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Validity of environmental kuznets curve: Some review findings

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Over the years environmental issues have been playing a remarkable role in the global debate. Recently, the question of the relationship between the global climate change and the level of economic activity becomes the major issue and comes to the focal point of research. The validity of the Environmental Kuznets Curve (EKC) has become standard fare in technical conversation about environmental policy due to its eventually promising implications for making economic growth sustainable in the future. In this connection, an attempt has been made in this paper to critically review the validity of EKC. It is found that the inverted 'U' relationship exists only for some pollutants. The EKC does not exist for the natural resources extraction problems like deforestation and biodiversity loss, etc. The expected shape of the EKC might not be same for every country and the predicted turning point in income is also not same for every country. Since countries show significant differences in political, social, economic and biophysical factors, one should expect that different countries exhibit different patterns for their relationships between environment (or the level of different pollutants) and income. Almost all the studies seem to agree that policy plays a more important role than income in the environmental transition observed in many countries. The main conclusion that should be drawn from this paper is that EKC hypothesis should not be taken for granted and further investigation needs to be done in this regard.

Key words: Environment, Income, Environmental Kuznets Curve (EKC).

INTRODUCTION

In recent years, there has been great debate about whether sustainable economic growth and environmental protection go hand-in-hand. In this regard, there exist two schools of thought. First school of thought advocates that economic growth leads to greater environmental degradation and according to second school of thought economic growth leads to improvement of environment. From classical economists to modern economics, scholars have developed their own doctrines pertaining to the environmental resources. David Ricardo (1772-1823) had expressed his 'environmental economic impact' in terms of the impact of the supply of good quality of land and therefore diminishing returns in farm production. Thomas Malthus (1766-1834) argued that the per capita food supply reduced as population grew in relation to the scarcity of fertility of land. According to Karl Marks (1818-1883) capitalist system is not sustainable because of environmental destruction. Therefore, early economists of the classical and neoclassical regime made specific comments about the significance of nature and environment, but did not include them in their exposition of theories.

Recently, the question of link or the relationship between the global climate change and the level of economic activity becomes the major issue and comes to the focal point of research and debate. Since 1991, when economists first reported a systematic relationship

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between income changes and environmental quality, the relationship was known as the Environmental Kuznets Curve (Ekc), which has become standard fare in technical conversation about environmental policy (Grossman and Krueger, 1991). There exists tradeoff between economic growth and environmental quality. There is evidence that the level of environment degradation and conventionally measured per capita income follows the same inverted U-shaped relationship as does income inequality and per capita income in the original Kuznets Curve.The EKC statistical relationship suggests that as development and industrialization progress, environmental damage increases due to greater use of natural resources, more emission of pollutants, the operation of less efficient and relatively dirty technologies, the high priority given to increases in material output, and disregard for environmental consequences for growth. However, as economic growth continues and life expectancies increase, cleaner water, improved air quality, and a generally cleaner habitat become more valuable as people make choices at the margin about how to spend their incomes. In the post-industrial stage, cleaner technologies and a shift to information and service-based activities combine with a growing ability and willingness to enhance environmental quality (Munasinghe, 1999).

Following Grossman and Krueger (1991), who first described the EKC, like other authors have been optimistic about the implicit premise contained in the inverted U relationship estimated for some pollutants in different countries or cities. These authors have the expectation that economic growth would restrain in some way by the increase in pollution generally provoked by the increase in production and economic activity. However, other authors are sceptical about this (Panayotou, 1997), since the inverted U relationship exists only for some pollutants, while other contaminants show a monotonically positive relationship with economic activity or income, such as carbon dioxide (CO_2) and methane (NH_4) which have been pointed out as two of the main green house gases responsible for climate change.

Not surprisingly then, learning more about the EKC, its determinants and the different institutional contexts in which it exists has been an important research challenge in the last fifteen years. As a result, a number of empirical studies have been carried out on the EKC for different countries and different types of contaminants. However, one crucial drawback of most cross-country studies empirically testing the presence of an EKC is their assumption that the coefficients of the inverted U relationship are the same for every country, implying that the expected shape of the EKC is the same for every country and the predicted turning point in income is also the same for every country.

