The long run relationship between economic growth and environmental quality

Abstract

One of the controversial debates in environmental economics, which began in the 1990s, is the relationship between environmental pollution and economic growth. We have investigated the relationship between per capita CO_2 emissions and GDP per capita in 63 countries over 51 years during 1960 to 2010. Using a graphical analysis approach, the results of this study showed that the relationship between per capita CO_2 emissions and GDP per capita amongst the sample data followed a sigmoid curve indicating that the per capita CO_2 emissions of a country increased when its economy transitioned from a labor-intensive technology to a capital-intensive one caused by an increase in the rate of economic growth. The results also showed that the amount of relative emissions varied amongst the countries. The variability could be imputed to the following reasons: (*i*) the heterogeneity in the structure of the economies, and (*ii*) the disparity in the mode of production used in the countries' manufacturing processes.

Comment [u1]: Contradicts U6below

Comment [u2]: The study

Comment [u3]: Full meaning. Do not abbreviate terms in abstract.

Comment [u4]: Same as U

Keyword: Sigmoid curve, CO_2 emissions, economic growth, economic structure, mode of production

JEL Codes: O40, Q50, Q56.

Comment [u5]: JEL Classification

Introduction

The industrial revolution resulted not only in rapid economic growth but also in increased environmental pollution (Kasman and Duman, 2015). The effects of the revolution, however, influenced the quality of human life in different ways. While global warming, climate change and the negative impact of environmental pollution can bring many complications to human life, economic growth is the most important precondition for economic development (Pettinger 2009, Rodrik 2014). As a result, researchers have been interested in discovering the relationship between economic growth and environmental pollution since the 1980s (Balibey 2015; Lacheheb et al. 2015; The United Nations 2016).

Comment [u6]: Contradicts U1 above

Carbon dioxide (CO_2) is considered one of the major pollutants contributing to climate change (Center for Climate and Energy Solutions 2013,; Environmental Protection Agency 2015,; Lacheheb et al. 2015), which has recently caused widespread impacts on the natural and human systems (IPCC, 2014). The impacts include, but are not limited to, altering hydrological systems, affecting water resources in terms of quantity and quality, impacting the biological activities of many species, and crop yields. It has been forecasted that there will be an increase in global temperatures - from 1.1 to 6.4 degrees Celsius due to increases in CO_2 emissions and other greenhouse gases (GHG) emissions. As a result, sea levels are projected to rise from 16.5 to 53.8 cm by the year 2100, which will cause diverse socio-economic complications in many coastal areas (IPCC 2007; Lacheheb et al., 2015). Though CO_2 emissions originate from both anthropogenic and natural sources, it is believed that human activities are responsible for altering the carbon cycle – both by increasing the concentration of CO_2 in the atmosphere and by lowering the earth's capacity to absorb CO_2 from the atmosphere (Environmental Protection Agency 2015, Phys 2015). The level of anthropogenic CO_2 emissions of a country depends on different factors such as the intensity of economic activity and the mode of production, the consumption level of the population, and the stringency of environmental regulations (Luptfáčik and Schubert 1982).

Comment [u7]: Remove

Comment [u8]: Remove

Comment [u9]: Remove to avoid too frequent usage.

Comment [u10]: Add unit of measurement

Comment [u11]: Use ; instead of ,

Countries vary in their modes of production, the level of output and consumption, and the level of CO_2 emissions. Economic growth is often accompanied by an increased demand for durable goods, which results in even more CO_2 emissions (EXEC 2015). It could be further extended that the relationship between consumption and CO_2 emissions implies that the more durable and non-durable goods a nation consumes, the higher is the level of its CO_2 emissions. The consumption level of a country depends primarily on its own production and partially on its imports from the rest of the world (Chacholiades, 1990). When a country specializes in export-based growth, it will have a comparative advantage in producing pollution-intensive output if its level of environmental regulations is weaker than the average (Cole and Elliott 2003). Since there is a strong positive correlation between the per capita income level of a country and the stringency of its environmental regulations developing countries will specialize in pollution-intensive production whilst developed countries will specialize in clean production due to comparative advantage (Cole and Elliott 2003). The same conclusion was supported by Shahbaz et al. (2012) who explained how environmental quality in Nigeria decreased substantially due to higher levels of pollution-intensive output production under the trade openness regime. In addition, many developing countries are addressing their pollution problems through formulating effective environmental policies, with or without the help of developed countries and/or international organizations like the United Nations Environment Program (Dasgupta et al. 2006). By adopting standards that exist in developed countries and by implementing them in society, these countries often perform better than developed countries (Stern 2004, Dasgupta et al. 2006). For example, Costa Rica received the 2010 Future Policy Award issued by the World Future Council for pioneering legal protection of biodiversity, which served as a model for other nations to follow (Theguardian 2016). Therefore, it cannot be maintained that all developing countries are lagging in formulating effective environmental policies.

