CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL STUDIES

EKC is the brainchild of two Princeton economists Eugene Grossman and Alen Krueger who reported their path breaking research that examined the relationship between environmental quality – measured in terms of few environmental indicators and per capita income of a country. What exactly is an EKC? EKC is a simple graphical representation of the measure of environmental quality and per capita income or GDP of a country considered for the study. A generic EKC is shown in Figure 2.1.

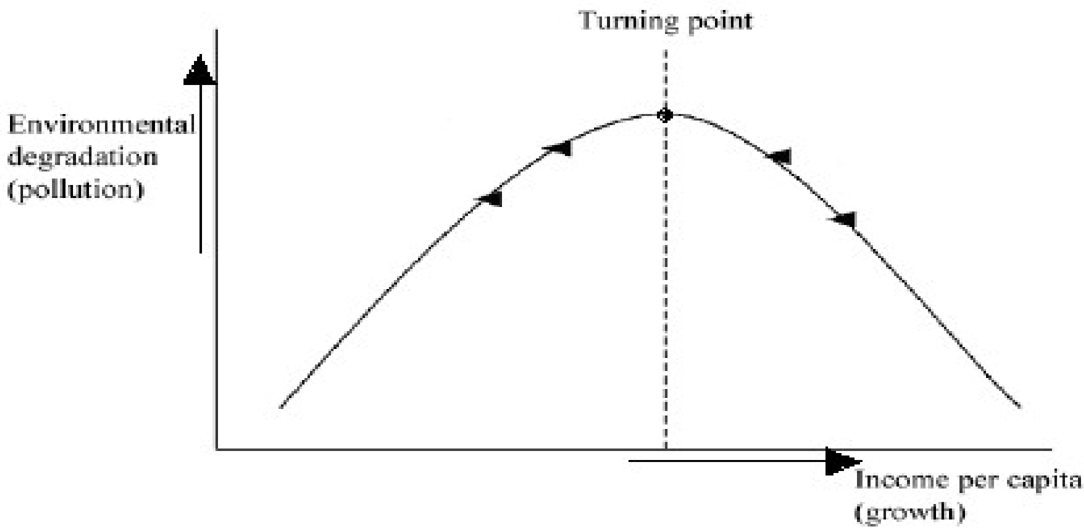

Figure 2.1: Generic EKC
Source: Yurttagüler, İ., & Kutlu, S. (2017)

Grossman's and Krueger's EKC was a consequence of the debate regarding the North American Free trade Agreement (NAFTA). The agreement was not supported by the opponents with arguments ranging from relocation of manufactures to jobs going south. "US would succumb to a dramatic race to the bottom" suggests **Lipford, J. W., & Yandle, B. (2010)**. The focal point of the debate was related to environment being a luxury for hungry stomachs and a necessity for the rest. It was amidst this ongoing saga the duo decided to establish some relationship between income growth and environmental quality to give an empirical basis to NAFTA.

Their study could successfully establish the relationship which supported the notion that lower income countries exhibit higher levels of air pollution whereas higher income countries are associated with lower levels of air pollution. They termed this relationship as inverted-U hypothesis. They could identify the turning points of GDP where this race to bottom ended and race to top begins. Coincidently Mexico's per capita GDP fell within this range resulting into higher GDP and better environmental quality.

A decade later the debate regains its popularity and reemerged during the 2008 presidential campaign. Candidate Obama was very well supported by organized labour and the environmental community as they were assured that he would not reopen the NAFTA. The post NAFTA analysis of Mexico shows a somewhat improvement in growth and deterioration in environmental quality.

Increasing concerns of the environmental advocacy groups in the United States over linking trade liberalization with environmental degradation resulted into a historic research by Grossman & Krueger (1991). In an attempt to answer host of questions posed by environmental groups they went on to explain the relationship between economic growth and the environment using three variables; Dark matter, SO_2 (Sulphur dioxide) and SPM (suspended particulate matter). The major concern was over environmental degradation due to trade liberalization through, North American free trade agreements between the U.S and Mexico. Due to non-availability of systematic data on pollution, they kept their findings tentative. They examined the economic growth – environment relationship in a cross-section of countries and found that economic growth tends to alleviate pollution problem once a country's per capita income reaches about $4000 to $5000 U.S dollars. Not overlooking the benefit, a more liberal trade regime generates income growth in the economy.

Secondly, trade liberalization increases specialization in sectors that cause less environmental damage. More labor-intensive and agricultural activities require less energy inputs and generate less hazardous waste per unit of output compared to capital-intensive sectors.

An important take away from their research is; environmental impacts of trade liberalization are country specific; it depends on effects of policy change on the overall scale of economic activity, change in the inter-sectoral composition of economic activity and the technologies used for production; elaborating the role of scale effect, composition effect and technological effect.

Shafik and Bandyopadhyay (1992) observed a comprehensive range of ten environmental indicators and the significance of ten policy variables for examining the relationship between economic growth and environmental quality. Income, consistently, has the most significant effect on all the environmental indicators. Most environmental indicators deteriorate initially with rising income with a few exceptions. But many indicators improve as countries approach the middle income levels.

They found that even in lower income countries certain environmental indicators were taken care of; one that had higher private and social benefits, for instance water and sanitation. As these countries moved to increased income levels, the indicators became relatively costly to abate and imposed an external cost.

The environmental variables are characterized by linear, quadratic and cubic functional forms. The greatest linear income elasticity is for carbon dioxide emissions, as one percent change in income results in 1.62 percent increase in carbon dioxide emissions. At higher income levels, Sulphur dioxide and deforestation decline quickly and hence exhibits an inverted-U shape.

In the foundation research on environmental degradation and growth relationship Panayotou (1993) played an important role by again empirically validating the existence of EKC for developing as well as developed countries. He also derived the policy implications of such relationship for employment, technology transfer and development assistance. He chose to emphasize that the process of economic growth of an economy will bring about a change in the levels of environmental degradation only if it is the 'right' kind of growth (figure 2.2). It is inevitable to recover the initial resource depletion. The variables chosen are deforestation as a representative of natural resource depletion and Sulphur dioxide (SO_2), nitrogenous oxides (NO_X) and solid particulate matter (SPM) for industrial pollution. For testing, whether EKC exists or not with regard to deforestation, trans log functional form is used to test deforestation as a function of income per capita and population density. Similarly, using log quadratic function for

SO_2 , NO_X and SPM as a function of income per capita he tested the EKC relationship and was successful in validating the existence of EKC.

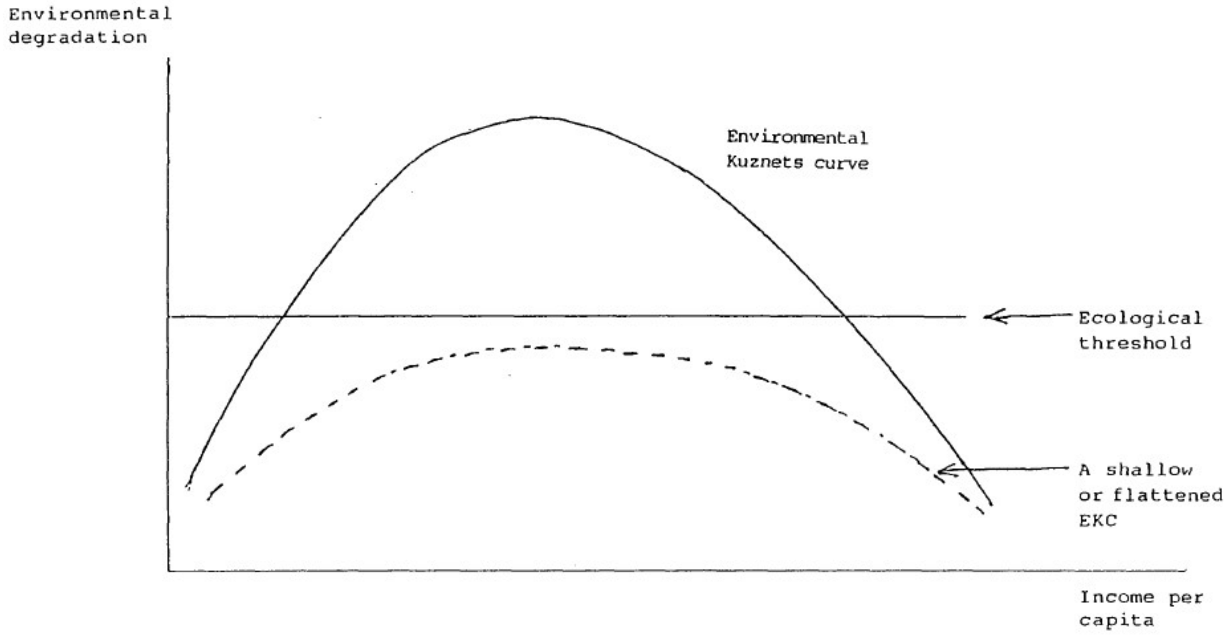

Figure 2.2: Environmental Kuznets Curve

Source: T Panayotou 1993

Implications for employment reveal that as labour movement takes place from agriculture sector to industrial sector, the burden on urban lands increases worsening the situation of public lands, infrastructure and solid waste scatters. This leads to a steeper and longer left leg of EKC and increases the probability of endangered ecological thresholds. Suggesting a cost effective solution to leapfrog the ecological thresholds Panayotou emphasizes three changes in the policy structure; removal of subsidies, reduction of protection for capital intensive industries and increased investment in education and training.

The case of technology transfer is more difficult than it is understood to be. The transfer of technologies at concessional terms by the developed countries to LDCs might reduce employment, intensify resource depletion and environmental degradation if the transfer is inappropriate. To overcome this, it is better to transfer information, know-how and skills to enable the LDCs to design the technologies best suited to their economic situation.

Krueger, A. B., & Grossman, G. (1995) re-examined the reduced form model with most comprehensive data available from different countries. There is no evidence that economic growth is harmful for the environment. However, initially the environmental quality worsens but later as the GDP levels increase and the economy reaches a critical level of income growth benefits the environment. An average income turning point estimated by them for different pollutants is around $8000 (1985 dollars). There are several interpretations pertaining to the results estimated by them. There is no reason to believe that improvement in the environmental quality at the income turning point will be automatic. The transition in the OECD countries suggests that there need to be policy responses induced by the demand for better environmental quality by the citizens. Secondly, it is possible that the improvement in environmental quality comes from imports of goods rather than producing domestically. If it is so, then this process will not go on forever, as after a certain point it would be difficult to find developing countries to relocate the dirty industries. Finally, the times when the transition took place the economic, political and technological patterns were different. The developing countries are now exposed to better information and technologies which can help achieve the turning point faster and lower than before.

Panayotou, T. (1997) attempts to answer few questions raised by some researchers in their work. The author rejects the claim that environmental quality improvement at earlier stages of income growth is automatic. Policy intervention is inevitable. This reduced functional form of EKC tends to improve the estimation technique by including the structural approach. Instead of level of income, he uses economic growth rate for the analysis and estimates that net effect depends on the magnitude of the pollution levels in the economy and extent of abatement efforts. The study identifies four factors that affect the environmental quality in the structural approach: scale of the economic activity in the economy, the composition of economic activity, the level of demand for environmental quality and the supply of environmental quality in the economy. To capture these factors the study identifies GDP per square kilometer, industry share in GDP and GDP per capita as new variables to be included in the cubic functional form. The results decompose the underlying process in the income-environment relationship. The panel regression using fixed effects model estimates that expansion of scale of the economy increases the SO_2 concentrations and abatement efforts reduce it. The structure of the economy also impacts the SO_2 concentrations positively. The study concludes that genuine abatement efforts through efficient environmental policies would enable the sync between economic growth and environmental quality. By efficient policy the author means secure property rights, enforcement of contracts and effective regulations that can help flatten the EKC curve.