However, since countries show significant differences in political, social, economic and biophysical factors, one should expect that different countries exhibit different patterns for their relationships between environment (or the level of different pollutants) and income. The investigation of the validity of the EKC hypothesis is of great interest and importance due to increasing environmental problems of today. If nations continue to ignore these problems then it will be catastrophic for all humanity. However, environmental policy must be based on a theory which has been validated by empirical results. In this connection, the paper has been made an attempt to present critically review the relevance of EKC theory.

The paper consists of three sections. Section I introduces the paper. Section II presents critical review of EKC and Section III concludes the paper.

2. Critical Review Of Environmental Kuznets Curve (Ekc) Literature

The EKC hypothesis has stimulated considerable discussion within and between the economics and environmental communities, and debate continues about the validity of EKC. Since 1991 a number of studies on the validity of the EKC hypothesis have been carried out. All these studies have applied different theoretical and econometrical methodologies to arrive at certain conclusions. It is found that empirical researchers are far from agreement that the environmental Kuznets curve provides a good fit to the available data, even for conventional pollutants. This section presents different studies; those have been carried out for testing the validity of EKC theory.

2.1 Panel Data Studies

The early studies of the EKC are based on panel data analyses which make use of random, fixed and pooled effects. The first study of the relation between environmental degradation and economic growth was conducted by Grossman and Krueger in 1991. They used pollution indicators such as suspended particles matter (SPM), dark matter (smoke) and sulphur dioxide (SO_2). More specifically in their panel data analysis which allows for random effects the data concern 42 countries for SO_2, 19 countries for dark matter and 29 countries for suspended particles. The years of investigation are 1977, 1982 and 1988. The results were not very optimistic because EKC was not confirmed in the case of SO_2 and dark matter which found to follow an N-shape pattern and an inverted U shape. SPM on the other hand confirmed the EKC hypothesis. The turning points for SO_2 were $ 4,500 and $15,000 approximately, for dark matter $ 5,000 and $ 10,000 approximately and for SPM around $ 9,000.

Following Grossman and Krueger, the study by Seldon and Song (1993) analyze the relation between growth

and pollution indicators such as SO_2, nitrogen oxide (NO_x), carbon oxide (CO_x), SPM for three different periods of time: 1973-1975, 1979-1981 and 1982-1984. Panel data analysis with cross section, fixed and random effects confirm the validity of the EKC hypothesis. The turning points for SPM and SO_2 range between $8,000-$10,300, for NO_x from $11,200 to $21,800 and for Co_x $5,900 to $19,100.

In another comprehensive study, Seldon and Song (1994) examine the validity of EKC hypothesis between CO_2 emissions and Gross Domestic Product (GDP) for the period 1951- 1986. The number of countries in their sample is 130. The panel data analysis that they apply allows for fixed and country specific effects. EKC hypothesis is confirmed for levels with turning point $ 35,428. For logs EKC is not confirmed because the turning point is very high $8,000,000 approximately. In her approach to EKC modelling, Shafik (1994) explored the relation between GDP and environmental degradation for 149 countries covering time period from 1960 to 1990. Panel data analysis based on Ordinary Least Square estimates show that from pollution indicators such as lack of clean water, lack of urban sanitation, SPM, SO_2, dissolved oxygen, fecal coli forms in river, carbon emissions, municipal waste and deforestation, the EKC hypothesis is confirmed only for SO_2 and SPM. The turning points for SPM and SO_2 are around $ 3,280 and $ 3,670 respectively. However, the general EKC shape did not hold for carbon emissions per capita dissolved oxygen in rivers, or forestation/deforestation.

Grossman and Krueger (1995) examine the reduced-form relationship between per capita income and various environmental indicators such as urban air pollution, the state of the oxygen regime in river basins, fecal contamination of river basins and contamination of river basins by heavy metals. The years and time periods that this study concerns are 1977, 1982, 1988 and 1979-1990. Panel data analysis with random effects confirms the validity of the EKC hypothesis with turning points varying but in most cases they come before a country reaches a per capita income of $ 8,000. Tucker (1995) investigated EKC hypothesis for 137 countries for the period 1971-1991 in panel data analysis. For the majority of the countries the findings shows that EKC is confirmed. In a study Moomaw and Unruch (1997) used a sample of 16 developed Organisation for Economic Cooperation Development countries for the period 1950-1992. The relationship between CO_2 emissions and GDP is examined in the panel data framework and with help of structural transition model. The results confirmed the EKC hypothesis for the period under examination but with inverted-V shape and not inverted-U shaped curve. Turning points for each country vary between $ 8,884 - $ 15,425.