Comment [u12]: Refer to u11

In formulating environmental policies, the main objective of policy makers varies by country. For instance, while reducing energy consumption as a means to reduce CO_2 emissions is important in developed countries, it is unrealistic to expect all developing nations to have the same goal, as their primary objective is to raise their standard of living rather than environmental quality (Han and Chatterjee 1997). Once a developing country starts its industrial development process, it will continue struggling to sustain its sustainable economic development as its ultimate goal. It is evident that the nature of a country's economy changes from a traditional economy (i.e., based on labor intensive technology) to a modern one (i.e., based on capital intensive technology). For each country, the transition period implies a change in the pattern of the relationship between CO_2 emissions and economic growth. Such a relationship is important in the domain of environmental policy where it allows policy makers to judge the impacts of economic activities on the environment, thereby enabling them to formulate effective conservation policies for sustainable development (Narayan and Narayan 2010).

The main objective of this research is to demonstrate the most likely pattern of the long run relationship between economic growth and CO_2 emissions of a country as it changes its mode of production from a labor intensive technology to a factor neutral economy (i.e. neither more labor nor more capital employed into the production process), and, ultimately, to a capital intensive technology because of its economic progress. The findings of the paper may benefit policy makers in formulating policies to facilitate long run sustainable development. The paper is organized as follows: after a survey of existing literature, the research methods are introduced followed by data analysis and a discussion, and a conclusion.

Comment [u13]: Reconstruct this section. Start it in a paragraph

Literature review

It is a general consensus that human economic activities appear to be the main reason for deteriorating environmental quality through emissions of anthropogenic GHGs such as CO_2. However, it is an interesting but unsettled debate in environmental economics whether economic growth is deteriorating or ameliorating the quality of the earth's environment (Grossman and Krueger 1994). On one hand, researchers argue that environmental pollution comes in many shapes and forms (e.g. SO_2, CO_2 emissions) and is positively correlated with economic growth (e.g., Shafik 1994, Holtz-Eakin and Selden 1995, Heil and Selden 2001, Bertinelli and Strobl 2005, Chen and Huang 2013). On the other hand, several researchers consider that economic growth is necessary to conserve the long run sustainability of the natural environment meaning that economic resources must be invested in research and development to discover pollution abatement technologies and in sustainability programs aimed at conserving the environment. In order to understand the debate, proper specification and justification of the relationship between environmental pollution and economic growth is required (Azomahou et al. 2006, Kijima et al. 2010, Narayan and Narayan 2010).

Comment [u14]: Refer to u11

Comment [u15]: Refer to u11

Using various methods, researchers have attempted to estimate the relationship between environmental pollution and economic growth by taking into account some figures such as GDP, GDP per capita and/or per capita national income and information on various pollutants such as emissions of CO_2, nitrogen oxide (NO_x), sulfur dioxide (SO_2) and suspended particulate matter (Grossman and Krueger 1994, Bo 2011). As mentioned earlier our focus will be on CO_2 emissions in this paper. The findings of most researches show no consistent relationship between CO_2 emissions and economic growth. However, in numerous studies the nexus is found as an inverted *U*-shaped curve that is known as the Environmental Kuznets Curve (EKC). The EKC shows that at the beginning of a country's economic development, environmental degradation rises and then it levels off and, eventually, falls with continuous economic growth (e.g., Azomahou et al. 2006, Galeotti et al. 2006). The findings imply that poorer nations, as they begin their economic growth process, pollute more while richer nations are cleaner due to their ongoing economic development. Chen and Huang (2013) described the relationship as a monotonically increasing or a non-declining one implying that higher levels of economic activity require the use of more natural resources (e.g. coal, oil, gas, etc.) which results in more CO_2 emissions. On the other hand, Sengupta (1996) and De Bruyn and Opschoor (1997) found the relationship to be a *N*-shaped curve meaning that environmental quality started falling again after an improvement to a certain level, Roy and van Kooten (2004) discovered the relationship followed a non-inverted *U*-shaped curve, and finally, Lacheheb et al. (2015) did not find the existence of any inverted *U*-shaped curve.