Dasgupta, S., Laplante, B., Wang, H., & Wheeler, D. (2002) compares the EKC status (year 2000) of the developing and developed countries of the world. On one hand, the developing countries have income per capita not more than $3000 while the developed countries on the other hand have already crossed the EKC turning point range of $5000 to $8000. The developed countries face a dilemma whether to restrict their trade & investments and move back to autarky and rely on the pessimists, or do with higher pollution levels in the process of unrestricted globalization.

Initiatives taken in order to better investigate this issue are: a) the need for more environmental data for efficient empirical analysis has prompted World Bank and the United Nations to sponsor environmental data collection till date. b) Another initiative is regarding collection of “criteria” pollutants such as ozone, carbon monoxide, suspended particulate matter etc., because the legal statutes demand it from the regulators c) the curvature of the EKC is an issue discussed widely as the results of higher order polynomial varies across countries. d) it is more useful if the environmental data is available for a country over the long run time period because the cross-section estimation techniques have generated spurious estimates of the EKC.

Webber, D. J., & Allen, D. O. (2010), attempts to investigate whether there is any consistent empirically identifiable relationship that exists between environmental degradation and income/GDP growth of the economy. With “going-for-growth” approach to solve the environmental degradation problems, some researchers believe that it is better to accelerate the growth process than to frame the environmental policies because higher growth might achieve economic as well as environmental goals whereas policies could hamper growth.

Empirically, the turning points of various pollutants have been significantly different and controversial in explaining the EKC relationship. The estimation techniques have been employed the investigation have a lot of variety. A standard single-equation model, reduced form fixed and random effect model are very common approaches in EKC literature. The most important assumption of unidirectional causality from income to environment which when relaxed can create technique issues.

This review concludes that "there is no single relationship between income and environment quality and the rate of environmental degradation"(Webber & Allen, 2010).

Khajuria, A., Matsui, T., Machimura, T., & Morioka, T. (2012), focuses on empirical evidence of decoupling economic growth and municipal solid waste management in India. The study analyses growth of GDP with municipal solid waste management from 1947 to 2004. The environmental situation of developed countries where with economic growth reduced pollution and less developed countries where economic growth increased pollution was observed. Thus, environmental degradation is expected to be temporary and with economic growth pollution indicators may decrease.

The regression results evidently show that with economic growth the turning point for solid waste generation was reached in 1997. The analysis used GDS (gross domestic savings) instead of GDP as it increases only after the investment recovery from the industrial production. The savings reflect the capacity of the economy to pay for the environmental recovery of the economy. The results can be robust as only two samples exist post turning points.

Carson, R. T. (2009), reviewed the EKC hypothesis in order to find out how it came about and what should be salvaged. Carson associated the EKC with pre-EKC literature that relates Impact (I) to Population (P), Affluence (A) and Technology (T). Popularly known as IPAT equation (I=PAT). It is a mathematical notation of formulae that describes the impact of human activity on the environment. The expression equates human impact of environment to Population, Affluence and Technology. It was an outcome of a debate between Commoner, Ehrlich and Holdren in 1970. Commoner put forward an argument that change in the production technology following World War II was the primary cause of environmental degradation. Ehrlich and Holdren emphasized the role of all three factors with population being the most important.

A similar question was raised: does economic growth need to slow down or stop to avoid increasing damage to environment. The EKC debate never referenced the IPAT or Club of Rome debate. But both the studies are prey to the same criticism that the model is misspecified and data availability is poor. The popular view that "economic growth is key to protect the environment" is still open to criticism. However the problem of EKC is inadequacy of the reduced form model to explain the causes underlying the phenomenon and the assumption of causal role of income growth.

Grossman and Krueger actually did not study Mexico city's air pollution. Instead it was their biggest assumption that something could be learned about pollution from Mexico's increasing income from a reduced form model. The analysis was performed using U.S. input-output tables and associated pollution if some sectors shifted to Mexico.

The initial criticism to the EKC view was related to the number of countries included in the sample. Later in an effort to increase the applicability of EKC it became clear that due to certain country specific characteristic the data was not comparable across countries. It was Carson, Jeon and McCubbin (1997) who extended the sample to 50 U.S. states increasing the reliability of the data. The estimates were as expected; air pollutants other than CO_2, would monotonically decline with income. The regulatory and technology factors explained the reduction in emissions in higher income countries and lower income countries respectively. Another research study by List and Gallet (1999) concluded that to force different states into a single underlying process would be statistically rejected. Owing to this, pooling OECD and Non-OECD countries in a standard EKC regression would reject the statistical test.

For developing countries the result of EKC were rejected outright, denying any relationship of economic growth with environment. The dependent variable in the EKC relationship has been very controversial. The results have varied across pollutants, countries, time line etc. This has questioned the existence of the EKC hypothesis time and again.

Furthermore, a plethora of traditional as well as modern and advanced statistical techniques together could not ascertain the reliability of the EKC hypothesis. The choice of air pollutant indicator has also been criticized. It was the availability of data on SO_2 emissions from GEMS, which was country specific, that became the poster child of EKC relationship. As CO_2 is more of a global than local indicator, it is easy to reject EKC hypothesis.

Panayotou, T. (2016) observes that growing economic activity in the world necessarily means increasing extraction of natural resources as it requires larger inputs of energy and material. This also leads to accumulation of waste and concentrations of pollutants burdening the carrying capacity of the biosphere. So the tradeoff between economic growth and environment, on one hand, argues to reduce the economic activity to sustain the environment while on the other hand, it is argued that the easiest route to save environmental degradation is economic growth.

This argument emerges from the environmental Kuznets curve hypothesis which states that with higher levels of income the demand for environmental friendly goods and services increases which leads to better environmental quality. However, there are others like Shafik and Bandyopadhyay (1992) and Grossman and Krueger (1993) who hypothesized that the improvement in environmental quality along the growth path is not fixed for each country. They argue that the characteristic of the country places an important role in doing so. As the economy moves along a development path and resource extraction intensifies, the economy gradually moves towards industrialization leading to larger environmental degradation. At a certain level of development with better technology and techniques of production the economy gradually moves towards service based industries reducing the environmental degradation and leading to better environmental quality.

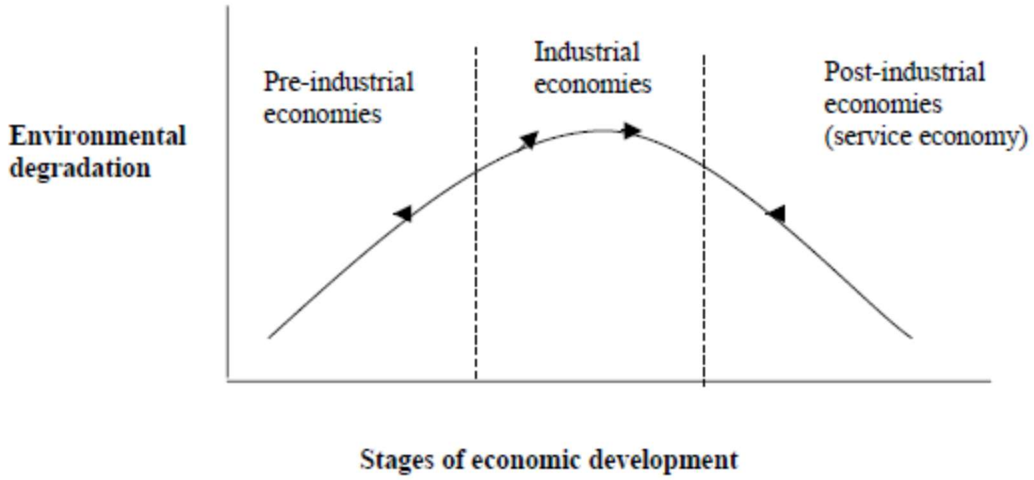

Figure 2.3: The Environmental Kuznets curve: a development-environment relationship Source: Panayotou, 2003.

A change in the slope of the curve has critical implications for policy. The change in environmental quality due to economic growth is not automatic. Initial increase necessitates stricter environmental regulations to ensure sustainable growth. And the later decline of the curve implies that developmental policies encourage changes in the environmental quality and no explicit environmental policy is needed. The offshoot created by this hypothesis is that the damage done to the environment in the short and medium run is questionable. The hypothesis owes an answer to many analytical questions that arise in the process of the inverted U shape curve. Some of them being: 1) what is the level of income that is considered a turning point? 2) How can the damage in the short and medium term be avoided? 3) Is this automatic? No other initiative is needed to decouple environmental degradation from economic growth.

Panayotou attempts to answer these questions in his research and supports them with empirical evidence from the experience of ECE region. It consists of 55 member countries divided into developed market economies and transition economies. The per capita income ranges from US $1,000 to US $ 30,000 with poor economies in the lower range and developed economies in the higher range.

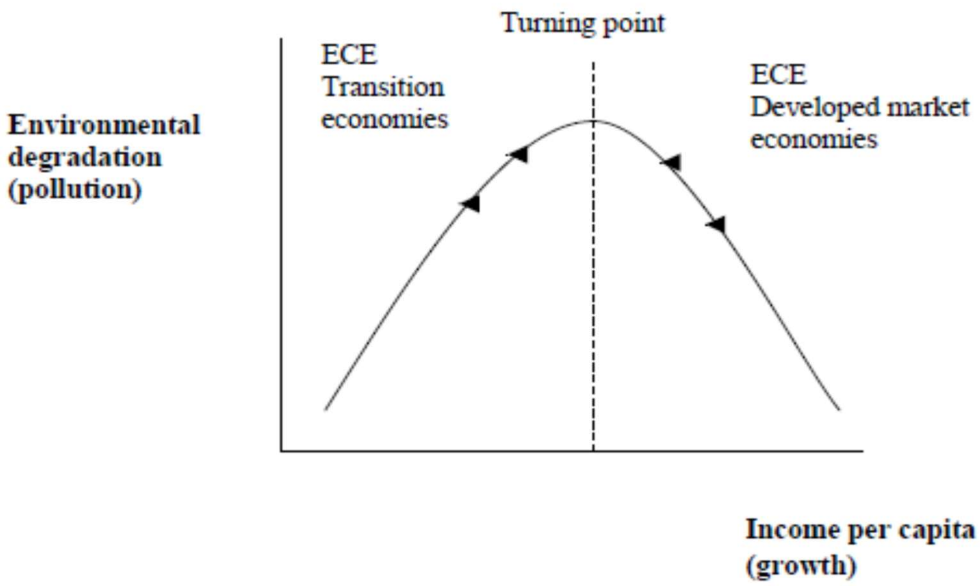

Figure 2.4: EKC of ECE region

Source: Panayotou, 2016.

The lower per capita income countries fall on left side of the curve and higher per capita income countries on the right side of the curve. The improvement of transitional economies can only take place with movement from left to right side of the curve. This is possible only if the transition countries can decouple the environmental pollution from economic growth.

The structural, technological and policy changes can help this transition of the economies. The most sustained decoupling can only be done through inclusive environmental externality. On the contrary, the developed market economies resort to environmentally harmful subsidies that encourage negative externalities. Thus, transitional economies end up paying a higher environmental cost for economic growth. This is the cause of the mere characteristic of transitional economies that is in stark contrast to the developed economies in terms of population and the process of convergence. Hence, some external forces are needed to fasten the process of convergence that will decouple the environment and economic growth of the economies. Such support from external factors is needed on the technological front too. Even though the decoupling process of environment and economic growth in developed economies is accomplished their unsustainable consumption patterns are still significant. While concluding, Panayotou highlights the initiatives that these countries can take to help decouple the environmental pressure off economic growth in both group of countries. These initiatives are in the form of: effective mix of economic instruments, efficient resource use, and specific policy initiatives, strengthening social and legal rights in the economy.