According to Aslanidis (2009) an important issue in panel data studies is the underlying assumption of homogeneity of income effects across countries (regions). As some studies show not all countries display the same relationship between emissions and income. This is particularly true when developed and developing countries are compared, the EKC holding for some developed countries only.

2.2 Studies Based on Time Series Models

There are number of studies have been carried out to test EKC hypothesis by using time series data.

Taking into account the fact that it is not right to treat developing and developed countries same way. Many studies have focused to the investigation of relationship between income and pollution applying time series regressions. The problem with these studies is that they give spurious results because the variables such as income and pollution are non-stationary so only if these variables are co-integrated one can rely on EKC results. Tests for unit root (in the case for example CO_2 and GDP per capita) find that these variables are integrated, although not always co-integrated, what casts doubt on the validity of the EKC (Aslanidis, 2009). In this connection, De Bruyn et al. (1998) investigated the relation between pollution and income in four countries (UK, USA, Western Germany and Netherlands) from 1961 to 1993. The three types of pollution indicators are CO_2, NO_x and SO_2 are used. They find that the time patterns of these emissions correlate positively with economic growth and emission reductions may have been achieved as a result of structural and technological changes in the economy.

Cole et al. (1997) carried out a study to examine the validity of the EKC hypothesis. The sample consists of a number of Organisation for Economic Cooperation and Development (OECD) countries and the period of analysis is from 1970 to 1992. They use variety of pollution indicators such as nitrogen dioxide (NO_2), SO_2, SPM, carbon monoxide and NH_4 municipal waste, Cloroflurocarbons. The findings show that meaningful EKCs exist only for local air pollutants. In his approach to test EKC theory for individual country, Roca *et al*. (2001) investigated the validity of EKC hypothesis for Spain. In order to do this the authors make use of six atmospheric pollutants: CO_2, NH_4, nitrous oxide (N_2O), SO_2, NO_x, and non-methanic volatile organic compounds (NMVOC). In the case of carbon dioxide time series covers the period from 1972 to 1996. For the other five pollutants the data which is used covers the period from 1980 to 1996. The OLS estimation of cubic functional specification confirms the validity of the EKC hypothesis only in the case of sulphur dioxide.

Following Roca *et al*. in a study, Friedl and Getzner (2003) explored the relationship between economic development and CO_2 emissions for a small open and industrialized country, Austria. The data covers period

from 1960 to 1999. Besides GDP, imports and share of the tertiary (service sector) are used as explanatory variables. The results do not confirm EKC hypothesis because N-shaped relationship between income and pollution is found to fit data most appropriately. In order to test the shape of EKC for economic development and CO_2 emissions, Lantz and Feng (2006) investigated EKC hypothesis using a five-region panel data set in Canada over the period 1970-2000. The explanatory variables are income, population, technology and CO_2 emissions are the pollution indicator. Panel data analysis with pooled and fixed effects is employed. The results show that inverted U shaped relationship exists with population and technology as explanatory variables. EKC not confirmed when only GDP and CO_2 as explanatory variable.

The main weakness in time series analysis of EKC hypothesis is that the analysis is only in one direction. Therefore, many studies have been carried out with new econometric techniques to test the validity of EKC hypothesis.

2.3 Studies Based On New Econometric Techniques

Many authors have been carried out studies to test the EKC hypothesis with new econometric techniques. Ekins (2000) pointed out the weakness of the time series analysis is may be due to only one direction.

