Bandyopadhyay, S., "Economic growth and environmental quality: Time series and cross-section evidence", World Bank, Policy research working paper [WPS904], 1992.
[27] Stern, D.I., "Progress on the environmental Kuznets curve?", Environment and Development Economics, 3(2), pp. 173-196, 1998.
[28] Stokey, N.L., "Are there limits to growth?", International Economic Review, 39(1), pp. 1-31, 1998.
[29] Suri, V., and Chapman, D., "Economic growth, trade and energy: Implications for the environmental Kuznets curve", Ecological Economics 25 (2), pp. 195–208, 1998.
[30] Thompson, A., "Environmental Kuznets curve for water pollution: The case of border countries", Modern Economy, 5, pp. 66-69, 2014.
[31] World Bank, World Development Report, Washington, D.C, 1992.