Borghesi, S. (1999) has structured his research by discussing the conceptual background of the environmental Kuznets curve hypothesis in terms of three effects: scale effect, composition effect and technique effect. Based on empirical evidence on the relationship he draws conclusions from cross-country water and air quality indicators as well as single country studies in which he emphasizes that **effect of EKC in one country is due to impact of changes in developed countries. Therefore, there is scope for further research to understand the evolution of environmental degradation in single country over time.** Criticizing the EKC studies on the grounds of use of estimates rather than actual measures, sample selection bias, limitations of reduced form models he concludes that simultaneous equation model may be appropriate to study the EKC relationship. He also questions the validity of the functional forms used to analyze the EKC. The cubic functional form implies plus or minus infinity as income increases and quadratic functional forms implies that environmental degradation will tend to zero or even negative at higher income levels. Hence, better techniques are needed for the analysis. Based on the analysis of earlier studies, he concludes that more research using time series technique to determine the pollution trajectory of each country should be used.

Roberts, J. T., & Grimes, P. E. (1997) critically examined the relationship between economic growth and environmental quality through stages of development of countries. His findings suggest that the inverted U-curve for carbon emissions intensity is the effect of small number of countries becoming more efficient in resource utilization. That is rather than passing through stages of development to reduce carbon emissions the historical data give an insight that only few countries could actually achieve a certain per capita income to achieve development in true sense. Other countries, presently in their developing stage would not be able to achieve this as they are structurally limited and many have colonial history.

So the dependence of countries to achieve a certain per capita income to reach a particular stage of development that will support the improvement in efficiency and fall in carbon emissions can be disastrous. Though not fully supported by evidence, the pollution haven hypothesis seems to be true. The shift of dirty industries from first world countries to third world countries to avoid the stringent environmental regulations is supported by anecdotal evidence. This can only be corrected if some proactive and explicit approach is developed towards improving environmental quality. Owing to the realization that it is cheaper to avoid environmental damages than cleaning them later.

Stern, D. I. (2004) lists proximate factors that explain EKC: a) scale of production b) output mix c) input mix d) state of technology involving production and emissions efficiency. The chronology of econometric framework suggests that earliest functional forms were simple quadratic functions of the level of income with the assumptions that though the level of emissions might differ, the elasticity is same at all given levels of income. Generally this model can be estimated through panel data fixed effects and random effect models. In fixed effects the alpha and gamma are treated as regression parameters; they are treated as components of the disturbance term in random effect models. The assumptions of the fixed effect model make it less reliable to predict the future of the developing economies based on the result of developed economies. Stern confirms the neglect of failure of orthogonality test. Also the integration and the cointegration of the regressions have been ignored.

The difference between early studies and the recent studies lies in the availability of data and the various permutations of variables and results mined from it. The earlier studies show positive relationship between economic growth and pollutants (especially local pollutants) whereas the recent studies find a monotonic relationship. Though variables included are significant, testing variables individually is subject to omitted variable bias.

Stern also tries to unfold the theoretical critiques of this inverted U hypothesis from the fundamental studies. He highlights the assumption that environmental damage does not reduce economic activity. As the income is not normally distributed the expectation that environmental degradation should decline is another assumption away from reality.

Stern has narrowed down four issues of econometric techniques used to analyze the environmental Kuznets hypothesis, such as heteroscedasticity, simultaneity, omitted variable bias and cointegration issues.

Holtz-Eakin, D., & Selden, T. M. (1995) forecasts the emissions of carbon dioxide (CO_2) and income to analyze the relationship between pollution and economic development. They adopt an intermediate approach where they estimate a reduced-form model to estimate relationship between per capita income and emissions with a panel of country-specific data for 1951-1986.

While on, the one hand, the relationship discusses the economic growth to be the solution to the environmental problems of a country, on the other hand it emphasizes the differences between the various pollutants studies earlier and peculiarities of greenhouse gases. That is, in cases of greenhouse gases the relationship examined will rise monotonically with income instead of declining at higher per capita income. Thus, CO_2, being one of the most important greenhouse gas, is studied to understand the income-emissions relationship.

Their estimates and forecasts yield four critical results: a) The marginal propensity to emit CO_2 diminishes as economy develops b) Despite the diminishing marginal propensity to emit the forecasts indicate an annual growth rate of 1.8% increase in global emissions of CO_2 c) As most of the world's population is concentrated in the developing economies they tend to offset the reductions in CO_2 emissions by the developed countries d) And lastly the sensitivity analysis suggests that pace of the development does not affect the flow of CO_2 emissions.

Hettige, H., Mani, M., & Wheeler, D. (1998) examine the Environmental Kuznets curve relationship between industrial water pollution and economic development using share of manufacturing in total output, the sectoral composition of manufacturing and intensity of industrial pollution at the end-of-pipe as the determinants of pollution and its effect on income growth. Using random effects model the manufacturing share in the national output is consistent with an inverted-U Kuznets hypothesis. The results show that manufacturing share rises with income till the countries reach middle-income status and then declines gradually with higher income levels. The changes in sectoral composition of pollution intensity show small but significant upward shift in the curve. In the context of end-of-pipe pollution intensity it is observed that Food and Paper industries have highest average organic water pollution and Metals and Mineral products have the lowest average organic water pollution. The income elasticities of labour-intensity and pollution-intensity is -1(minus one). That is, the pollution/labour ratio is constant. The combined result of the three pollution determinants do not follow Kuznets curve trajectory. Estimating water pollution trends for fifteen major industrial countries it is evident that emissions are stable in OECD countries; moderately increase in newly industrial countries and rapidly increase in less developed Asian countries.

He, J. (2007) studies the applicability of Environmental Kuznets curve to developing countries. Environmental degradation is considered an unavoidable stage of economic development meaning, to necessitate pollution abatement activities after achieving a certain level of income, a country has to emerge through a temporary phenomenon of high pollution. The various interpretations of EKC hypothesis in his research are categorized as: the most optimistic spectrum argues that the easiest way to improve environmental quality is to grow with and transient environment deterioration; the pessimist spectrum argues that the inverted-U pattern is purely due to “trade liberalization” justifying with the help of “pollution haven” hypothesis; and the neutral spectrum argues that inverted-U captures only “net effect” of income-environment relationship. The study also compares the existing EKC empirical analysis and categorizes it into: a) choice of time period b) country sample c) estimation functions and d) methods of analysis. Elaborating it they suggest that the turning points of developed countries are much lower than the turning points of developing countries. This leads to inaccurate prediction for developing countries. Another variable in question is whether the studies on EKC consider emissions or concentrations. Concentrations have more direct impact on productivity and health and it is easier to obtain an inverted-U hypothesis.

The study lists the shortcomings of models used in EKC literature: a) Most of the literature ignores that there can be simultaneity and feedback effects between economic growth and pollution b) cross-country static relationship ignores the assumption that sample countries follow same income-pollution trajectory c) one of the assumptions of the relationship is that it is valid only for pollutants involving local short term costs but not for pollutants involving long-term and more dispersed costs.

The study finally concludes that each country has its own specific sustainable development path depending upon its characteristic and acknowledges that there is no one-fit-for all growth pollution relationship.

Selden, T. M., Forrest, A. S., & Lockhart, J. E. (1999) examine the reductions in U.S. Air pollution emissions through five effects- U.S. criteria pollutants, Particulate matter (PM), Sulphur oxide (SOX), nitrogen oxides (NOX), non-methane volatile organic compounds (VOC), carbon monoxide (CO) and lead (Pb). The U.S. air emissions trajectory follow an inverted U- shaped curve explaining an increase and then a decline in the emissions as a country progressed (already a developed country). The time period considered for observation is from 1970 to 1990. The authors discuss the competing explanations of inverted-U trajectory ranging from shift in the composition of economic activity to economic growth, global energy prices and increased environmental regulations. In the process of identifying the source of emission reductions they believe five effects can give some details on the emission reductions in U.S. These effects are: scale effect, composition effect, energy-intensity effect, energy-mix effect and other technique effect. They conclude that change in composition of the U.S economy was not sufficient, though offsetting a few emissions, to offset per capita growth in GDP. Instead the changes in energy intensities had greater impact on emissions reduction than composition effect. The changes in energy mix impacted the least. These four effects together could offset growth at the per capita level for SOX and CO only.

Dinda, S. (2004) gives an overview of the EKC literature, background and history. He compiles the conceptual and methodological critiques. He begins with the argument required attention should be given for multiple factors that can be a part of this EKC relationship rather than a single factor. This can only be done if underlying causes can be determined which is impossible with the use of reduced form models. Absence of an understanding regarding the underlying process causes simultaneity bias since both are endogenous variables impacting each other. Secondly, many researchers argue that EKC is not a short term process; it is a long term transition that takes place in the economy. But the author believes in re-linking hypothesis. In the long run a so-called N-shape curve, instead of inverted-U, is exhibited as income-environment relationship again turns positive. Thirdly, the inability of the EKC hypothesis in determining industrial share of output and industrial water pollution relationship leads to increased debates about the existence of EKC. Fourthly, majority of the world's population is on the upward sloping portion of EKC which makes it difficult to believe that income growth across the global population will benefit the environment.

Lastly, the most important critique is related to the methodology adopted by the plethora of empirical studies of EKC. Most of the EKC studies have used cross-section data for estimation. The basic assumption that these countries display uniform social, economic, political and environmental conditions is invalid. This justifies the use of time-series data and individual country analysis. The robustness of EKC is debatable due to absence of estimation of structural models to understand the mechanism.

Dinda, S. (2006) examines the factor endowment and pollution haven hypothesis that explain how free trade/globalization impacts the environment of a country. He uses a panel data of 54 countries divided into three groups of OECD, Non-OECD and world group to test the impact of the basic characteristic of the economy on the CO_2 emissions and in turn on the environment of the country. Investigating the PHH (Pollution haven hypothesis) he argues that it is a natural tendency of a pollution intensive country to migrate to a lax regulatory environment. It is encouraged with free trade as MNCs can easily relocate their polluting industries. Gradually this works to the comparative advantage of the developing countries and they become pollution "haven" for developed countries. Consequently the free trade or globalization regime impacts negatively the environment of developing countries. On the other hand, FEH (Factor endowment hypothesis) emphasizes that it the difference in factor endowments that determine trade between countries. The comparative advantage of a country governs the composition of its trade. Thus a capital abundant country specializes in capital-intensive exports and a labor abundant country specializes in labor-intensive exports. This happens due to stimulus that these industries receive due to free trade. Variables like per capita real GDP (PCGDP), capital labor ratio (K/L) ratio, trade openness, population, relative income, relative capital ratio and time trend are incorporated in the equation to estimate a model by both fixed effects and random effects technique.

Dinda concludes that net emissions increase due to globalization as it reduces emissions marginally in OECD countries and increases in non-OECD countries. Hence countries with higher K/L ratio switch to cleaner production techniques compared to other countries.

Managi, S., & Jena, P. R. (2008) use determinants of environmental productivities to examine an environmental Kuznets curve relationship between environmental productivity and income. The research makes use of state-wise gross domestic product (GSDP) of 16 states of India. The environmental productivity determinants include the market input/output and environmental input/out to measure productivity. The measurement is based on an index that is calculated from these two data points. The total factor productivity (TFP_{ENV}) measures productivity changes in technology and efficiency. The expectation from higher income states is that they are more sensitive in implementation of environmental regulations following the EKC literature. The results show that environmental productivity of SO_2 indicates increased implementation of environmental regulations over time whereas for NO_2 the results are quite contrary raising questions on implementation efficiencies of the state. The results of SPM (suspended particulate matter) are similar to that of NO_2. The results evidently conclude that environmental management is not satisfactory and unless environmental practices are initiated the consequences might be dangerous.

Moomaw, W. R., & Unruh, G. C. (1997) developed two methodologies for analyzing the type of countries that he classified for the study. The study covers a period from 1950 to 1992. The data on CO_2 emissions per capita and real per capita GDP is utilized for the analysis. The authors of this study classify countries into three types. Type 1 countries which pass through a discontinuous transition from strong correlation to that of weak. These are OECD member countries. Type 2 countries are present and former centrally planned economies that show a reduction in CO_2 emissions as income declines. Type 3 is a group of "chaotic" countries which show no consistency in the relationship between economic growth and CO_2 emissions.

