IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 15, Issue 9 Ser. II (September 2021), PP 27-34
www.iosrjournals.org

Empirical Study On The Environmental Kuznets Curve On CO_2 Emissions In France And Sweden

Polytimi Farmaki[1]
Apostolos Tranoulidis[2]
[1]*Department of Accounting and Finance, University of Western Macedonia, 50132 Koila Kozanis, Greece*
[2]*Department of Chemical Engineering, University of Western Macedonia| Bakola and Sialvera, Kozani, 50132, Greece*

Abstract:
Background*:*
The present study examines a theoretical approach to Kuznets environmental curve and has led to some conclusions about the overall growth - environment relationship. The Environmental Kuznets Curve (EKC) and related approaches to human-environment problems generally posit an inverted U-shaped relationship between environmental degradation and economic development since economic growth is proportionally related to rapid environment deterioration due to air pollution, deforestation, soil, water contamination, and several other factors.
Materials and Methods*: To assess environmental burden, we chose the carbon dioxide emission variable, as it holds the largest percentage among the Greenhouse Gas Emission while all environmental policies focus mainly on its reduction. The Gross Domestic Product variable was chosen for the study of the economic* ***development, as the most widespread and widely accepted measure of economic success.***
Results*: Analysis data was extracted from annual survey statistics referring to a period between 1960 and 2015 for Sweden and France. For both countries, the existence of the EKC was confirmed diagrammatically, showing similar behavior.*
Conclusion: *While EKC has several weaknesses and has been strongly criticized by a significant part of the academic community, it remains a useful econometric method to assess and forecast statistical correlation of pollutant emissions and economic growth.*
Key Word*:Kuznets Curve; Carbon Dioxide Emissions; Gross Domestic Product; water use*

Date of Submission: 01-09-2021 Date of Acceptance: 15-09-2021

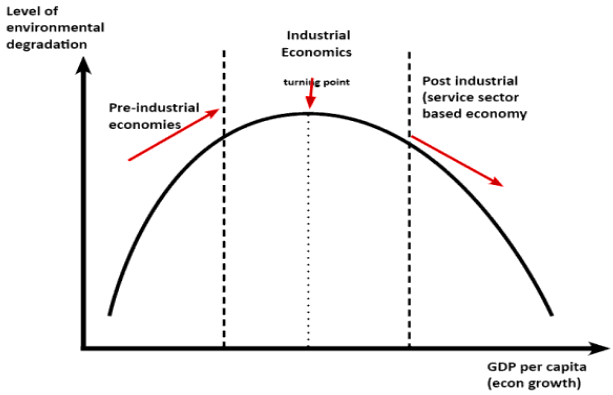
I. Introduction

Environmental Kuznets Curve (EKC) formulated by Kuznets in 1955 [1] involves the hypothesis of economic inequality over time and is one of the most celebrated hypotheses in the history of modern socio-economic sciences. According to Kuznets, economic growth in early stages is accompanied by increasing inequality, and, as development increases, incomes tend to be distributed to lower income classes. Thus, in the last stage of development, the inequality-development relationship is reversed, and there is a parallel increase in income per capita as well as a decline in inequalities.

An interesting modification of the specific economic inequality hypothesis in the field of environmental economics is Kuznets environmental curve. Based on the extant literature, the first application of Kuznets Curve in environmental studies was made by Grossman and Krueger [2] followed by Holtz-Eakin and Selten [3] and more recently by McKitrick and Strazicich [4] and Aldy 2006 [5]

EKC suggests that there is an inverted U-shaped relationship between economic growth and environmental degradation [6]. As shown in the following diagram, the vertical axis Y´Y reflects environmental degradation and the parallel axis X´X economic growth.