The relationship varies across countries, especially between developed and developing countries. Using different datasets collected by the Organization for Economic Cooperation and Development (OECD) and the non-OECD countries, Galeotti et al. (2006) examined the relationship between CO_2 emissions and income level and found that the inverted *U*-shaped curve only applied for the former group. Lapinskienė et al. (2014) found the inverted U shaped nexus for 29 European countries whereas Huang et al. (2008) could not provide any evidence to support the same relationship for developed countries. In order to test the validity of the inverted U shaped relationship for developing countries, Apergis and Ozturk (2015) conducted empirical tests for 14 Asian countries, using data that were collected from 1990 to 2010 and found the relationship across these countries to be valid. Narayan and Narayan (2010) tested the relationship for 43 developing countries and found an inverted U shaped relationship for only a few Middle Eastern and South Asian countries. The pattern of the relationship between pollution and economic growth that is mostly reported in the literature is an inverted U shape. According to the pattern, environmental degradation in a country starts to fall when its per capita GDP reaches a turning point at 3,137 USD (Panayotou, 1993) or a per capita income of less than 8,000 USD (Grossman and Krueger 1994). In recent years, the GDP per capita of developed or high-income countries (HICs) has increased beyond the turning point. However, both real GDP per capita as well as per capita CO_2 emissions continue to increase (Ang 2008), disproving the hypothesis of *pollution-income progression of agrarian communities (clean) to industrial economies (pollution intensive) and to service economies (cleaner)* (Arrow et al. 1996). More importantly, as Holtz-Eakin and Selden (1995) and Roberts and Grimes (1997) stressed out the EKC or the inverted U shape relationship does not describe CO_2 emissions in a meaningful way, as these emissions have been commonly used as the proxy for the level of pollution in the existing literature. Furthermore, the EKC does not exist in the long run (De Bruyn et al. 1998, Dinda et al. 2000). Therefore, an attempt is necessary to estimate the long run relationship between CO_2 emissions and economic growth, which may enable policy makers to formulate policies facilitating long run sustainable development.

Research methodology

We used a graphical method and a line chart to explore the long run relationship between economic growth and CO_2 emissions in line with (see Törnros 2013). We placed the economic growth variable measured by GDP per capita on the horizontal axis and the CO_2 emissions variable measured by per capita CO_2 emissions on the vertical axis. All low-income countries are assumed to aspire to transition from a low-income status to a middle-income status and then a high-income status by means of economic growth. Countries are classified as high, middle and

Comment [u16]: The study

Comment [u17]: remove

Comment [u18]: correct it

low-income following the most recent UN country classification list (The United Nations 2014). However, in the study, the lower middle and low-income countries defined on the list are combined as one low-income country category.

For exploring the pattern of the long run relationship, data on both variables are required over a period long enough to cover an entire transitional phase. An entire transitional phase can be explained as a period when a previously low-income country which is currently a high-income country managed to transform its economy from a traditional economy based on labor power mostly to a modern economy based on machineries because of economic progress. What has generally been the time frame for a developing low-income country to become a high-income country? Some countries took more than a hundred years and others needed less than a hundred years to become high-income countries from their initial low-income position. Currently, no database provides time series data on per capita CO_2 emissions and GDP per capita for any country before 1960 (Törnros 2013). This limitation may be overcome if an assumption is made following Rostow's (1959) theory on the stages of economic growth. The assumption is that every country – either low or middle-income or both - follows a growth path similar to what the current developed countries had experienced prior to becoming high-income countries, since both low and middle-income countries desire to become high-income countries. This assumption is in line with Han and Chatterjee (1997) who argued that developing countries should pursue the strategies used by advanced economies to develop theirs.

The per capita CO_2 emissions data are plotted against the corresponding GDP per capita for all three categories of countries – low, middle and high-income in a same diagram. Thus, the first segment of the chart represents the relationship between these two variables for a low-income country whose mode of production is labor intensive; the middle fragment is for a middle-income country which follows a factor neutral mode of production, and the last segment is for a high-income country whose mode of production is capital intensive, respectively. The resulting combined line chart will specify the most likely pattern of the long run relationship between economic growth and CO_2 emissions of a country when it improves its economic status from a low-income country to a middle-income country and then to a high-income country, following a change in its mode of production from labor intensive to factor neutral and then to capital intensive, respectively. However, before exploring the long run relationship, an analysis of the recent per capita CO_2 emissions trends in the countries belonging to all three categories is necessary.

Comment [u19]: Rewrite Methodology. It lacks clarity

Data description

The study depends largely on secondary sources for data collection. Data on both GDP per capita and per capita CO_2 emissions have been collected from the World DataBank website (World Bank 2016). Data on both variables have been collected over 51 years from 1960 to 2010 and for 63 countries comprising 25 low-income (LICs), 16 middle-income (MICs), and 22 high-income countries (MICs). Only 63 countries have been selected due to availability of full data sets for these countries over the period. These 63 countries are listed as: low-income countries (LICs) - Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, Côte d'Ivoire, Ghana, Guatemala, Honduras, Kenya, Liberia, Madagascar, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Papua New Guinea, Philippines, Rwanda, Sierra Leone, Sri Lanka, Togo and Uganda; medium-income countries (MICs) - Algeria, Brazil, Chile, China, Costa Rica, Dominican Republic, Ecuador, Gabon, Jamaica, Mexico, Panama, Peru, South Africa, Suriname, Thailand and Turkey. And high-income countries (HICs) - Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Netherlands, Norway, Portugal, Singapore, Spain, Sweden, UK and USA. In order to plot the data on a graph, the panel data have been converted into time series data by taking the average of values of same category countries (i.e., LICs, MICs and HICs) across the 51-year period.