The study utilizes data of Type 1 countries to analyze the relationship between CO_2 emissions and economic growth using two methodologies. One of the methodologies is use of Econometric modelling approach. They test two functional forms under this approach. A) Traditional EKC model. B) Structural transition model. To test the traditional model they use the following equation: $Yit = b_0 + b_1Xit + b_2Xit^2 + b_3Xit^3 + eit$, where i = 1, . . . N countries t = 1, . . . T years, Yit = CO2 emissions per capita, b0 = country specific intercept, Xit = real GDP per capita, eit = an error term. The presence of cubic term clearly influences the results to an N- shaped curve of EKC, i.e., the emissions again begin to rise after reaching a trough. The first turning point ($12,813) is low as compared to the previous studies and the second turning point ($18,333) is not far from the first one. The policy implication of this result is to keep the real GDP confined between $12,813 and $18,333. To test the structural transition model the researchers run a piece-wise linear spline function from 1950 to 1973 and 1974 to 1992. $Y_t = b_0 + b_1X_t + e_t$ where, t = 1. . . T years, Y_t = CO2 emissions per capita, b_0 = country specific intercept, X_t = GDP per capita, e_t = an error term. The results of the above function indicate that there is positive emissions elasticity in the first period but negative emissions elasticity in the second period. This transformation in the relationship is not due to the unique turning point but as a result of historic exogenous events in 1973. The researcher explains that there is an inextricable link between the transformation in the variables and the oil price shock of 1973. The use of fossil fuel energy intensity decreased the economic activity of OECD countries post 1973.

One can interpret from the nonlinear dynamics of the above model that the economy follows a regular path until a shock disrupts its trajectory. The shocks may take any form. Another interpretation is of the rate at which these economies can shift their trajectories post shocks. The economies that are unable to recover from the shock could not generate the EKC effect. Sustained economic growth is seen to be crucial to generate

EKC effect. These results can only be observed if long time series data is available for a specific country.

2.2 STUDIES ON DEMOGRAPHIC VARIABLES

Cropper, M., & Griffiths, C. (1994) investigate the changing role of population towards natural resources. The most popular theory that studies the population and environment relationship is that by the Malthusian population theory which states that population growth puts pressure on agricultural land which in turn lowers labour productivity. A modern view replaces agricultural land with that of non-renewable resources and states that natural resources limit the economic growth as they limit the productivity of labor. More recent views have changed the role that environment played in earlier theories. The environment is no longer limiting growth; instead it is now a factor whose quality deteriorates as the population increases. Population growth leads to environmental degradation as it exerts pressure on resources around them with increasingly more resources being overexploited. However, there is little empirical evidence that supports this argument. The researchers in their study attempt to observe empirical evidence on whether population pressures have significant effect on environmental degradation. Environmental degradation here is captured in terms of deforestation in 64 developing countries. The equation also includes rural population density and rate of population growth. Cropper and Griffiths highlight the causes of deforestation and population as being the underlying causes for all of them. Population pressure converts pastures to cropland and increases demand for wood and so on.

They use an unbalance panel for some countries for reduced form fixed effects model. They estimate the model for Asia, Latin America and Africa. The results are significant for Africa and Latin America. The insignificant result for Asia states the significance of Forest for this continent. For Africa, it is the rural density that shifts the EKC upward and for Latin America there is evidence of a hump shaped relationship.

In spite of these results, it is not only the population that exerts pressure on deforestation. In developing countries it is market failure that has created the problem of deforestation. Because in such countries property rights are not well defined, the costs incurred by individuals is almost zero.

Neha Khanna (2001) studies socio-economic factors including race, education, housing and propensity for collective action – Carbon monoxide, ozone, nitrogen oxides and Sulphur dioxide and particulate matter (PM_{10}). The research is based on 1990 ambient concentrations of five Clean Air Act criteria pollutants and data for U.S. census tracts. The preliminary analysis supports the EKC literature where pollution is found to be negatively related with income, education and propensity for collective action. Pollution is positively related to population density, proportion of minorities and unemployment rate.

She estimated two separate models. One in which the coefficients were estimated using weighted least squares with number of data points as the weights and two using ordinary least squares. The results were satisfactory and consistent for population density, proportion of minorities in the population and proportion of workforce employed in manufacturing. For all the three variables the coefficient is positive and statistically significant. Higher the population density higher will be the ambient concentrations and higher the proportion of workforce in the manufacturing worse is the air quality.

She concludes that the income variables are statistically insignificant, i.e. other things remaining constant changes in income are not related with changes in pollution levels.

Cole, M. A., & Neumayer, E. (2004) empirically examined the link between population size, other demographic factors and pollution by using more reliable estimation techniques that included, urbanization rate and average household size.

They use a stochastic IPAT model to examine the population-pollution relationship. The linearity (logged) between emissions and population implies the direct estimation of population on emissions only. For CO_2 the elasticity of emissions with respect to population is one across all population sizes. This result is contrary to other studies that estimate the same between 1.45 and 1.65. The difference in their result is justified with a better approach to deal with non-stationarity issue. Also in terms of CO_2, urbanization rate and average household size are significant determinants of emissions. The demographic trends also suggest that the rising share of global emissions will be accounted for by developing countries. The reason being the difference in the demographic factors of developed as well developing countries.

Sadorsky, P. (2014) examines the effect of urbanization on CO_2 emissions with modern estimation techniques- CO_2, Affluence, population and urbanization. The study attempts a dynamic framework to model the impact of urbanization on carbon dioxide emissions. The panel regression technique allows for homogeneity in the estimation of the slope coefficients. He uses a Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) model to explore the relationship in emerging economies and the estimated coefficients on affluence and energy intensity are similar across different estimation techniques. The estimated coefficient on urbanization is sensitive as it varies according to the estimation techniques. Omitting urbanization will have less impact on the emissions reduction strategies or policies because it can have both positive and negative impact on natural environment.

He concludes that the most direct way of carbon dioxide reduction for emerging economies is to work on affluence (natural log of real GDP per capita), population and energy intensity.

Martínez-Zarzoso, I., Bengochea-Morancho, A., & Morales-Lage, R. (2007) use panel data regression fixed effects model to analyze the impact of population growth on CO_2 emissions in European Union countries. The degradation caused to environmental resources due to production and consumption activities aggravates with rising population. The authors use an econometric model to decompose emissions into scale effect, composition effect and technique effect. The variables used to investigate the above effects are: income per capita, population size, industrial structure and energy intensity. The data is divided into two groups: old EU countries and EU recent accession countries (countries that joined EU in 2004). The results of both groups vary significantly. While the old EU countries have lower explanatory power of some of the variables due to change in emissions structure in countries like UK and Germany, the results of recent accession countries are significant. The major difference between the two groups is population. The emissions-population elasticity of old EU members is much lower than the recent accession countries. Specifically the change in population in developing countries was seen to cause greater impact on population as compared to developed countries. The researchers find that emissions-population elasticity vary from 0.83 to 1.58. The developed countries have lower elasticity as compared to developing countries. The result of mixed group show unitary elasticity.

2.3 STUDIES ON ECONOMIC VARIABLES

Grossman, G. M., & Krueger, A. B. in 1991 presented their findings at the conference on the U.S.-Mexico Free trade Agreement which brought a new wave of research that contemplated the relationship between economic growth and environmental degradation. Environmental degradation in Mexico was already on the rise due to weak environmental regulations and then the authorities got into trouble with new free trade agreement between U.S. and Mexico. The environmentalists voiced their concerns over NAFTA (North American Free Trade Agreement) with arguments of expansion of markets leading to inevitable pollution and depletion of natural resources on one hand and worsening pollution due to free trade on the other. Some quoted the experience of the "Maquiladora" sector in Mexico. Some concerns were related to challenging the regulatory standards of the U.S. Scared of less stringent regulatory framework to maintain international competitiveness, the environmentalists were worried of the regional terms of trade.

Emphasizing the need for theoretical as well as empirical studies the research attempts to answer a lot of questions through three separate mechanisms namely scale effect, composition effect and technique effect. If the economic activities rise due to trade and investment liberalizations then pollution is bound to increase as per scale effect. Often the countries tend to specialize in sectors where they enjoy a comparative advantage over other countries. If this advantage is due to difference in the stringency of environmental standards, then trade liberalization increases environmental damage as per composition effect. The change in the technique of production of output post trade and investment liberalization is what is called the technique effect. This can be the consequence of two things: either transfer of modern technologies to local economy or people demanding better environmental quality consequent to higher income levels. In their research they empirically explored the likely impacts of a NAFTA on the pollution levels.

Grossman and Krueger use cross-country sample of comparable measures of pollution to examine the relationship between economic growth and urban air pollution. Using **UNBALANCE** and unrestricted panel data they conclude that a cubic functional form of GDP per capita would give better results. The equation includes dummies for location, method of measurement, coastline location, and communist government. The equation also includes a linear time trend. The regression equation for suspended particles and dark matter is similar except for the method of measurement dummy. The implication of the results of the random effects model concludes that air quality has deteriorated with economic growth in Mexico. The situation is quite likely in poor countries and when a country reaches a certain level (US $5,000) of per capita income the relationship between environmental degradation and economic growth ceases. Thus, further increase in economic growth in Mexico will result in intensification of pollution abatement policies.

If the stringency of environmental standards in both the countries differs the country with lower pollution controls has an advantage to attract business and relocation of industries from U.S. to Mexico. The concept of "pollution haven" was empirically tested to bring about change in pattern of trade as a result of environmental regulations. Using pollution abatement cost data they test three sets of relationship: U.S. imports pattern from Mexico in 3-digit SIC manufacturing industries, pattern of offshore assembly provisions and the sectoral pattern of value added by maquiladora plants in 2-digit industry category. Neither are the coefficients strong enough to be significant nor do the variables have a positive sign to establish a relationship. Relative factor supplies govern the pattern of trade between Mexico and U.S.

Addressing the resource reallocation issue they investigate whether trade liberalization stimulates, production in unskilled-labour intensive industries or whether production may expand in capital and skilled labour sectors if foreign firms bring in scare resources in Mexico. As Mexico is more on the "cleaner" side of production activities, the reallocation may result in reduction of pollution. On the other hand, U.S. might specialize in physical and capital-intensive activities to harming the local environment. Overall a net effect may lead to a movement from lax regulatory framework to a more stringent one.

The conclusion of their research can be summed up as "The environmental impacts of trade liberalization in any country will depend not only upon the effect of policy change on the overall scale of economic activity, but also upon the induced changes in the inter-sectoral composition of economic activity and in the technologies that are used to produce goods and services" Grossman, G. M., & Krueger, A. B., (1991).

"It is possible to "grow out of" some environmental problems, but there is nothing automatic about doing so" (Shafik, N., & Bandyopadhyay, S., 1992). The research attempts to answer a host of questions by exploring the relationship between economic growth and environmental quality by analyzing the change in environmental quality at different stages of development using eight environmental indicators and panel regression analysis.

Discussing the pattern of environmental degradation they emphasize that countries act upon the environmental problems that have lower cost and higher (social and private) benefits first. The assumption that poor countries do not act at all is not correct. They are concerned about the environmental problems most relevant to their stage of development. Later as the economy develops the environmental problems that are relatively expensive to abate are taken care of. The optimality of environmental degradation is to be analyzed in terms of intergenerational well-being, technological possibilities, and environmental regeneration rates.

The independent variables included are: income per capita, investment as a share of GDP, growth of real income, electricity tariff, trade share in GDP, parallel market foreign exchange premia, dollar's outward orientation index, debt as a share of GDP, political rights index and civil liberties index. Of these, income has the most significant effect on all indicators of the environment. There is evidence that high investment rates and rapid economic growth impact natural resources negatively. Better technology leads to improvement in environmental quality. Trade, debt and political environment fail to create any generalized effect on environmental quality. They conclude by citing that the results are inconclusive.

