Environmental Kuznets Curve (EKC): A Review of Theoretical and Empirical literature

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1.0 INTRODUCTION AND BACKGROUND OF THE KUZNETS CURVE

The changing relationship between income quality and per capita income which can be observed empirically and figuratively with latest developments in tools of economic analysis can be represented by the Kuznets Curve. The proponent of the theory was of the idea that the distribution of income is unequal at different levels of income growth.

However, as the economy grows, income distribution tends to become more even. Simon Kuznets brought the line of reasoning that as income per head (per capita) increases or rises, income inequality will also be on the rise initially after a maximum point begins to decline.

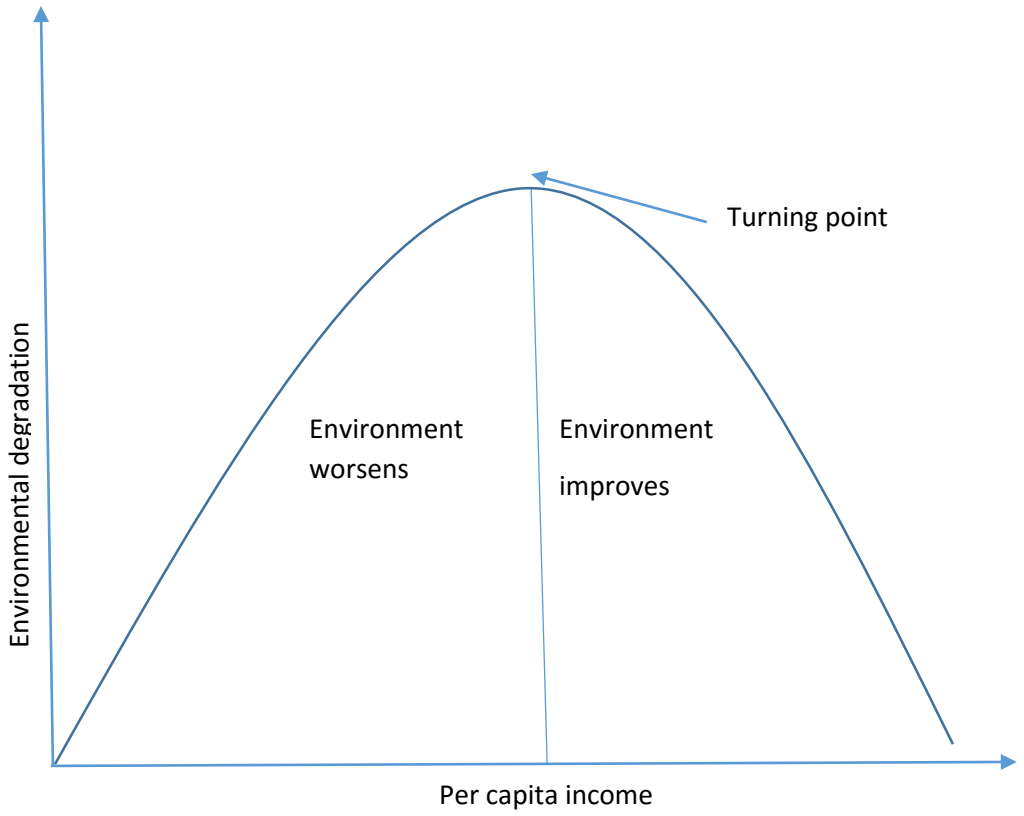
The issue of achieving and sustaining economic growth nay development without altering the natural composition of the ecosystem and environmental quality is an issue of discourse for scholars in the Natural/Physical sciences as well as the Social sciences. Economic growth requires more amounts of capital, labour and other resources which subsequently leads to higher amounts of waste being generated in the environment such as emission of gases and fumes making it unfit for human existence.

The Environmental Kuznets Curve (EKC) conjecture seeks to establish an inverted U-shaped nexus between income per capita and environmental degradation. It posits that at early stages of economic growth and development, environmental degradation rises or increases at an increasing

rate. Nonetheless, after some threshold of economic development, the co-movement tends to reverse at higher levels of economic progress.

The Kuznets curve when used to analyze environment, income and pollution relationship is referred to as Environmental Kuznets curve (EKC henceforth) in the analysis that shall follow.

For a society to attain a higher level of development, she must then employ natural resources which will inadvertently have some residual effects on the environment thereby achieving prolonged and sustainable development in the process. Pollution grows at a faster rate since priority and attention are given to rising and increasing material productivity cum output. This leads to insensitivity of people which translates to them becoming more interested in financial gains other than the environment in which they live in. The rapid growth therefore leads to higher use and utilization of natural resources and subsequently, higher level of pollutants which degrades and reduces environmental quality.