Empirical findings and discussion

Table 1 shows a summary of statistics of GDP per capita and per capita CO_2 emissions for all the three categorized countries. In addition, Figure 1 exhibits trends in per capita CO_2 emissions for all three categories of countries – LICs, MICs and HICs - over the last five decades. It is evident that the per capita CO_2 emissions in all categories of countries rose with per capita GDP overtime. Unlike the rate of change of the per capita CO_2 emissions in HICs, the rate of the per capita CO_2 emissions in both MICs and LICs was much higher in 2010 compared to that in 1960. However, HICs emitted higher levels of per capita CO_2 emissions than the MICs and LICs.

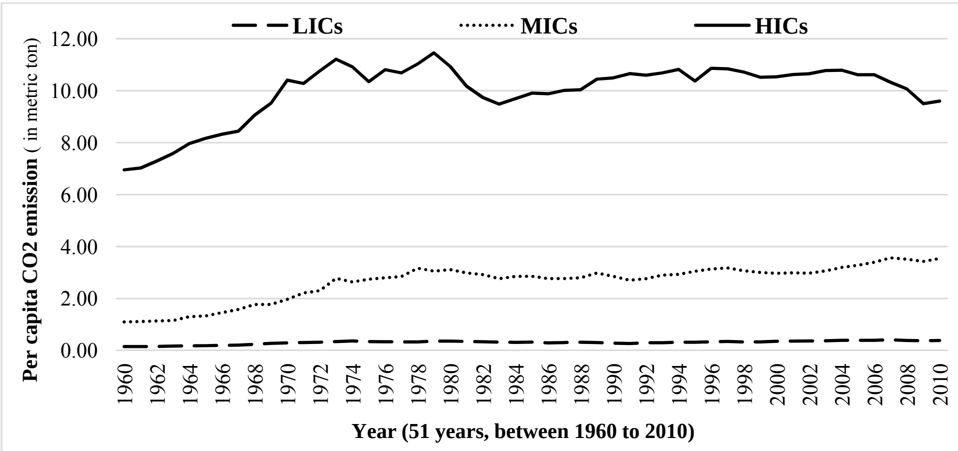
Table 1. Summary statistics of GDP per capita and per capita CO2 emissions (1960-2010)

Range of values								
	For GDP per capita (in US$)				**For per capita CO_2 emissions (in metric tons)**			
Country	**1960**	**2010**	**Min**	**Max**	**1960**	**2010**	**Min**	**Max**
LICs	122.99	1208.13	122.99	1208.13	0.15	0.39	0.15	0.41
MICs	307.70	7381.72	300.88	7381.72	1.10	3.54	1.10	3.56
HICs	1262.91	47313.74	1262.91	51420.19	6.95	9.60	6.95	11.46

Source: The World Bank.