Figure 1 Kuznets Environmental Curve



According to Figure 1, the curve is divided in 3 stages:
1. In the first stage, there is a sharp increase in environmental degradation and a proportionally lower economic growth. This stage involves developing and pre-industrial economies.
2. In the second stage, environmental degradation is mitigated, and, after the turning point, starts to decrease, whereas economic growth is, in parallel, increased. This stage includes industrial economies and an increasingly high number of developed economies.
3. In the third stage, environmental degradation tends to decline, whereas economic growth increases at the same rate. This stage includes service-based developed economies.
To date, numerous empirical and theoretical surveys have been carried out on Kuznets curve, most of which are critical of the hypothesis, holding that EKC makes a very naive assumption. The present section examines the various criticisms, problems and research findings in relation to EKC.

II. A theoretical and empirical approach to EKC

There are various studies carried out to determine Kuznets curve and discover the relationship between economic growth and environmental impact. Aldy [7] asserts the existence of the curve, but suggests that further analysis be required, in view of a number of unbalanced factors. Stern [8] accepts the existence of EKC, and estimates the turning point in very high income levels ranging from 55,000 to 90,000 annual income per capita. Estimates demonstrate that poor and developing countries require a lot of time and high economic growth to enable awareness raising and substantial reduction of CO_2 emissions. The research findings demonstrate that it is not explicit that the emissions-income relationship contributes to a specific reduction of high emissions.

Eunho Choi et al. [9] investigate EKC in Central Asian countries, China, Japan and Korea, and discover major differences between them. The research demonstrates that in Korea the turning point occurs at 8,210 USD. However, there is a normal U relationship rather than a typical inverted U-shaped curve. As far as Japan is concerned, the research results demonstrate that Kuznets curve is N-shaped, that is, it displays an expected inverted U-shaped relationship, followed by an upward trend of the curve. Finally, in case of China, where there is an inverted N-shaped relationship between emissions and economic growth, the research findings reveal that economic growth alone is not sufficient for environmental protection, and also that the results of the EKC hypothesis are inconclusive.

Yaya Keho [10] holds that there is a Kuznets environmental curve, that is, CO_2 emissions increase during economic growth and start to decrease at a specific turning point. Katsuhisa Uchhiyama [11] verifies the existence of the Kuznets curve and finds that the turning point occurs at 30,000 USD. He also maintains that the Kyoto Protocol has had a limited impact on the global warming countermeasures, as most countries are on the left upper part of Kuznets curve, which implies they affect environmental degradation. The research suggests that financial support and know-how be provided to developing countries to reduce carbon dioxide emissions, which are usually due to application of outdated technologies. Finally, it is recommended that citizens should be educated on reducing emissions and become aware of the future impact of emissions.

The key assumptions related to EKC can be summarized as follows: First, the early stages of development include an exchange relationship between economic growth and environmental degradation; in addition, various environmental pollution types are inevitable during growth. However, in some cases, pollution may permanently affect and damage the environment. Second, as pollution increases, and causes permanent damage to the environment, exploitable resources are more difficult to be found and are, thus, more highly priced. Thirdly, by applying poor environmental protection policies, the proportional relationship between economic growth and environmental degradation is steadily unaffected.

Arrow et al. [12] were among those who first criticized Kuznets curve, by arguing that many empirical findings demonstrate that, although economic growth helps to improve environmental indicators, it is not sufficient for environmental improvement. In addition, they maintain that the environmental impact of economic growth could not be ignored and that environmental improvement and protection measures are vital.

Apart from Arrow et al. [12] other relevant research highlights the various problems related to Kuznets curve. More specifically, Kuznets curve is criticized for not taking into consideration:

A) The interdependence between economy and the environment, since empirical research examines income as an exogenous variable affecting the environment unilaterally; in effect, however, this is not a pertinent assumption, that is, environmental disaster will affect economic growth.

B) Other pollutant emissions, such as Sulfur Dioxide and Sulfur Trioxide (SO2, SO3), Nitrous Oxide, Nitric Oxide and Nitrogen Dioxide (N2O, NO, NO2), Carbon Monoxide (CO), Ozone (O_3), Methane (CH_4) , Hydrocarbons (HC), and disposal to other countries.