2.0 REVIEW OF THEORETICAL LITERATURE

All economies make use of natural resources and a host of other inputs including labour and capital to help transform them to usable and end-use forms. The production and consumption process that brings about these goods generates wastes which are re-introduced and recycled into the environment that in turn deplete environmental quality.

Furthermore, human beings use air, water and other natural resources provided by nature to sustain life. The environment therefore provides a number of services to facilitate economic activities. These resources and services are not infinite in nature hence risk the probability of being plunged into extinction and danger of negatively affecting the environmental quality.

When the environment is used as a receptor of wastes, there is a limit up to which it can absorb the wastes and assimilate in its system. This capacity is referred to as the absorptive or assimilative capacity. Beyond this capacity, wastes become accumulated in the environment (Bhattacharyya, 2011).

The environmental debacle begins when the waste rejection crosses the assimilative capacity of the environment. Wastes may take different forms such as solid, liquid and gas. Often, users who generate these problems are not often responsible for bearing the cost of the damage creating a negative externality in the process. Environmental issues of degradation and depletion are better seen as multi-dimensional and having such impacts too.

Income growth and its effect on environmental quality can be seen as being transmitted in three channels says Grossman (1995). It is possible to generate a *scale effect* on the environment: *a larger scale of economic activity results in increased environmental degradation*. More natural resources are depleted and used in the transformation of input to output.

Ante and Heidebrink (1995) points out that economic growth is likely to be accompanied by environmental degradation at low income levels but as income grows, the demand for environmental protection also tends to increase leading to a development path characterized by both economic growth and environmental quality improvements.

There is also the *composition effect* which posits that the *structure of the economy tilts towards changes as the overall income level grows which gradually and succinctly increases the share of dirt-free and cleaner activities in the Gross domestic product of a nation*. Environmental degradation tends to increase as the structure of the economy changes from rural to urban, agrarian to industrial but starts falling with the second structural change from energy intensive heavy industry to services-based and technologically-driven industries. This results in the substitution of archaic and dirty technologies with cleaner ones which in the process leads to improvement in environmental quality. This is the much touted *technique effect* of growth in relation to the environment.

The theoretical literature as far as the EKC is involved has undergone substantial and rapid changes and adjustments with different scholars contributing to extant and already existing body of literature. For instance, Banerjee and Newman (1990) analyzed the theory of insurance, incomplete markets in conjunction with the neoclassical theory of economic growth. Their model seems to be in unison with the Kuznets hypothesis.

Galor and Tsiddon (1996) are of the view that an unequal distribution of capital in the form of income may originally be a precondition for investment in human capital to occur while later on accumulated knowledge declines so that inequality declines in the long run.

Political participation which is exogenously determined emphasizes that demographic factors also contribute to income inequality and environmental inequality in terms of the interaction between the economic structure and the political mechanism. These belong to the class of models that assume that growth is actually an outcome of investment in physical capital or the acquisition of useful knowledge and skills for technical progress with major emphasis on public education.

Many attempts have been made to provide the theoretical underpinnings of the EKC relationship. The approaches vary but conclusively leads to one path. It is often common to segment theoretical literature into static and dynamic analysis.

STATIC MODELS OF THE EKC THEORETICAL LITERATURE

Lopez (1994), Jaeger (1998), Elkins (2000), Andreoni and Levinson (1998) in Lantza (2000) provide an illuminating exposition to the EKC phenomenon.

Lopez (1994) for instance develops a model of output-pollution relationship that infers that consumers have preferences over defined income, output price vector and pollution levels. Quasi-fixed capital and labour inputs together with a pollution input produce output according to constant returns to scale technology and weak separability between pollution and conventional factors of production where technology and output factors are assumed exogenous.

His result shows that if a producer pays a zero or fixed pollution price, then increases in output results in increase in pollution levels regardless of the features of technology or preferences.

A tabulation of the static theoretical EKC literature is made for ease and convenience of reading below.

Authors	Model specification	Findings/conclusion
Andreoni and Levinson (1998)	Employed a static-partial equilibrium model where the choice is between consumption and investment in pollution minimization.	*More investment will be made on curbing pollution as income rises. Increasing returns to pollution curbing technologies causes the EKC to rise.*
Elkins (1997)	Adopts the *scale*, *composition* and *technique* effects in a static but single equation framework	*If technique and composition effects overcome the scale effect, an EKC can possibly arise in the process.*
Jaeger (1998)	Specifies a static General equilibrium model where a choice of dirty and clean good is made. A technique effect is also specified.	*As income level increases, the environment transits from an abundant to a scarce factor so agents choose cleaner goods and technologies over time. The EKC results from these minimization lapses.*

Lopez (1994)	Makes use of the static General equilibrium model where welfare and output are functions of the environment.	*Finds that Non-homothetic preferences may cause the EKC.*

2.1 CRITIQUE OF THE STATIC ENVIRONMENTAL KUZNETS CURVE (EKC) MODELS

The Static models are often at times criticized for their gross inability to account for decision making and planning in the long run. This may therefore lead to spurious and inaccurate predictions/conclusions about the exact and precise relationship that exists between pollution in relation to output.