Panayotou, T., Peterson, A., & Sachs, J. D. (2000) test the strength of the inverted U shape of the Environmental Kuznets curve using time series data rather than cross section and explore the role of structural change in the environment-income hypothesis. Using CO_2 emissions per capita, Income per capita and Gross non-residential capital stock per unit of GDP, the study examines the structural change hypothesis in that as economic growth takes place, countries move from low-polluting agriculture to high-polluting industry and back to low polluting services. The study attempts to examine eight different models with a variety of variables such as non- residential capital per unit of GDP, controlling for population density, including international trade and later including an interaction term between trade and GDP. The time period considered is from 1870-1990 which is broken into three sets of 40 years each.

They conclude that in the early stages of development, capital accumulation results in increasing emissions and as the country industrializes emissions fall and later become negative as in the post-industrialization period. The results for trade are consistent with the "pollution-haven" hypothesis. In his words "trade cannot explain away the EKC for CO_2 emissions even if it contributes to it". Lastly they emphasize on looking for development and energy paths that limit growth of developing countries.

Gamper-Rabindran, S., & Jha, S. (2004), investigate the relationship between removal of trade barriers and its impact on the change in the composition of manufacturing output during pre and post liberalization period in India. They went on to test whether there is a shift in production and exports towards "dirty" industries due to greater inflow of foreign direct investment into dirty industry as compared to clean industries. They use the Cobb-Douglas production function to estimate domestic manufacturing. Pollution is considered as an input into the production process. Firstly, the total output added by manufacturing, from capital intensive as well as labour intensive industries is measured across time. Secondly, utilizing 3-digit NIC level manufacturing data, they measure changes in exports from capital intensive or labour intensive industries. And finally they measure inflow of FDI in dirty compared to clean industries in the post-1991 period. The study uses fixed effects model and binary probit regression technique.

They conclude that foreign direct investment grew in the more polluting sectors post liberalization. Specifically, trade liberalization increased exports from industries that utilized water and air as input variable. Also, foreign investment was higher in such industries and the coefficients on air and water are positive and significant. An important limitation of the study is the use of pollution measures from the US as proxies for Indian pollution-intensity data**.**

Cole (2004) examines the evidence for pollution haven hypothesis (PHH) and its relevance to air pollutants and water pollutants. He uses NO_2, SO_2, CO, SPM, VOC,CO_2 ,BOD, Dissolved oxygen, Nitrates and Phosphorous. Net exports as a proportion of consumption (NETXC) is calculated for four trade pairs (USA-Asia, USA-Latin America, UK-Asia and Japan-Asia). The sectors included are from the UN industry classification ISIC (International Standard Industrial classification). This analysis suggests that pollution havens, if formed, are temporary and are limited to certain regions and sectors only. The study also undertakes the EKC analysis for 6 air and 4 water pollutants to analyze the effect of income, trade openness, and structural change and trade (dirty) between developed and developing countries. Trade only partially explains the emissions and all pollutants were found to be statistically significant. Two important highlights of the study are: the share of manufacturing output in GDP has a positive statistically significant relationship with pollution and trade openness exhibits a negative relationship with pollution. It also raises a question whether the present developing countries can expect a decline in their share of manufacturing and experience a fall in emissions over time.

Yandle & Lipford (2010) attempt to assess the post-NAFTA experience of Mexico. In terms of improvement, the access to clean water rose to 97% of the population and sanitation to 79% in 2004. During this decade Mexico's real GDP per capita increased to $10,208 from $8,582 which established some evidence for EKC hypothesis. The entire water quality indicator performed poorly. Similar results have been found for the other indicators. The Air pollution indicators – carbon monoxide, nitrogen oxide and sulfur emissions – show some evidence for EKC hypothesis. In the early NAFTA years the emission levels fell only to rise later i.e. post 2000. The conclusion drawn from this performance is that Mexico is yet to reach a turning point that brings about a widespread improvement in environmental quality. The carbon dioxide emissions are still growing but at a slower rate than before. Also the emissions of greenhouse gases continue to increase in total as well as per capita terms. Finally, the study concludes that EKC can be a helpful guide in predicting long term environmental decisions of the country that favor or disfavor economic growth.

Acharyya, J. (2009) studies the cost – benefit analysis of foreign direct investment on economic growth and environment in India from 1980 to 2003 using FDI inflow, GDP growth and CO_2 emissions. The FDI inflows generate both scale and composition effects. The empirical testing the significance of this relationship involves a series of statistical analysis. With the cointegration analysis of this relationship in India, it is evident that during 1980-2003 FDI inflow had some positive effect though marginal impact on economic growth. The declining share of dirty industries in the total number of industries in India, the "pollution haven" hypothesis, is not evident post 1990s. Thus, the cointegration analysis reports that FDI inflows increased the CO_2 emissions by 0.86% for every 1% growth in GDP in India.

Copeland, B. R., & Taylor, M. S. (2004) observe that assessment of trade policy effects on growth and environment is inevitable for an economy. Summarizing the previous researches of second best policy they conclude: a) if environmental costs are internalized free trade may improve welfare b) trade policy can serve as a substitute to environmental policy and c) Free trade commitments may create distortions in the environment policy.

They inferred a shift of the literature on EKC towards empirical research and concluded that "rising incomes affect environment quality in a positive way", i.e increase in income per capita in the economy will have a positive impact through environment policy and that the net effect may be unclear. Secondly, they concluded that "trade and investment are influenced by environmental regulations" and deny the fact that "pollution haven" hypothesis exists as there is very little evidence.

Tiwari, A. K. (2011) uses advanced panel data techniques to examine the relationship between energy consumption, CO_2 emissions and economic growth in India. Tiwari establishes four sets of hypothesis for testing the Granger causality between energy consumption and economic growth.

Firstly, he tests the "growth hypothesis". This hypothesis states that as energy consumption is an input in the production process, it can have detrimental impact on economic growth if the country adopted energy conservation policies. Only if the country switches, to efficient energy saving technologies the impact of conservation policies can have positive results on economic growth.

Secondly, he tests the "conservation hypothesis". If the causality is unidirectional, i.e. it runs from economic growth to energy consumption, then such conservation policies may not reduce economic growth. As a result the economy can not only focus on environmental friendly projects but also on energy consumption projects.

Thirdly, he tests the "feedback hypothesis". It states that energy consumption and real output are complementary to each other. There is bidirectional causality between energy consumption and output which leads to economic growth becoming the solution to environmental degradation. The growth stimulating policies are good for boosting growth.

Lastly, he tests "neutrality hypothesis". If there is absence of any causality between energy consumption and economic growth, the conservation policies may not impact economic growth substantially.

Tiwari uses Granger approach in VECM (Vector Error Correction Model) framework and DL (Dolado and Lutkepohl) approach. The results support the "neutrality hypothesis", i.e. energy conservation policies may not adversely impact economic growth as energy consumption in the production process is not substantial. The variance decomposition estimation analysis suggests that two-way causality is possible between electricity energy consumption and economic growth in future. Appropriate policy measures should be adopted by the government to handle the two-way causality along with carbon tax and tradeable emissions permit for the Indian economy.

Jalil, A., & Mahmud, S. F. (2009) study the Environmental Kuznets curve for over three decades for China. They make use of Auto Regressive Distributive Lag (ARDL) framework to study the environment-growth and growth-energy nexus into a single model. The empirical result reflects the presence of a long-run robust relationship. The causality test implies one way causality from economic growth to CO_2 emissions. Energy consumption is an important and significant determinant of CO_2 emissions resulting into greater environmental degradation with economic growth. The government needs to take more initiatives to control the environmental degradation taking place because of higher consumption of energy in China.

Suri, V., & Chapman, D. (1998) incorporates the impact of the actual trade movement of goods that embody pollution. They use pooled time-series and cross-section data. The income effect is the most common explanatory variable that has been incorporated in most of the EKC studies. GDP represents the scale of economic activities in the economy. The squared term of GDP represents the changes in the economy as GDP grows i.e. structural changes, environmental awareness and regulation. As structural change takes place the GDP first moves towards industrial sector and then towards the non-pollution-intensive service sector. Therefore the squared GDP term is expected to take a negative sign.

In this process environmental regulations place an important role of reducing pollution per unit of energy but do not have an impact on energy demand itself. To capture the impact of openness on the movement of goods that embody pollution, it is important to categorize trade into energy intensive and non-energy intensive goods. It is to be noted that some goods when produced do not use energy directly but the inputs that go into production are high on energy content and pollution.

Wyckoff and Roop (1994) estimate the carbon embodied in the goods imported by the countries. The ratio of carbon embodied in imports to the total emissions in some of the countries ranged from less than 10% in Japan to more than 40% in France.

To underscore the aforementioned point, they analyze the import-manufacturing ratio across cross-section data. During 1971-1990 this ratio increased in almost all industrial countries, was stable in developing countries and the increase was less than developed countries in some countries. The purpose is to analyze the commodities that get imported instead of being domestically produced to reduce the energy requirement of the countries. Similarly the export-manufacturing ratio represents the impact of participation in trade by a country. This ratio has been increasing for all the countries over time. The industrialized countries initially export light manufactures and then turn to heavy manufactures.

The total manufacturing of the country includes production for domestic as well as international market. The structural transformation in an economy is measure by this ratio. Higher Manufacturing-GDP ratio reflects not only industrialization but also reflects urbanization, transportation etc.

They tested two types of models: a model similar to the earlier studies where GDP squared term captures all the implicit impact and another that analyzed the impact of international trade on energy consumption. The turning points of both the models are quite different with the second model having a much higher turning point implying that with international trade the environmental degradation increases for some time before it slows down. The higher income countries are on the flatter region of the curve because 10% increase in import-manufacturing ratio leads to approx. 1.5% reduction in the energy requirements of the country.

Chandran, V. G. R., & Tang, C. F. (2013) attempt to validate the Environmental Kuznets curve for five ASEAN economies namely Malaysia, Indonesia, Singapore, the Philippines and Thailand by investigating the pollution haven hypothesis and role of transport in CO_2 emissions. The growth rate of these economies has prompted the researchers to look for an answer to various interesting questions among policymakers. The approach to this study overcomes the drawbacks of panel data analysis and involves a time series analysis with cointegration and Granger causality tests. The variables used for empirical analysis are per capita carbon dioxide emissions, per capita energy consumption for road transportation sector and per capita real GDP. The results suggest that there is a long run relationship between these variables and CO_2 emissions in these ASEAN economies. To achieve the emissions target the policymakers should consider road energy consumption, FDI inflows and economic growth.

Two policy implication they suggested are: enforcing energy efficient vehicles and selective FDI to control relocation of polluting industries. Fuel subsidy is to be revoked.

2.4 STUDIES ON GOVERNANCE VARIABLES

Panayotou, T. (1993) sums up his research by highlighting the importance of property rights and removal of harmful subsidies through efficient policy implementation. The acceptance of Environmental Kuznets curve has deeper policy implications. The relationship between economic growth and environment quality is not automatic. It cannot be taken for granted thus leading to irreversible damages caused to the ecosystem. It is important to clearly define property rights while an economy grows. The effective implementation of the government policies can help flatten the curve. This can be done through removal of harmful subsidies and internalizing the externalities. As resources become fully priced, extraction reduces and the externalities can be internalized. This can help restrain the exploitation beyond the ecological threshold.

The study highlights the importance of effective policy initiatives that the government can take and realize the benefit of the trade-off at a later stage.