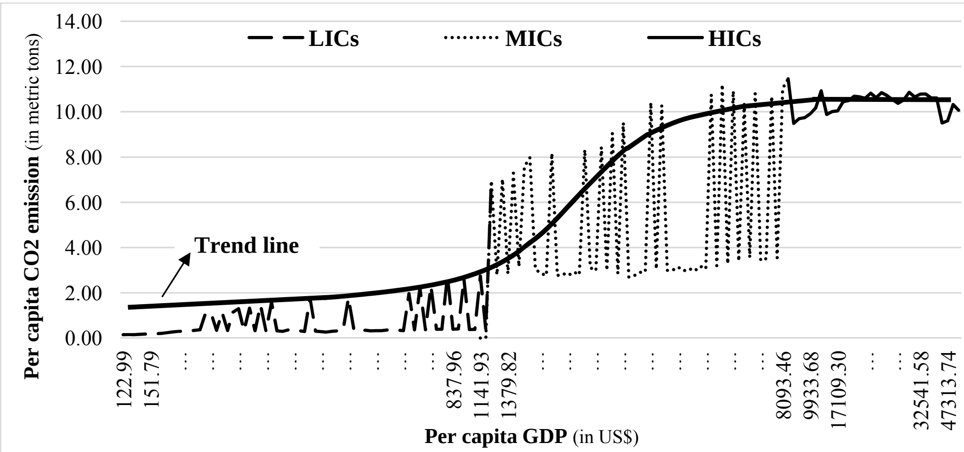
The increase in per capita CO_2 emissions in all groups of countries occurred primarily due to expanding economic activities, since output is positively correlated with pollution in the long run (Han and Chatterjee 1997; Ang 2008). These results indicate that emissions rise monotonically with output. Other precedent studies reported similar findings (e.g., Shafik 1994, Holtz-Eakin and Selden 1995). Among the three groups of countries, per capita CO_2 emissions in HICs experienced significantly more fluctuations, especially a continuous rise until 1973 and then an overall decline, with some modest fluctuations. The nature of the fluctuations in HICs' per capita CO_2 emissions raises the question what initiatives had been taken by developed countries before 1973 to reduce the overall per capita CO_2 emissions trend, or even to level it off in later periods? Developed countries began formulating and implementing environmental policies vigorously since the 1960s. Andrews (2006) stated that the end of the1960s could be marked as the beginning of the modern environmental policy-making era. In the USA, the Environmental Protection Agency (EPA) was established in 1970 to protect all Americans from significant risk to human health and the natural environment (EPA, 2016). The U.S. president at the time, Richard Nixon, signed the Clean Air Act in 1970. This act marks another milestone for environmental conservation in the USA. In Europe, the EU Council of Environmental Ministers adopted the very first Environmental Action Program in 1973 and since then the EU environmental policy has become a core area of European politics (Knill and Liefferink 2012). Other developed countries along with global organizations have undertaken initiatives to conserve the natural environment, aiming to protect all living beings from significant risk**.** All of these initiatives contributed to the leveling off or the falling trend in per capita CO_2 emissions in HICs in the 1980s and onwards.

Figure 1. Trends in per capita CO_2 emissions of LICs, MICs and HICs over the last five decades



The line chart in Figure 2 is derived by plotting per capita CO_2 emissions data against the corresponding GDP per capita. The trend line of the chart is a curve, similar to a sigmoid curve. The curve shows a monotonically increasing relationship between per capita CO_2 emissions and GDP per capita. This is compatible with the findings of Shafik (1994) and Holtz-Eakin and Selden (1995). However, the distinctive feature of the curve is its two wiggles, which split it into three segments. The first segment represents the per capita CO_2 emissions of LICs, which was at a lower level with a gradual increase. The traditional economies of the LICs were mostly dependent on agricultural activities, which employed more labor than capital (Han and Chatterjee 1997). Less capital use in the production processes consumed less fossil fuel, which resulted in lower levels of per capita CO_2 emissions. Structural change is essential for these traditional economies, without which modern economic growth would not be possible (Kuznets 1971). However, the structural shift from a rural, and predominantly agricultural, economic base, to a manufacturing one resulted in increasing energy demand (Han and Chatterjee 1997), and therefore a gradually increasing rate of per capita CO_2 emissions. The middle segment shows a dramatic rise in the per capita CO_2 emissions of the MICs. Industrialization was emphasized highly in developing countries to accelerate economic growth aiming to improve the standard of living of the societies in the region (Han and Chatterjee 1997). The ongoing industrialization required a continuous process of capital formation for higher economic growth. According to Solow's theory of economic growth, countries invest more resources in their physical capital aiming to realize their potential economic growth, since an increase in the stock of physical capital results in higher growth rate both in the short run and in the long run (Solow 1956, Bond et al. 2010). Since industrialization in the MICs resulted in a substitution of labor by machines, the MICs were becoming more and more energy intensive, and the corresponding per capita CO_2 emissions rate was rising higher and higher. The last segment represents the higher level of per capita CO_2 emissions in the HICs. Developed economies are highly industrialized. Industrial revolution in these countries transformed their economies from organic economies based on labor power to inorganic economies based on fossil fuels (Kasman and Duman 2015). Developed countries use more physical capital or capital-intensive techniques in manufacturing output (Cole and Elliott 2003). Capital-intensive techniques are more pollution-intensive since more fossil fuels are necessary to operate machineries in the production process (Gradus and Smulders 1993). Therefore, the use of capital-intensive techniques was one of the main reasons for which the HICs emitted a higher level of per capita CO_2 emissions.