The EKC hypothesis implicitly assumes that the relationship between economic growth and pollution only goes one way, ignoring the fact that there can be simultaneity and feedback effects between the two. In this connection, Coondoo and Dinda (2002) tested the causality process between income and CO_2 emissions and showed that it could go either and even both ways according to the country considered. Indeed, it appears that only for a very limited number of countries in South America, Oceania and Japan have the causality run from income to emission, in accordance with the EKC hypothesis, while for most of the developed countries in North America and Western Europe, causality goes from emission to economic growth. For most of the developing countries, the process actually goes both ways.

In a comprehensive study by Aslanidis and Xepapadeas (2006) explored the idea of regime switching as new methodological approach in the analysis of the emission-income relationship. The basic idea according to authors is that when some threshold is passed, the economy could move smoothly to another regime, with the emission-income relationship being different between the old and the new regime. The period the study covers is from 1929 to 1994 and refers to the 48 states of the USA. The methodology is applied in a panel data analysis. The pollution indicators that they use are state-level emissions of SO_2 and NO_x. EKC hypothesis is confirmed only for sulphur dioxide. They found a robust smooth inverse-V shaped pollution-income path for sulphur dioxide. Following Aslanidis and Xepapadeas, Cialoni (2007) explored the relationship between carbon dioxide emissions and income for Italy. The period of the research is from 1861 to 2002. Apart from ordinary least square estimation of the reduced form model, the author also applies the Index Decomposition Analysis (IDA) in order to investigate changes in emissions from 1990 to 2002. The findings do not confirm the EKC hypothesis. There is a positive relationship between economic growth and CO_2 emissions. Following the trend, the maximum emission of CO_2 emissions per capita in Italy would be reached when GDP per capita will be about $ 26,900.

With a view to apply new econometric technique to test EKC hypothesis, Soytas *et al*. (2007) investigated the effects of energy consumption and output on carbon emissions in the United Sates for the period 1960 – 2004. As additional explanatory variables apart from GDP, labour and gross fixed capital formation is used. The authors employ the relatively new time series technique known as the Toda-Yamamoto procedure to test for long run Granger causality. The results show that income does not cause CO_2 emissions and so economic growth may not become a solution to problem as suggested by the EKC hypothesis. In connection to this, Ang (2008) examined the dynamic causal relationships between pollutant emissions, energy consumption, and output using co-integration and vector error correction modelling techniques. The country under examination is France and the period that the study covers is from 1960 to 2000. The causality results support the EKC hypothesis. Unidirectional causality running from GDP growth to growth of pollutant emissions in the long-run is found.

In another study by Halicioglu (2008) investigated the validity of the EKC hypothesis for Turkey for the period 1960-2005. A CO_2 emission is used as pollution indicator. Apart from GDP other explanatory variables such as trade openness and energy consumption are utilized. ARDL co-integration approach and Granger causality test are applied in order to validate the relationship between income and pollution. The author concludes that there is some support of the EKC hypothesis which is strong enough. He finds that there is bidirectional short and long-run causality between CO_2 emissions and GDP. From all the explanatory variables the empirical results suggest that income is the most significant variable in explaining the carbon emissions which is followed by energy consumption and foreign trade.

Annichiarico *et al*. (2009) carried out a study to examine the relationship between economic growth and CO_2 emissions in Italy. The period the study covers is from 1861 to 2003. In order to check the existence of the EKC the authors apply several different techniques such as co- integration, rolling regression and error correction modelling. The results show that growth and CO_2 emissions are strongly interrelated and elasticity of pollutant emissions with respect to income has been

decreasing over time. More specifically the EKC hypothesis is confirmed for total period with turning point at $ 39,000 which is a quite reasonable. EKC hypothesis is rejected for the first sub-period 1861-1958 and accepted for the second sub-period 1960-2003 with turning point reaching $ 20,000 approximately.

In a comprehensive study, Akbostanci *et al*. (2009) investigated the relationship between GDP and environmental quality for Turkey. The pollution indicators in their study are CO_2, SO_2 and Particulate Matter (PM_{10}) emissions. The relationship between the CO_2 emissions and GDP is examined by the use of a time series model employing co-integration techniques. On the other hand the relationship between GDP and SO_2 and PM_{10} measurements is estimated by panel data techniques. The time series model covers the period from 1968 to 2003 and the panel data model covers the period from 1992 to 2001 including observations from 58 provinces. The results show that there is a monotonically increasing relationship between CO_2 and GDP in the long-run according to time series analysis and N-shaped relationship between GDP and SO_2 and PM_{10} according to panel data analysis. Therefore the EKC hypothesis is confirmed neither for time series model nor for panel data model. Recent studies allow for spatial dependence in emissions across countries to account for the possibility that countries' emissions are affected by emissions in neighbouring countries. The results so far support the use of spatial econometric models over the polynomial EKC specification.