Furthermore, when analyzing economies over their phases of development, it is possible to establish possible feed-back and monitoring effects of pollution on the market economy (such as acidification of soils). Treating pollution as a harmless flow variable in previous analysis existing in extant literature is not only deceptive but erroneous and misleading.

2.2 DYNAMIC MODEL OF THE EKC THEORETICAL LITERATURE

Dynamic models have also been used to describe the Environmental Kuznets Curve. It is worthy of note that many modern studies are empirical in nature and as such do not dwell on theoretical literature. However, studies by John and Pecchenino (1994), Jones et al. (1995), Seldon and Song (1995), Stockey (1998), Anusuategi and Perrings (1999) etc explain the EKC by developing dynamic models of economies overtime.

The Overlapping generations model (OLG) are being captured in the first two studies who are of the opinion that environmental quality is a stock and finite resource in the economy. As the economy grows, the stock degrades unless investments are made to replenish it.

Authors	Model specification	Findings and results
John and Pecchenino (1994)	Dynamic Overlapping generation model where environmental quality is captured in utility	*At low income levels, zero-maintenance may be optimal. As income increases, higher capital stock may be associated with higher environmental quality resulting in the EKC*
Jones and Manuelli (1995)	Dynamic Overlapping generation model where pollution enters utility and is a by-product of capital. Pollution taxes and standards are specified and producers have a choice of input efficiency and pollution emissions.	*Optimal taxes and standards will cause producers to choose less intensive inputs overtime. This leads to the EKC*
Seldon and Song (1995)	Dynamic infinite horizon growth model where pollution stock is affected by capital abatement and affects welfare.	*As income increases, preferences and increasing returns to pollution*

		abatement technologies may cause an EKC to exist.
Stokey (1998)	Dynamic infinite horizon two country growth model where pollution enters utility and is a by-product of production. Technological restrictions cause less pollution per unit output.	*There is a critical level where technological restrictions come into effect. This is the turning point of the EKC.*
Ansuategi and Perrings (1999)	Dynamic infinite horizon, two country growth model where pollution (affected by capital) enters utility and may have cross-boundary effects. Pollution abatement effects are specified.	*EKC is less likely when transboundary pollution externaltities predominate.*

The relationship between economic growth and environmental pollution is rather complex to say the least having been appreciable and numerous research efforts on the relationship between environmental quality and economic growth especially in developed countries although with limited works in Africa (Nigeria inclusive). The results from these existing studies as regards the EKC have been mixed and diverse.

Some scholars (Grossman & Krueger, 1991; Selden & Song, 1994) have found evidence supporting the EKC, while others hold a contrary view (Gershuny & Weber, 2009; Saboori & Soleymani, 2011). The EKC offers some explanatory power demonstrating the linkage between economic growth and its effects on environmental pollution. It suggests that as income increases, environmental degradation increases first at an increasing rate and then at a decreasing rate.

Grossman (1995) noted that the inverted 'U-shaped' pattern in the EKC hypothesis arises as a result of the joint effects of the *scale of the economy*, its *composition* and *technology*. Initially, there was an assumption that the relationship between economic growth and environmental degradation was monotonic ignoring the widely-held belief that economic growth leads to environmental degradation.

2.3 EMPIRICAL LITERATURE

A number of empirical studies in the early 1990s however established the existence of a non-monotonic, inverted-U shaped relationship between a number of pollutants such as CO_2, Sulphur Dioxide and income therefore suggesting a dynamic relationship between the environment and growth along the course of economic development (Larson et al., 2012).

In addition, a dual relationship exists between sustainable development and climate change as concluded by the Intergovernmental Panel on Climate Change (2007) fourth assessment report. The EKC hypothesis was attributed largely to behavioural factors: as income rises the effective demand for environmental quality rises and eventually overwhelms any scale effects of economic growth on pollution (Stern, 2004). At higher levels of economic development, there will be a structural change in the economy coupled with increased environmental awareness, enforcement of environmental regulations and better technology.

Shafik and Bandyopadhyay (1992), Heitage, Lucas and Wheeler (1992), Panayotou (1994), Shafik (1994), Cropper and Griffiths (1994) and Holtz-Eakin and Selden (1995) and a host of other researchers adopted the econometric technique since it was generally believed that economic theory provided no structure for the EKC analysis.

All empirical studies such as the aforementioned specify a reduced-form equation that includes a dependent pollution variable, independent quadratic/cubic GDP capita value.

These can lead to a gradual decline of environmental degradation. Conversely, if there are no changes in the structure of technology or scale of the economy, there would be higher forms of environmental pollution from economic activities.