Figure 2. The long run relationship between per capita CO_2 emissions and GDP per capita



In examining how the findings of this research compare with other findings available in the large body of literature about the relationship under consideration, we have found both similarities and dissimilarities. The most reported shape of the relationship is an inverted *U*-shaped curve. The left segment of an inverted *U*-shaped curve before its turning point expresses a monotonically increasing relationship between environmental pollution and economic growth of a country when it was a developing country. The first and second segments of the sigmoid curve depict a similar increasing relationship in the case of developing countries. On the other side, the right segment of the inverted *U*-shaped curve after its turning point, which implies environmental degradation, is declining when a country becomes developed. However, the last segment of the sigmoid curve depicts a leveling off in the pollution trend for developed countries. Other empirical findings had shown that the per capita CO_2 emissions of developed countries were much higher, but the trend was either leveling off or slightly declining (Olivier et al. 2015). As mentioned earlier, the findings of our research are compatible with other researches (see, Shafik 1994, Holtz-Eakin and Selden 1995**,** Heil and Selden 2001, Bertinelli and Strobl 2005, Chen and Huang 2013). In comparison with the *N*-shaped curve (Sengupta 1996, De

Bruyn and Opschoor 1997), initially both findings provide a similar relationship that is increasing. After that, these findings vary with each other. In fact, the sigmoid curve shows a significantly unique relationship between the per capita CO_2 emissions and the GDP per capita in the long run. The sigmoid curve indicates that all three categories of countries emitted increasing amounts of per capita CO_2 overtime, but that the relative emissions varied by category or country. This can be explained by the fact that different countries adopted different modes of production and produced different levels of output. They also emitted different levels of CO_2 emissions. Limiting emissions while encouraging growth is necessary for sustainable development, but it is challenging. Investment in green technologies and in human capital rather than in fossil fuel technologies may be a good policy towards sustainable development. Green technologies consume less fossil fuels and more renewable energy, and are more labor-intensive. Formulating and implementing a consistent environmental policy is another factor facilitating the process towards sustainable development through limiting pollution. Therefore, investment in green technologies and human capital along with proper environmental policy design and implementation may make the curve flatter or change the direction of the curve and make it downward sloping, meaning that more output is being produced while limiting emissions.

Conclusion

The most likely pattern of the long run relationship between per capita CO_2 emissions and GDP per capita is a sigmoid curve. The curve shows that per capita CO_2 emissions begin rising gradually from an initial low level and then reach a higher level following a dramatic increase. According to the curve, all three categories of countries emit per capita CO_2 increasingly overtime, but their relative emissions vary. The variation in relative emissions is due to heterogeneity in both the structure of their economies as well as the mode of production used in their manufacturing processes. The findings of the paper are significantly unique; however, they are consistent, in varying degrees, with other findings of previous studies. Effective environmental policy implementation along with investment in green technologies and human capital may change the direction of the curve and make it downward sloping. Panel data in the study have been converted into time series data by using the average of values for same category countries. The average measure is convenient to provide a general view; however, it cannot provide an in-depth view of all countries under consideration. Development strategies vary by countries. For various reasons, developing countries may not require fulfilling all of the five stages of Rostow's economic growth model to improve their economic status. Australia, Canada and the U.S. are good examples, because they did not pass through the five stages of the growth model.

References

Andrews, R. N. (2006), *Managing the environment, managing ourselves: A history of American environmental policy*, Yale University Press: New Haven, Connecticut, U.S.A.

Ang, J. B. (2008), "Economic development, pollutant emissions and energy consumption in Malaysia," *Journal of Policy Modeling*, Vol.30, No.2, pp.271-278.

Apergis, N. and I. Ozturk (2015), "Testing environmental Kuznets curve hypothesis in Asian countries," *Ecological Indicators*, Vol.52, pp.16-22.

Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C. S. and D. Pimentel (1996), "Economic growth, carrying capacity, and the environment," *Environment and Development Economics*, Vol.1, No.1, pp.104-110.

Azomahou, T., Laisney, F. and P. N. Van (2006), "Economic development and CO_2 emissions: a nonparametric panel approach," *Journal of Public* Economics, Vol.90, No.6, pp.1347-1363.

Balibey, M. (2015), "Relationships among CO2 emissions, economic growth and foreign direct investment and the EKC Hypothesis in Turkey," *International Journal of Energy Economics and Policy*, Vol. *5*, No.4, pp.1042-1049.

Bertinelli, L. and E. Strobl (2005), "The environmental Kuznets curve semi-parametrically revisited," *Economics Letters*, Vol.88, No.3, pp.350-357.

Bo, S. (2011), “A literature survey on environmental Kuznets curve,” *Energy Procedia*, Vol.5, pp.1322-1325.

Bond, S., Leblebicioğlu, A. and F. Schiantarelli (2010), “Capital accumulation and growth: a new look at the empirical evidence,” *Journal of Applied Econometrics*, Vol.25, No.7, pp. 1073-1099.

Center for Climate and Energy Solutions (2013), *Main Greenhouse Gases*, Retrieved from the *World Wide Web*: http://www.c2es.org/facts-figures/main-ghgs (accessed on May 14, 2017).

Chacholiades, M. (1990), *International Economics*, 1st edition, Lincolnshire: UK, *McGraw Hill* Inc.