From the above, it is clear that the studies have led to different outcomes. There are many factors which are responsible for this and none of them can be regarded as the main one. The major factors responsible for different findings pertaining to EKC are as follows:

- Different pollution indicators such as CO_2, SO_2, NO_x, SPM, lead, deforestation, DDT, biological oxygen demand, water contamination etc;
- Different functional forms e.g. quadratic, cubic etc;
- Different econometric techniques;
- Different sets of explanatory variables. Apart from standard variables such as income other explanatory variables such as energy use, levels of education, population density, regulations, etc;
- Different framework analysis: panel data, cross-country, time series regressions etc;
- Different time periods and sets of sample size; and
- Different measures such as taking the variable in intensive or non intensive form e.g. GDP, GDP per capita, pollutant level, pollutant per capita and of course the logarithms of these measures;

Due to the above factors there is perplexity among the researchers to conduct studies on validity of EKC hypothesis, given the socio-economic, political and biophysical factors in various countries.

According to Ekins (2000), consideration in assessing the robustness of the estimation is the reliability of the data used. However, there is little indication that the data problems are serious enough to cast doubt on the basic environment-income relationship for any particular environmental indicator, but the results in fact suggest that this might be the case. Fare *et al*., (2001) refer that the non-availability of actual data on environmental quality is the major limitation of all EKC studies. Environmental quality is something that is not measured accurately. Therefore, an index of environmental quality, which measure better, should be developed and used to examine the EKC hypothesis. In this regard, Schubert and Dietz (2001) question that how does one quantify biodiversity and does EKC exists for biodiversity?. As the general case of environmental damages, the existence of an EKC for biodiversity cannot be proven empirically. The EKC does not exist for biodiversity. Given the rapid rate of depletion of species diversity, policy measures to protect or even increase the number of species play an important role. In particular, property rights regimes seem to matter with respect to the biodiversity issue. Doubts over the existence of an EKC for biodiversity casts doubts over the corresponding sustainability implications. However, it seems reasonable to interpret losses in species numbers as a signal of danger for sustainability. Therefore, co-ordinated global conservation strategies seem to be the only way forward.

The stakes in the environmental Kuznets curve debate are high. Per capita GDP in 1998 in purchasing power parity dollars was $1440 in the nations of sub-Saharan Africa, $2060 in India, $2407 in Indonesia, and $3051 in China (World Bank, 2000). Since these societies are nowhere near the income range associated with maximum pollution on the conventional environmental Kuznets curve, a literal interpretation of the curve would imply substantial increases in pollution during the next few decades. Moreover, empirical research suggests that pollution costs are already quite high in these countries. For example, recent World Bank estimates of mortality and morbidity from urban air pollution in India and China suggest annual losses in the range of 2–3 percent of GDP (Bolt, Hamilton, Pandey and Wheeler, 2001).

However, since countries show significant differences in political, social, economic and biophysics factors, one should expect that different countries exhibit different patterns for their relationships between environment (or the level of different pollutants) and income. If nations continue to ignore environmental problems then it will be catastrophic for all humanity. Environmental policy must be based on a theory which is tested empirically. There exist some dangers, if EKC is taken for granted without comprehensive research and debate.