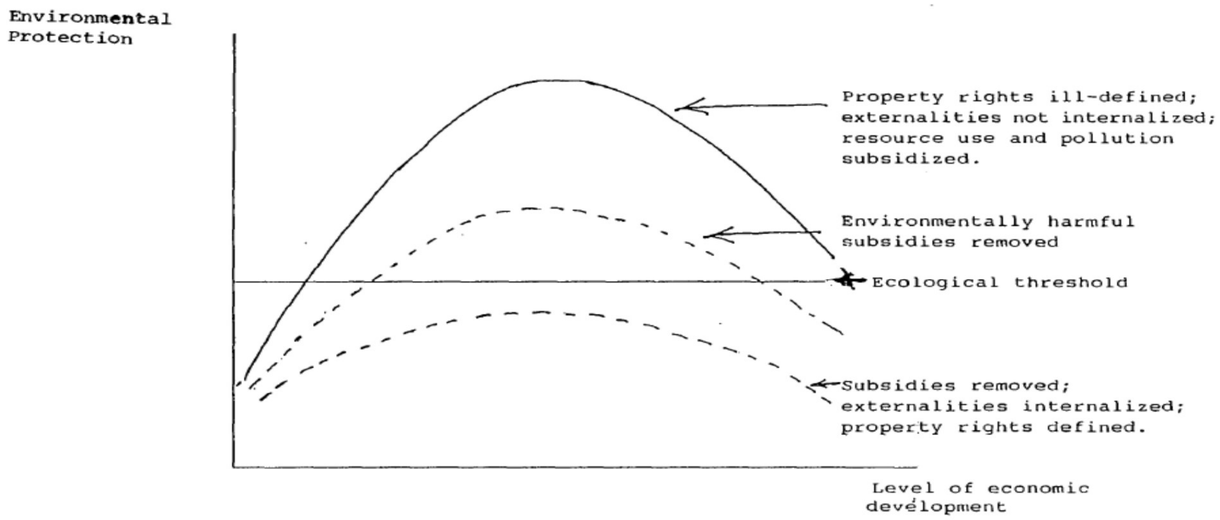

Figure 2.5: Removal of harmful subsidies, internalizing externalities and well defined property rights can flatten the Environmental Kuznets Curve
Source: Panayotou, 1997.

Bhattarai, M., & Hammig, M. (2001) investigate the role of institutional factors in the rate of deforestation in a country. The studies uses change in annual percentage in forest and woodlands area to measure environmental degradation. The institutional factor is a summation of political and civil liberties within the country. The study assumes that with growth of income in an economy the socio political institutions, environmental rules and regulations, considered as public goods also improve. The study computes an index for political rights of a country based on 12 freedom-related criteria. The civil liberty index comprises of 25 different individual freedom –related factors. By adding these two indices, they create a new variable called political institutions. The quantification of marginal improvement in the institutions helps in determining the impact on the deforestation process. The results derived from the pooled-regression of fixed effects model and random effects model vary significantly. The results of fixed effects models estimated using weighted least square (GLS) imply that improvements in institutions in the economy empowers the citizens to enforce the rule of law that reduces pressure on environmental resources.

The EKC study assumes that low-income countries clear forests at a rate that is less than its replacement rate. Alongside growth and change in demand pattern, structural change compensates for the forest area lost. Thus strengthening the sociopolitical system helps in flattening the EKC curve. Also institutional factors need greater attention while designing an environmental policy for the country.

Yandle, B., Vijayaraghavan, M., & Bhattarai, M. (2002) in their primer addresse questions raised at the advent of the EKC hypothesis. The theme of their study focuses on the changes in the status of property rights along with the movement of EKC. In the initial primitive stage of the economy, where resources are treated as commons, the private property enforcement is negligible. As resource scarcity manifests individuals believe in managing and accumulating wealth and the concept of "propertyness" expands. Thus the process of EKC starts with commons and ends with well-defined property rights.

In the given context, the study also comments on the price of natural resources like air and water. In the initial stages, environmental quality is unpriced and environmental degradation is easy. But as income grows the demand for better environmental quality rises and so does the price. The study also reviews the empirical evidence based on two areas: the threshold income that improves the environmental quality and the shape of the given environmental indicator. The author also compiles studies that focus their research on deforestation in the economy and the status of property rights and rule of law.

Finally the authors conclude by discussing the priority assigned to local air pollutants as compared to global air pollutants. The turning points for water pollution are much lower than for air pollution, stressing the fact that people are more concerned with water quality than air quality. Economic growth accompanied by better institutional reforms, removal of distortionary subsidies and improvement in the property rights regime help flatten the EKC curve.

Biswas, A. K., Farzanegan, M. R., & Thum, M. (2012) examined the shadow economy – pollution nexus. Their dependent variable is Carbon dioxide (CO_2) and Sulphur dioxide (SO_2) and independent variable is the share of shadow economy in the GDP. The study attempts to develop a model that tries to establish the relationship between the shadow economy and its impact on the environment. The study identifies that when high regulatory pressures are exercised there are high chances of firms shifting their activities to the shadow economy. Regulatory control over informal activities is the key to implementation of effective environmental policies in an economy. Corruption plays an import role in this relationship between pollution and shadow economy. The results may also vary between high-income and low-income countries. They develop a simple model that demonstrates the effect of corruption on the pollution-environment relationship. They observe that a 1% increase in the size of the shadow economy increases CO_2 emissions per capita by 1.14% in the absence of corruption. The result is that the interaction term between the shadow economy and corruption index is significantly positive. The paper concludes that the destructive effect of the shadow economy on the environment can only be lowered by lowering corruption levels in the economy.

2.5 STUDIES ON EMPIRICAL EVIDENCE

Lieb, C. M. (2003) presents a survey of empirical evidence and possible causes of the Environmental Kuznets Curve. The survey attempts to investigate through critical surveys on the pollution-income relationship (PIR) whether EKC exists. And if it does exist then for which pollutants.

Majority of the research on EKC has been on cross-section analysis of countries. Very few researches have gone for country specific pollution analysis. The dominant technique to estimate environment income relationship is:

$$P_{it} = \alpha + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 Y_{it}^3 + \beta_4 X_{it} + \varepsilon_{it} \quad ....$$

Where p is a pollution term measured in emissions per capita (or sometimes concentration of certain pollutant), y is GDP per capita measured in PPP, x is a vector of other explanatory variables, i is an index for a country, t is an index for time and ε is the error term.

The above equation can be estimated in the following ways: a) panel data set from a maximum number of countries and years possible – sometimes pure cross-section is also estimated. But panel data is preferred as it is more efficient than other techniques. This can be estimated using OLS (ordinary least square) if fixed effect model is tested or GLS (generalized least square) if random effect model is tested.

b) The above equation can be tested without the cubic term as it is too favorable for the EKC hypothesis. Sometimes with the presence of the cubic term, the other coefficients become insignificant which allows both an inverted U-shaped and a monotonically rising curve. Various combinations of the functional forms as proposed by Shafik and Bandyopadhyay produce any of the seven results: monotonically falling or rising curve, inverted U-shape, a U-shape, N-Shape, inverted N-shape, or a flat curve. c) This equation can be estimated in terms of data or logarithms whichever has higher explanatory power. d) The equation can also be estimated using time trend "$\beta_5 t$" term. This is done to segregate the environmental effect of technological progress or environmental awareness. But it has its own limitations. e) The equation can also be estimated in fixed effect model by introducing an intercept dummy for each country. It incorporates the characteristic difference in the countries. Random effects can also be calculated. A Hausman test check to random or fixed effect is suitable for the data set.

Cavlovic, T. A. et. al (2000) synthesize the results of the Environmental Kuznets curve findings by employing a statistical meta-analysis and attempt to predict new income turning points. The meta-analysis is a statistical analysis that combines the results of multiple scientific studies addressing the same question. This study is an analysis of 25 EKC studies using more than 120 observations, various pollutants methods and research choices.

The vector X used in various traditional reduced form equations controls for the influence of population, climate, geographical location, manufacturing output etc. This results in appropriately fitting the available data in a linear functional form, sometimes with a third order polynomial sometimes without it. An alternative to this is to include time trend as a separate regressors. Some studies acknowledge the fact that many exogenous variables not included in the model may influence the results, hence they estimate fixed effect and random effect models.

The income turning points are not the same for all pollutants across countries. This is due to the difference in cost of abatement of local pollutants and global pollutants. As a result, higher income turning points are estimated using random effects than fixed effects. The study uses nine variables to capture the methodological (independent) factors. The environmental indicators are classified into 11 categories. The study estimated the turning points of those not previously estimated in the studies. Altogether four models are estimated, two specifying Tobit model and other two specifying GLS model.

The results indicate that studies that estimated EKC hypothesis for developed countries tend to find lower income turning points. Also, the emissions exceed their ambient counterparts resulting into non-comparable income turning points. Finally, the higher income turning points are observed in studies that include trade effects as one of the explanatory variables.

De Bruyn, S. M., van den Bergh, J. C., & Opschoor, J. B. (1998) have examined the empirical evidence of EKC previously discussed by the authors. They try to re-examine this relationship and investigate the proposition that economic growth benefits the environmental quality. Reviewing these studies, the authors discover that empirical researches depend upon the type of pollutant investigated and the choice of model for estimation. The order of theoretical arguments in favor of inverted-U hypothesis is as follows: positive income elasticities for environmental quality lead to structural changes in production and consumption patterns. Increased awareness amongst people on the consequences of economic activities leads to more international trade, which further increases the income level in the economy.

However, many researchers observe an N-shaped curve instead of inverted-U shape curve. The traditional functional form is tested with a cubic term and if the parameter of this term is equal to zero, then an inverted-U shape curve is obtained. If not zero, it results in an N-shaped curve.

These results have been challenged for various reasons: a) the EKC studies lack the explanation of carrying capacities of the ecosystems. b) the income turning points that these studies observe are barely achievable by most of the developing countries of the world. c) income growth mainly gives priority to the local problems that seem to obtain a solution at a lower cost than global problems such as CO_2 emissions.

One of the disadvantages of the reduced form approach is the interpretation that can be attached to various estimated coefficients of the polynomials. The three foundational studies on EKC have modelled time in such a way that it influences the intercept. The EKC obtained in a cross-section estimation will shift downwards overtime. This is due to the negative time-effects for most of the pollutants. If this is true then the EKC for cross-section panel data will keep shifting inwards over time. Thus the actual turning point for an individual country may be lower or higher than the estimated turning points.

If the time-trend behaves in a non-linear fashion or is not significantly different from zero, then the EKC will no longer shift inwards over time. It can be described as an N-shaped curve proving that after reaching an income level the environmental pressure again rises. Hence to de-link economic growth from environmental pressure a negative time-effect is essential.

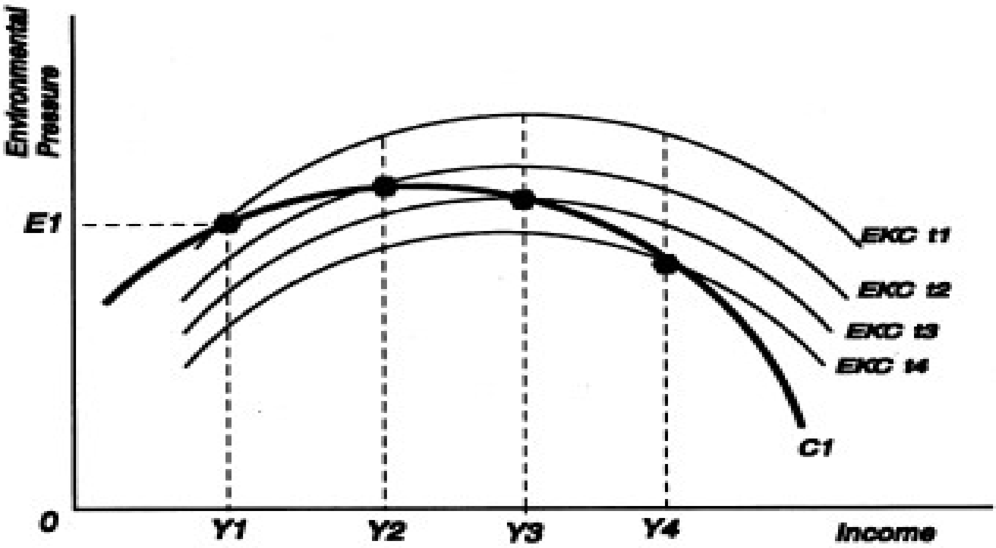

Figure2.6: Development of a single country across different cross-section based EKC's with a significant negative time trend.
Source: S.M. de Bruyn et al., 1998.