Chen, J. H. and Y. F. Huang (2013), “The study of the relationship between carbon dioxide (CO2) emission and economic growth,” *Journal of International and Global Economic Studies*, Vol.6, No.2, pp.45-61.

Cole, M. A. and R. J. Elliott (2003), “Determining the trade–environment composition effect: The role of capital, labor and environmental regulations, *Journal of Environmental Economics and Management*, Vol.46, No.3, pp.363-383.

Dasgupta, S., Hong, J. H., Laplante, B. and N. Mamingi (2006), “Disclosure of environmental violations and stock market in the Republic of Korea,” *Ecological Economics*, Vol.58, No.4, pp.759-777.

De Bruyn, S. M. and J. B. Opschoor (1997), “Developments in the throughput-income relationship: theoretical and empirical observations,” *Ecological Economics*, Vol.20, No.3, pp.255-268.

De Bruyn, S. M., van den Bergh, J. C. and J. B. Opschoor (1998), “Economic growth and emissions: reconsidering the empirical basis of environmental Kuznets curves,” *Ecological Economics*, Vol. 25, No.2, pp.161-175.

Dinda, S., Coondoo, D. and M. Pal (2000), “Air quality and economic growth: an empirical study,” *Ecological Economics*, Vol.34, No.3, pp.409-423.

Environmental Protection Agency (2016), *Our Mission and What We Do*. Retrieved from the *World Wide Web*: https://www.epa.gov/aboutepa/our-mission-and-what-we-do (accessed on May 14, 2017).

Environmental Protection Agency (2015), *Overview of Greenhouse Gases*, Retrieved from the *World Wide Web*: http://www3.epa.gov/climatechange/ghgemissions/gases/co2.htm (accessed on May 14, 2017).

EXEC (2015), *Charting Our Course: Climate Change Action Plan 2011*, Retrieved from the *World Wide Web*: http://www.exec.gov.nl.ca/exec/ccee/publications/climate_change.pdf (accessed on May 14, 2017)

Galeotti, M., Lanza, A. and F. Pauli (2006), "Reassessing the environmental Kuznets curve for CO_2 emissions: a robustness exercise," *Ecological economics*, Vol.57, No.1, pp.152-163.

Gradus, R. and S. Smulders (1993), "The trade-off between environmental care and long-term growth—pollution in three prototype growth models. *Journal of Economics*, Vol.58, No.1, pp.25-51.

Grossman, G. M. and A. B. Krueger (1994), *Economic Growth and the Environment*, Working paper No. w4634, National Bureau of Economic Research, Cambridge, Massachusetts, The United States, Retrieved from the *World Wide Web*: http://www.nber.org/papers/w4634 (accessed on May 22, 2017).

Han, X. and L. Chatterjee (1997), "Impacts of growth and structural change on CO_2 emissions of developing countries," *World Development*, Vol.25, No.3, pp.395-407.

Heil, M. T. and T. M. Selden (2001), "Carbon emissions and economic development: future trajectories based on historical experience," *Environment and Development Economics*, Vol.6, No.1, pp.63-83.

Holtz-Eakin, D. and T. M. Selden (1995), “Stoking the fires? CO_2 emissions and economic growth,” Journal of public economics, Vol.57, No.1, pp.85-101.

Huang, W. M., Lee, G. W. and C. C. Wu (2008), “GHG emissions, GDP growth and the Kyoto Protocol: A revisit of environmental Kuznets curve hypothesis, *Energy Policy*, Vol.36, No.1, pp.239-247.

IPCC (2014), “Summary for Policymakers,” In: *Climate Change 2014*: Mitigation of Climate Change, Contribution of Working Group III to the 5th Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)], Cambridge University Press, Cambridge, New York, USA, pp. 1-32.

IPCC (2007), “Summary for Policymakers,” In: *Climate Change 2007: The Physical Science Basis,* Contribution of Working Group I to the 4th Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, New York, USA.

Kahn M. E. (1998), “A household level environmental Kuznets curve,” *Economics Letters*, Vol. *59*, No.2, pp. 269-273.

Kasman, A. and Y. S. Duman (2015), "CO2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: A panel data analysis," *Economic Modelling*, Vol. *44*, pp. 97-103.

Kijima, M., Nishide, K. and A. Ohyama (2010), "Economic models for the environmental Kuznets curve: A survey," *Journal of Economic Dynamics and Control*, Vol.34, No.7, pp. 1187-1201.

Knill, C. and D. Liefferink (2012), "The Establishment of EU Environmental Policy," In: Jordan, A.J. and C. Adelle (ed.) (2012) Environmental Policy in the European Union: Contexts, Actors and Policy Dynamics (3e). Earthscan: London and Sterling, VA, pp.13-31.

Kuznets, S. (1971), *Economic Growth of Nations: Total Output and Production Structure*, Cambridge. MA: Harvard University Press.