Ravallion et al. (2000) pointed out that development processes that are essentially resource-driven will depend on how well a society manages its resources in order to avoid or encourage pollution. Panayotou et al (2000) investigates the role that policies and institutions play in influencing environmental quality and discovered that better governance and policies make a moment improving environmental quality. Thus, policies and institutions that focus on development will also affect environmental pollution.

The role of strengthened institutions in reducing the environmental impact of Multinational Corporations has recently been stressed in Osabuohien et al. (2013) that environmental hazard occurs at a decreasing rate when strong environmental policies are implemented. Assessing the robustness of different parametric analyses conducted and using alternative emissions data, Galeotti et al. (2006) finds that EKC does not depend on the source of data with respect to CO_2 and provide evidence of EKC for Organization for Economic Co-operation and Development (OECD) countries but not for non-OECD countries.

Similarly, Lipford and Yandle (2010), focusing on G8 and five developing countries assess the relevance of EKC and their findings raised doubts about the feasibility of reducing global CO_2 emissions with improvement in income.

Taguchi (2012) found that sulphur emissions follow the expected inverted-U shape while CO_2 tends to increase in line with increase in per capita income. Furthermore, Rothman (1998) using a variety of environmental indicators finds that CO_2 emissions and municipal waste do not tend to decline with increasing per capita income. Efforts to test the hypothesis using cross-sectional data have been criticized as misleading (Stern, 2004). The trend of methods used in testing EKC has evolved from the simple quadratic functions used in early studies of Grossman and Krueger (1991) to the application of panel data methods as in Perman and Stern (2003).

Perman and Stern (2003) employ panel unit root and cointegration tests and find that there is a long-run relationship between sulphur emissions and GDP per capita.

Furthermore, Coondoo and Dinda (2002) used CO_2 and found similar results that in developed countries causality runs from emissions to income while in developing countries there is no significant relationship. To buttress this, Villanueva (2012) assessing the impact of institutional quality on the environment employing World Governance Indicators (WGI) of the World Bank found support for EKC hypothesis using CO_2 emissions as a measure of environmental change for the period 1985–2005.

2.4 RECENT EMPIRICAL LITERATURE ON THE EKC

This mainly relates to the sophistication of methodology in recent studies on the EKC. Examples of these studies include those carried out by Panayotou et al (2000), Dinda (2002), Perman and Stern (2003), Galleotti et al (2006), Lipford and Yandle (2010), Akpan and Chuku (2011), Taguchi (2012), Osabuhien et al (2013) among other works numerous to cite here.

Generally, the results obtained from this studies which was initially aimed at improving the methodology and analysis of the Kuznets curve tend to cast aspersion on the reliability of previous EKC studies.

For example, Dijkgraaf and Vollenbergh (1998), Stern (1998), Perman and Stern (1998) attempted to compare pooled/cross-sectional data results in relation to results obtained from time-series while Cole et al (1997), Moomaw and Unruh (1997) Roberts and Grimes (1997) and List and Gallet (1999) found evidence supporting the proposition that substituting time series data for cross/sectional data or replacing world data with regional/country data leads to different turning points of the EKC and in some cases no establishment of turning point at all for the Environmental Kuznets Curve.

Furthermore, other studies also were devoted to correcting statistical and econometric flaws in previous works and extant empirical literature. The studies found out that Environmental Kuznets curve is highly dependent on functional forms and that omitted variables could also tend to affect the shape of the curve. This is consistent with the works of (Hilton and Davidson, 1998), Harbaugh et al (1998), Koop and Tole (1998), Galeotti and Lanza (1999) etc.

Osabuhien et al (2013) and Akpan and Chuku (2011) established that a long-run relationship exists between indicators of environmental pollution (CO_2 and Premium motor spirit emissions), per capita income and its square, institutional variable and trade thus denoting the possibility of chosen explanatory variables converging with environmental pollution in the long run. *This implies that jointly, institutional quality, trade and economic development can explain the extent of environmental pollution parameters in the long run* which therefore validates the existence of the EKC hypothesis in Africa.

CRITIQUE OF RECENT EMPIRICAL LITERATURE

Recent empirical literature exhibits large and swing in estimation results. Some studies establish EKC result for specific data and geographical locations while others find N-shaped results, U-shaped relationships and in some cases, no relationships at all.

Monotonic relationships between output represented by Gross Domestic product and different forms of pollution also do occur periodically.

Reduced-form studies most at times lack policy implications as found in the overlapping generations model hence cannot really be used for policy purposes implying that some works existing on the subject matter is merely academic and intellectual.

Some pollutants tend to rise with income increase hence are increasing functions of income and subsequently, damages caused by these pollutants may not be reversible if pollutants tend to be accumulated in forms of stocks over a period of time.

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