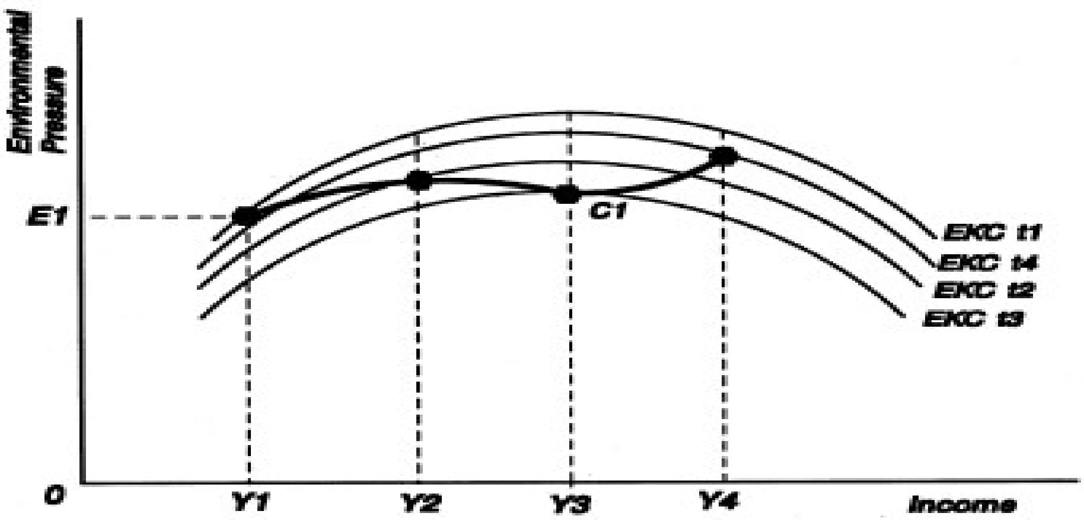

Figure 2.7: Development of a single country across different cross-section based EKC's linear time trend is not significantly different from zero.

Source: S.M. de Bruyn et al., 1998.

The researchers in their study propose an alternative model for direct estimation of the effects of economic growth on patterns of emissions in individual countries. They investigate the "intensity-of-use hypothesis" in the absence of price and demand for material using income, being able to explain decline in emissions over time. This hypothesis explains an inverted-U relationship between intensity of metal use and income. They give following reasons: a) technological improvement increases the efficiency of processing the material b) technological changes also result in substitution of the material c) shift in economic activity of the economy from industry to service sector. Since emissions can be regarded as dependent on the total material used in the economy, an EKC relationship may exist for an individual country over time.

$E_{j,t} = Y_{j,t}\, U_{j,t}$ ....

Emissions level of an economy is a function of income level and emission intensity. Changes in Uj imply that over time there are changes in the composition of economic activity, technological improvement, processing of material and its substitution.

The researchers conclude that economic growth may improve environmental quality but is not supported by the evidence they derive. Better functional forms and model specifications are required to study this complex relationship.

Carson, R. T. (2009) has given a deeper insight into the caveats of the empirical analysis of EKC. The empirical criticisms are:

a) The reliability of the GEMS data is a critical issue. A slight variation in data can question the location of the turning point of EKC.

b) The EKC studies have always faced criticism for being more a cross-section study than time series one. The possibility that few variables, to be specific two, can predict the future without understanding the underlying process is itself questionable.

c) Over the decade in which the whole argument is seeded, developing countries were not given much importance, which is clearly reflected in the lack of availability of GEMS data of such countries. Moreover the estimates examined for a group of countries could not be generalized for any other group of countries since these countries were selected solely on the basis of data availability.

d) EKC, in earlier studies have focused more on local issues than global ones. Majority of EKC studies have SO_2 emissions as their environmental indicator for which it was easier to estimate an inverted-U shape curve. It was obvious for the global indicators to not display an inverted-U shape curve. Some critical studies have chosen specific countries where changes in technological levels have brought down SO_2 emissions.

e) Problems with environmental data quality have persisted since ages. Few studies have acknowledged the fact that data quality is poor and have worked on it for best results. The data for any EKC study is more critical due to it being termed as a “Black Box”

f) Researches have concentrated on other variables to increase the efficiency of the EKC estimates. This includes population density, trade openness, policy variables etc. Policy variables later entered the discussion because of their being directly associated with provision of public goods.

g) The most noticeable caveat of the reduced form models is the problem of estimation of causality. Along with it, there are some other econometric issues such as data-specification, effective covariates, stationarity etc. that question the validity of the results.

h) Lastly, the practice of fitting a cubic function to the EKC’s quadratic form sometimes takes a turn and the environment quality worsens as income increases. Also, if the quadratic form is not well estimated, it simply flattens the curve.

Perman, R., & Stern, D. I. (2003) conclude that the data properties used for empirical evidence should be considered prior to the analysis. The selection of appropriate methods depends on whether the data are stationary or non-stationary. The absence of time series analysis of EKC is due to non-availability of data over long time periods. That makes the cross-country studies more plausible. However, possible presence of unit root makes statistical analysis more complicated. Since presence of unit root indicates a time series that is not stationary. When the series is non stationary, error terms are cointegrated. And if a non-stationary series is included in the analysis the results, though significant, cannot be relied upon. Even if the regression is not spurious, the classical inference is invalid. In EKC analysis, as income is an integrated variable, the data should be tested for unit root and cointegration tests should be applied. The utility of EKC model cannot be questioned on the basis of failure of a few empirical studies.

2.6 REVIEW OF STATISTICAL TECHNIQUES:

Table 2.1 Glimpse of CO_2 studies (Dependent variable is CO_2)

Authors	**Explanatory variables**	**Time**	**Countries**	**Turning points**	**Shape**	**Functional form**
Lipford and Yandle (2010)	Per capita GDP	1950-2004	G8 (exc RUS),	NA	N-Increasing N-Inverted U	Cubed Linear Cubed Quadratic
Martinez-Zarzoso et.al (2004)		1975-1998	22-OECD countries	\$4914-\$18364	N Shaped	Linear, quadratic, cubic
Magnani (2001)	Per capita GDP, time	1970, 1975, 1980, 1985, 1990	152 countries	For CO_2 NA	N shaped	Cubic
Dijkgraaf and Vollebergh (2001)		1960-1997	24-OECD countries	\$20647	Inverted U shape for 5 rich countries	Linear, quadratic, cubic
Panayotou, Peterson and Sachs (2000)		1870-1994	17 developed	\$29732-\$40906 (1950-1990)	Inverted U shape	Quadratic
Agras and Chapman (1999)	Price and trade variation	1971-1989	34	\$13630	No shape	Quadratic (logs)

Cole et al. (1997)	Per capita GDP, exogenous variables	1960-1992	Up to 88 countries	For CO_2 62,700	Inverted-U	Quadratic logs
Robert and Grimes (1997)	Per capita GDP	1962-1991	Develope d and developin g	8000	Inverted U	Quadratic
Moomaw and Unruh (1997)		1950-1992	16 developed countries	$12813	N Shape	Cubic form,
Holtz-Eakin & Selden (1995)	Per capita GDP, fixed effects	1951-1986	130 countries	35,400	Inverted-U	Quadratic (logs)
Shafik (1994)	Per capita GDP			NA	Linear upward	Linear, quadratic & cubic log
Shafik & Bandyopadhya y (1992)	Per capita GDP	1960-1990	149 countries	4000 (GDP per capita)	Inverted U	Quadratic
World Bank (1992)	NA	NA	NA	NA	Linear upward	NA

2.7 STUDIES ON SEM

Kukla-Gryz, A (2006) attempts to examine the traditional EKC by estimating the relationship using a new econometric technique viz; Structural Equation Model (SEM). The study pools two groups of countries for the analysis low income and low-middle income countries. He estimates a SEM with two latent variables: structure of economic activity and air pollution intensity. The conjecture is that there are some causal paths between these two factors and they are influenced by per-capita income, international trade intensity, political rights and civil liberties. The objective is to estimate the "net effects" of international trade and economic growth and decompose the results into scale and composition effects. While the scale of the activity directly affects air pollution, the composition of economic activity indirectly affects air pollution.

The study also estimates an Alternative Model to select the best fit model. The results estimated suggest two implications: the structure of economic activity, which includes level of urbanization and the share of industry, significantly affects the level of pollution per capita. Secondly, level of per capita income and trade intensity indirectly affects air pollution.

The results of the Structural Equations confirm a significant and positive effect of income per capita and trade intensity on the change in the structure of the economic activity in the economy.

Buehn, A., & Farzanegan, M. R. (2013) criticize the earlier studies of EKC and point out that these studies considered only one environmental indicator at a time. To overcome the statistical caveats of the earlier studies they use a variant of the Structural Equation Model (SEM). They use Multiple Indicators Multiple Causes (MIMIC) model for the analysis. They create an Environmental Pressure index for 122 countries between 1985 and 2005. They short list two major environmental indicators on the basis of priority at local and global level i.e SO_2 sulfur dioxide emissions and CO_2 carbon dioxide emissions. The causes of environmental pressure are categorized into three categories namely: economic, demographic and governance factors.

The Economic factors include real GDP per capita, energy consumption, share of industry and share of import and export in GDP as a measure for trade openness. The demographic factors include urbanization and population in the working age as a measure. The governance factor includes quality of institutions. The estimation that derives the parameters minimizes the functional form of the equation. The results of the index are interpreted as - higher the index value higher will be the environmental pressure in the country. The results estimated conclude that highly developed countries have higher environmental pressure. The group of countries with a lower value of index includes developing and transition countries.

The major policy implications are: a) more investment in green technologies b) more investment to improve energy production and consumption technologies in the economy and c) switching to alternative energy sources.

Fan, Y., Chen, J., Shirkey, G., John, R., Wu, S. R., Park, H., & Shao, C. (2016) discuss the applicability, variants and unexplored areas of the Structural Equation Modeling (SEM) in ecological studies. Their review revolves around three questions: a) are the results of SEM statistically sound for ecological research? b) Issues of SEM applications and c) is there any future of SEM in ecological studies?

One of the strengths of the SEM is that it can test direct and indirect effects of the anticipated causal relationship. Initially the causal models using path analysis were developed to include factor analysis for social science researchers. The Structural causal modeling was then followed by Bayesian modeling.

The heterogeneous database such as non-randomly distributed and hierarchically organized database with potential autocorrelations in social sciences is not new to researchers. Variants of SEMs exist to overcome these caveats in the database for better research. Latent Growth curve model (LGC), Bayesian SEM and Partial least Square SEM (PLS-SEM) are a few variants. Despite the flexibility to model unique datasets, the application of SEM is limited and full of challenges. Identification of causal relationship along with its statistical evidence, model specification and variable selection, estimation techniques and reporting the model fit indices remains a matter of concern in many researches.

Kukla Gryz, A. (2006) tries to overcome the statistical issues of the previous studies due to lack of data availability by constructing a structural equation model using three latent variables. The ambiguous empirical results of the relationship between trade, growth and environment draw the author's attention to this debate. The earlier literature mainly focuses on developed countries while this relationship is still uncertain for developing countries. As SEM allows for estimating direct and indirect causal relationship it becomes an advantage to estimate the error terms on each observed factor's indicator. This increases the comparability of the data and increases the chances of efficient estimation. The GDP per capita has negative as well as positive effect on the environmental quality.

The estimation results of the final model, using maximum likelihood method, suggest that there are indirect effects of per capita income and international trade intensity on the levels of air pollution. The results of structural equations are in favor of changes in the structure of economic activity per capita income and trade intensity in the economy. This confirms that international trade may affect the shape of the EKC. The results are somewhat similar for the governance factors such as political rights and civil liberties index.

The author tries to decompose the net effect of scale of economic activity and structural changes due to international trade intensity on the environmental quality. The alternative model suggests positive and significant results for indirect effects than the direct effects. The author concludes that if relation between economic growth and environmental quality exists for developing economies, the shape of EKC will largely depend on international trade.