Lacheheb, M., Rahim, A. S. A. and A. Sirag (2015), "Economic Growth and CO2 Emissions: Investigating the Environmental Kuznets Curve Hypothesis in Algeria," *International Journal of Energy Economics and Policy*, Vol. 5, No.4, pp. 1125-1132.

Lapinskienė, G., Tvaronavičienė, M. and P. Vaitkus (2014), "Greenhouse gases emissions and economic growth–evidence substantiating the presence of environmental Kuznets curve in the EU," *Technological and economic development of economy*, Vol.20, No.1, pp. 65-78.

Luptfáčik, M. and U. Schubert (1982), “Optimal economic growth and the environment,” In *Economic Theory of Natural Resources*, Eichhorn, W. et al. (Eds.): Physica-Verlag, pp.455-468.

Narayan, P. K. and S. Narayan. (2010), “Carbon dioxide emissions and economic growth: panel data evidence from developing countries,” *Energy policy*, Vol.38, No.1, pp.661-666.

Olivier, J. G., Janssens-Maenhout, G., Muntean, M. and J. A. H. W. Peters (2015), *Trends in global CO_2 emissions: 2015 report*, The Hague: PBL Netherlands Environmental Assessment Agency.

Panayotou, T. (1993), *Empirical tests and policy analysis of environmental degradation at different stages of economic development*, Working Paper No. 238, World Employment Programme Research, International Labour Organization, Geneva, Switzerland.

Pettinger, T. (2009), *Economic Growth and Economic Development*. Retrieved from the *World Wide Web*: http://www.economicshelp.org/blog/1374/economics/economic-growth-and-economic-development/ (accessed on May 14, 2017).

Phys (2015), “*As carbon emissions climb, so too has the Earth's capacity to remove CO2 from the atmosphere*,” Retrieved from the *World Wide Web*: http://phys.org/news/2015-05-carbon-emissions-climb-earth-capacity.html (accessed on May 14, 2017).

Roberts, J. T. and P.E. Grimes (1997), “Carbon intensity and economic development 1962–1991: a brief exploration of the environmental Kuznets curve,” *World development*, Vol.25, No.2, pp.191-198.

Rodrik, D. (2014), “The past, present, and future of economic growth,” *Challenge*, Vol. *57*, No.3, pp.5-39.

Rostow, W. W. (1959), “The stages of economic growth,” *The Economic History Review*, Vol.12, No.1, pp.1-16.

Roy, N. and G. C. van Kooten (2004), “Another look at the income elasticity of non-point source air pollutants: a semiparametric approach,” *Economics Letters*, Vol.85, No.1, pp.17-22.

Sengupta, R. (1996), “CO_2 emission–income relationship: policy approach for climate control,” *Pacific and Asian Journal of Energy*, Vol.7, No.2, pp.207-229.

Shafik, N (1994), “Economic development and environmental quality: an econometric analysis,” *Oxford economic papers*, Vol.46, pp.757-773.

Shahbaz, M., Lean, H. H. and M. S. Shabbir (2012), “Environmental Kuznets curve hypothesis in Pakistan: Cointegration and Granger causality,” *Renewable and Sustainable Energy Reviews*, Vol. 16, No.5, pp. 2947-2953.

Solow, R. M. (1956), "A Contribution to the Theory of Economic Growth," *The Quarterly Journal of Economics*, Vol.70, No.1, pp. 65-94.

Stern, D. I. (2004), "The rise and fall of the environmental Kuznets curve," *World development*, Vol.32, No.8, pp.1419-1439.

Taskin, F., & Zaim, O. (2000). Searching for a Kuznets curve in environmental efficiency using kernel estimation. *Economics letters*, *68*(2), 217-223.

Theguardian (2016), *Costa Rica recognized for biodiversity protection*, Retrieved from the *World Wide Web*: http://www.theguardian.com/environment/2010/oct/25/costa-rica-biodiversity (accessed on May 16, 2017).

The United Nations (2016), *Global Issues – Environment*, Retrieved from the *World Wide Web:* http://www.un.org/en/globalissues/environment (accessed on May 14, 2017).

The United Nations (2014), *Country classification – World Economic Situation and Prospects 2014*, Retrieved from the *World Wide Web*: http://www.un.org/en/development/desa/policy/wesp/wesp_current/2014wesp_country_classification.pdf (accessed on May 14, 2017).

Törnros, S. (2013), "Economic Development and Pollutants: Brazil's Economic Development," Jönköping University, Jönköping International Business School, Jönköping, Sweden.

World Bank (2016), *The WorldData Bank*, Retrieved from the *World Wide Web*:

http://databank.worldbank.org/data/home.aspx (accessed on May 19, 2016)