2.4 Dangers Of The Acceptance Of Ekc Hypothesis

When a country tries to develop, the pollution of the

environment is an unavoidable effect of this development. However this doesn't mean that the development of one nation's economy should simply grow out of environmentally damaging activity. Many dangers could arise if then EKC hypothesis is taken for granted. Some of the concerns regarding the EKC hypothesis are the following:

- It is not clear until today if all the pollution indicators follow the pattern that EKC postulates. It could be argued that local pollutants such sulphur dioxide follow the inverted U shape but the same cannot be supported for global pollutants such as carbon dioxide;
- The ability of our planet to absorb pollution or the "absorptive capacity" is still unknown. Tisdell (2001) notes that the models related with the EKC hypothesis face pollution as flows rather than stocks. A comparison between flows and stocks of pollution reveal that the latter sometimes may be a greater problem. If the rate of emissions of pollutants exceeds the capacity of the natural environment to 'absorb' or neutralize them, then stocks of pollutants accumulate in the environment. Depending upon accumulation thresholds, pollution emissions may cause the stocks of pollutants in the natural environment to continue to rise even when pollution emission intensities have passed their peak and even when the total level of emissions per period of time have declined. Furthermore, in many cases, the greater the level of accumulated stocks of a pollutant in the natural environment, the lower is the capacity of the environment to absorb extra pollution. In such cases, a level of pollution intensity above the peak of an EKC will be more damaging environmentally than the same level below it:
- The turning point could be very high and the period of increasing environmental degradation too long. This mean that the pollution of the environmental could have catastrophic and irreversible effects before even the turning point is reached. According to Hill and Magnini (2002) many damaging agents may respond to income levels, but not until GDP per capita approaches out-of-reach levels. If in a developed country, the turning point for a damaging agent is above, say, $50,000 then neglecting to react will create damage for a considerable amount of time. Over the time it takes to achieve the turning point, the environmental damage may prove more costly than it's worth;
- The EKC hypothesis can be used as a policy tool only in a proper and suitable back- ground. This implies that many countries are unable to use the EKC due to the lack of this back ground. Based on this concern Lekanis and Kousis (1999) say that even if developing countries can achieve high levels of income per capita they may not possess a political back ground conducive to environmental protection. Assuming that the aggregate turning point in a country is reached, that country it is not necessarily going to enact protection. Countries that possess sufficient demand for environmental quality still only achieve it with policy revisions. The most successful avenues for obtaining environmental quality are lobbyists.

After thorough review of the existing literature related to the validity of EKC, we found the following important questions, which need to be answered by research in this area. The major research questions are as follows:

- For example, it is very interesting to know how much of the environmental pollution will incur before the economy reach the turning point?;
- Should policy makers encourage through their decisions the economic growth to bring the economy to the turning point?; and
- What kind of institutional reforms should be implemented in order to hasten the improvement of the environment?

The fact that nations which formerly had or currently have low per capita income are experiencing increasing pollution while industrialized countries are successful in abating emissions does not imply that economic development will solve environmental problems quasi automatically.

3. Conclusions And Policy Implications

The EKC hypothesis has stimulated considerable discussion within and between the economics and environmental communities, and debate continues over the validity, and more importantly, the policy implications of EKC studies. If the EKC exists, one can say that economic growth is compatible with improvements in environmental quality if appropriate policy responses have been taken. It is found that the inverted 'U' relationship exists only for some pollutants. The EKC does not exist for the natural resources extraction problems like deforestation and biodiversity loss, etc. The expected shape of the EKC might not be same for every country and the predicted turning point in income is also not same for every country.

The EKC holds for a limited set of pollutants in a limited set of circumstances, and might not be more than a reflection of a historical pattern of trade. The EKC hypothesis makes too strong assumptions about the similarity of the development path for all countries, but it is too early to reject the hypothesis. In general, it has not been tested on sufficient time series to see if it holds for individual countries over time. Also, both empirical results and theoretical discussions seem to agree that policy plays a more important role than income in the environmental transition observed in many countries. This does bring with it some positive policy implications:

- It is not necessary for a country to reach a certain level of per capita income before environmental quality will start to improve.
- A further implication is that an income turning point, which is the main focus of many EKC studies, should largely be ignored as having little relevance.

The main conclusion that should be drawn from this paper is that EKC hypothesis should not be taken for granted and that further investigation needs to be done. When a country tries to develop, the pollution of the environment is an unavoidable effect of this development. Economists all over the world assert that if a country can achieve sufficient economic growth in a short period of time then the degradation of the environment should be accepted and tolerated. It is a cost that country must pay. However this does not mean that the development of one nation's economy should simply grow out of environmentally damaging activity.

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