Stern, D. I., Common, M. S., & Barbier, E. B. (1996) identify the various assumptions that the EKC studies make and try to overcome the violation of these in the studies in the functional forms of their respective models. The main assumption in the hypothesis that further development will reduce environmental degradation is based on the normality of world per capita income. They identified the most important EKC studies and discussed the drawbacks of their empirical estimation. For their study they selected Grossman and Krueger (1994), in which they include site-related variables, a time trend and trade intensity variable. Using cubic function they estimate that even though economic growth at a certain income level would improve environmental quality, at high-income levels economic growth would be harmful to environmental quality. Shafik And Bandyopadhyay (1992) use three different functional forms namely log-linear, log-quadratic and log cubic polynomial in GDP per capita. The results of the additional regressions were difficulty to interpret. Higher R^2 is due to inclusion of site-dummies in the equations. Not only does this make interpretation of these equation difficult but also that estimation of such a complex relationship cannot be done in a single-equation model.

Selden and Song (1994) estimate very high turning points for the environmental indicators suggesting that decline in ambient pollution is easier to achieve than aggregate emissions. Their results for coefficients of income per capita were significantly different from zero, stating that even at very high levels of income pollution will not fall to zero. Panayotou (1993) estimated log quadratics using only cross-section data. The emissions data was estimated from fuel use and fuel mix data which have a higher chance of being inaccurate because of single source of data collection. The data related to deforestation was a "net effect", i.e. there was afforestation as per data due to inclusion of open as well as closed forests. This creates a bias in the estimation. In contrast to all the above studies Cropper and Griffiths (1994) conclude that economic growth alone cannot solve the problem of environmental degradation.

The study also identifies three important issues with the statistical models used for EKC analysis. Simultaneity is one that has received quite a lot of attention but a study justifying feedback from environment to economic growth is difficult to find. The dependence of economic activity on the natural resource base, its assimilative capacity and irreversible damage cannot be captured in a single equation model assuming uni-directional relationship between economy growth and environment. Secondly the study highlights the impact of international trade as a problem to EKC estimation. Change in energy intensity of imports and overall reduction in the energy to GDP ratio in the economies lead to structural changes within economies and differences with other countries. Following the traditional trade theories developing countries specializing in labour intensity are polluting more than the developed countries. Therefore it is difficult to achieve a worldwide structural transformation in favor of environmental quality and so environmental regulation in developed countries may further lead to concentrating polluting activities in developing nations. Finally the data problem that has persisted commonly in environmental economics still remains a challenge.

The study suggests that better and more comprehensive statistical models such as structural models rather than reduced form models are needed for an efficient approach to policy implication of EKC results.

Grace, J. B., & Bollen, K. A. (2008) present a framework that discuss the use of a composite variable to overcome the parameter estimation problem. SEM is useful to researchers in many ways such as it has capacity to evaluate multivariate hypothesis, flexibility, and capacity to include unobserved variables. Priority is not given to null hypothesis. The unobserved variables are included in the model to represent the underlying cause while the observed variables serve as effects. This framework sometimes may be inappropriate. A related issue is the use of composite variables which helps researchers to represent theories based on causal indicators.

Emphasizing the importance of theoretical knowledge in the process of construction, evaluation and interpretation of the results of SEM models, the authors discuss the role composite variables can play in bridging the gap between available data and constructs of interest. They define composite variables as those that represent the heterogeneous collection of causes. In their theoretical framework they elaborately explain the relationship between manifest (observed) indicators and latent variables/ composite variables with the help of blocks as shown in the figure below.

In the first block L to M (latent to manifest), the latent (unobserved) variable is assumed to cause correlation among the manifest (observed) variables. In the second block M to L (manifest to latent), manifest variables influence the latent variables. In this case the effect indicators of latent variables exist independently. In the third block M to C (manifest to composite), the composite variables summarizes collective influence of the manifest variables.

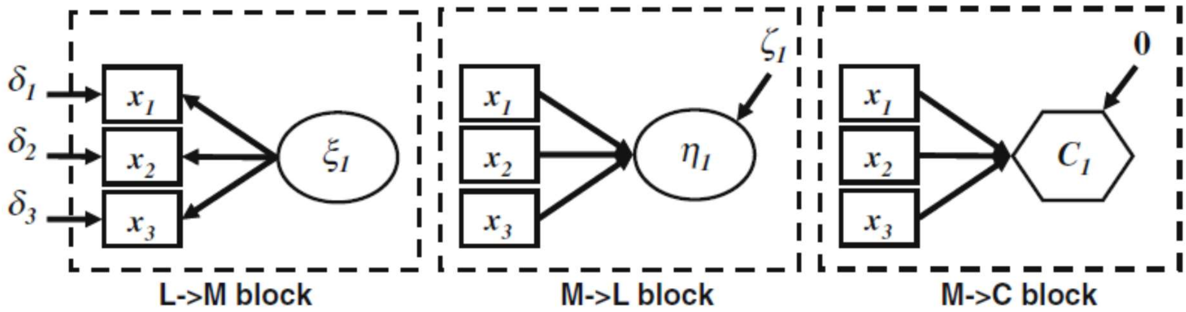

Figure 2.8: Various specification between manifest, latent and composite variables. Source: Grace, J. B., & Bollen, K. A. (2008)

The study illustrates these models using ecological example of colonization of forest patches by understory herbs. The authors differentiate the effects of two exogenous influences using endogenous or internal variables. The authors use a stage analysis and provide a formal theoretical framework. For analysis they illustrate three possible model structures.

The use of composite variable reduces the number of pathways to be estimated in the model. It maximizes the ability of the model to get closer to the general theory. The use of composites is limited due to the problem of parameter identification for models with single effects. The authors have recommended the use of partially-reduced form model to overcome this problem. The new age structural equation modelling has developed through applications to social and economic sciences where the concepts and constructs can be effectively presented using composites.

Bollen, K., & Lennox, R. (1991) critically examine the conventional guidelines for selection of good measures and behavior of valid and reliable indicators. Examining the source of contradictory guidelines they recommend theoretical clarity as the most important criteria. The main purpose of their article is to differentiate the applicability of these criteria when indicators act as causes and effects of latent variables.

They are of the opinion that following the traditional internal consistency premise among constructs might not work in case of a causal indicator model. The traditional premise is that indicators should be positively associated with other measures of the same construct. Whereas in causal indicator model the association can have positive, negative or even no correlation amongst the measures. Similarly they recommend high correlations for effect indicators and less correlation for causal indicators. With high correlation amongst the measures the individual impact of the indicators on the construct is unknown. This also creates the problem of multicollinearity.

As effect indicators incorporate measures that are closely knit to one another, omitting one doesn't impact the construct validity. The story of causal indicators is different, for omitting one measure might severely question the validity of the construct. The reason is causal indicators combine various facets of one construct and effect indicators are unidimensional.

Inter and intra correlation among the construct is another criteria that needs attention. Typically the correlations amongst the measures of the same construct should exceed the correlation between the indicators of other constructs. That is to say two constructs should have non zero correlation. And in case of causal indicators there should be no such restrictions on the extent of the correlations between the indicators.

The main highlight of their article is the use of linear composites as substitutes for latent variables. The relevance of linear composites depends on whether the latent is measured with effect or causal indicators. Interestingly, in both the cases, the linear composite has less correlation which can be transformed by using weighted indicators. In a nutshell the measurement of latent with effect or causal indicator cannot be treated equally.

The knowledge as well as statistical evidence of whether observed variables are causal or effect indicators is presented by **Bollen, K. A., & Ting, K. F. (2000)** in their research. The distinction is not only important for model specification but also for using correct statistical techniques. It can rarely be identified through experiments as traditional likelihood test is also unable to give an appropriate fit. In their article they attempt to develop a test that provides an empirical test of whether an indicator is causal or effect. They develop a Vanishing Tetrads test. They are of the view that in future the use of causal indicator or the determinants of a factor rather than reflection will increase. This will require a tool to distinguish between the two indicators. Specifying the model once with causal indicators and then with effect indicators can be less useful as the model fit statistics might not differ significantly. Tetrads also has its own limitations. In sum, the test provides researchers with an important tool to specify the relation between the observed and latent variables.

The economic growth and environmental degradation debate is highly pitched than ever. The outcomes of the enormous literature on this relationship remains as contradictory as it was. Researchers cross the world have tried different statistical tools and combination of variables to provide an insight to policy makers regarding the underlying causes for efficient and informed decisions. It still remains unclear and there is need for more research on this relationship. The main drawback identified by **das Neves Almeida, T. A., Cruz, L., Barata, E., & García-Sánchez, I. M. (2017)** is the use of a single environmental indicator to capture the diverse characteristics of the ecosystem. They explore the use of an environmental variable index that can overcome this drawback. Using a set of 19 variables, which includes all dimensions of environmental quality, the researchers attempt to estimate a Composite Index of Environmental Performance (CIEP). The data extracted from the World Bank database includes 152 countries and a time period of 6 years. The model is estimated by considering different levels of development in order to distinguish the behavior for each group. Furthermore the model uses Principal component analysis (PCA) to construct factors for evaluating the relationship between the CIEP and economic growth. The empirical output based on CIEP rejects the EKC hypothesis. The PCA – factor 1 results support N-shape EKC, where the environmental damage increases in early stages, decreases thereafter to increase again at later stages of growth. Factor 2 results are insignificant. The level of development has an insignificant impact on the aim to control pollution. The authors also recommend policy makers to consider accumulated stock of pollution instead of emissions while drafting environmental policies. In sum, use of composite indexes in understanding the EKC literature is scarce and should be considered by future researchers.

"The econometric grounds of EKC models are brittle and prone to criticism" as argued by Carson**, R. T. (2009).** Carson systematically criticizes the statistical evidence used in earlier EKC studies. Firstly, the GEMS database use by Grossman and Krueger

(1991) was modified and analyzed by Harbaugh, Levinson, and Wilson (2002) to conclude that the evidence for an inverted-U shape curve is not strong. Secondly, the focus of the EKC on cross country analysis which predicts economic growth as a function of input variable ranging from economic policy, political approach and institutional indicators was also fragile.

Thirdly, there is an absence of developing countries in the GEMS data and the generalization of fixed-effect parameter estimates for random-effect estimates. Fourthly, the focus of EKC studies in on SO_2 emissions. It is easy to estimate a strong EKC relationship for SO_2 emissions because it is more of a local issue than global. Fifthly, the quality of data available has been part and parcel of economic research. The data on environmental variables are sparsely available. Sixthly, using alternative covariates instead of income improved the precision of EKC estimates. In one of the researches, Torras and Boyce (1998) show an improvement in pollution levels with changes in political rights and civil liberties in the economy. Seventhly, establishing "causality" between growth indicators and environmental variables has been an ultimate concern as there is little statistical support for presence of cointegrated relationship that might be consistent with EKC. Lastly, the common practice of fitting a cubic functional form to any dataset will be consistent to the EKC relationship for reasons well known. The empirical evidence of pollution havens by Tobey (1990) suggested that stringent the strictness of environmental regulations have insignificant impacts on trade patterns as it is one of the sources of EKC. Summarizing his arguments Carson suggested more research work to done in identifying factors that can transform the benefits of economic growth towards improved environmental quality.

Jha, R., & Murthy, K. B. (2003) argue the case for developing a composite index, specifically an environmental degradation index (EDI) and relating to Human development index (HDI). They also attempt to develop a Global Environmental Degradation (GED) consensus and support the requirement of an international body for global environmental management. The study chooses principal component analysis (PCA) over regression analysis for three reasons: a) PCA is based on linear transformation of the regressors b) normality assumption is not essential and c) PCA maximizes variance rather than minimizing the least square.

Data of 174 countries from the Human Development Index (1999) was used to estimate global EKC. Six variables were shortlisted from the report and used for constructing a composite index.

The results present an inverse link between HDI ranks and EDI ranks. More importantly, only US has an adverse influence on all the six environmental degradation indicators.

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