C) Several papers [13,14,15] have attempted to analyse if there is an environmental Kuznets curve for water use and concluded that there are limitations of EKCs in terms of water use policy and planning. Most of them find some support for the existence of an EKC, but results are highly dependent on choice of datasets and when using the water footprint as a dependent variable to explore the relationship between economic growth and water use, there is no evidence of an inverted-U trend.

D) Impacts on trade, as developing countries, where human and natural resources are relatively abundant, have a comparative advantage over developed countries in terms of high-pollution production. This, in combination with stricter environmental protection regulations in developed countries, forces large industries to move to developing countries, which offer more favorable economic growth conditions. However, environmental degradation in these countries is higher.

E) Differences in income distribution, which is globally variable, as the vast percentage in developing countries includes low-income populations. As a result, even if the existence of the EKC is established, global pollution ratios are expected to increase if economic growth of the countries in the upward part of the EKC curve tends to increase [16]

Relevant empirical research has identified several weaknesses in EKC, the most important of which is related to the hypothesis modeling. To date, there are only a few empirical studies established as theoretical approaches. In addition, simple regression models employ income per capita as an explanatory variable. Thus, it becomes difficult to assume economic interpretations about the value of estimated parameters, and, accordingly, there is a gap between theoretical and empirical findings.

However, the application of the specific model is vital, in view of data availability and quality for research and use. Several EKC analyses made with data panels display weaknesses and failures, as they view all countries in the same location and ignore a number of significant considerations, such as the physical and social conditions, which differ from country to country. In addition, a number of researchers have speculated about the methodology of panel data analysis. Dijkgraaf and Vollebergh [17] argue that estimating homogeneous parameters using panel data is problematic, and challenge the existence of EKC.

Greenhouse gas and Carbon dioxide emissions

For the last 150 years, the main aim of all human activity has been to optimize utility through the consumption of goods and to maximize profits. A result of this effort has been an increase in greenhouse gas emissions and the overall environmental burden. The most significant and dangerous increase is that of carbon dioxide, which is a by-product of the combustion of fossil fuels, such as coal, oil, gasoline, gas, and other organic compounds. Figure 2 shows the main greenhouse gases and their individual percentages. Carbon dioxide has the higher percentage with an overwhelming difference, amounting to an overall percentage of 76%, of which 65% comes from industrial activity and 11% from agricultural or similar activity. It is this overwhelming superiority which makes it the most dangerous greenhouse gas, and for this reason it is the subject of study in this research.

Figure 2 Global greenhouse gas emissions. Source, Intergovernmental panel on climate change 2014 [18]

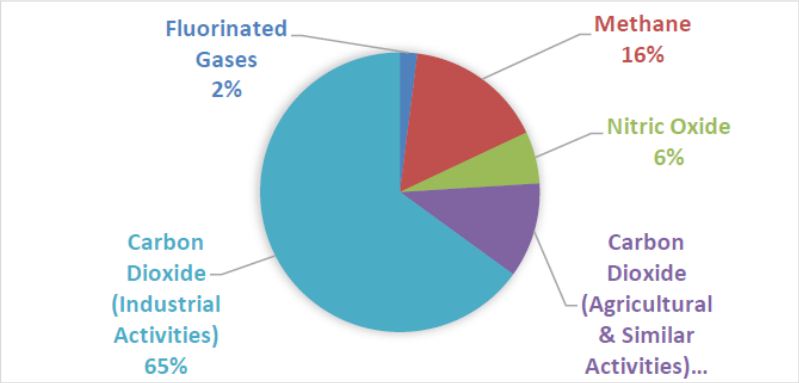


Figure 3. Global greenhouse gas emissions by economic sector. Source, Intergovernmental panel on climate change 2014 [18]

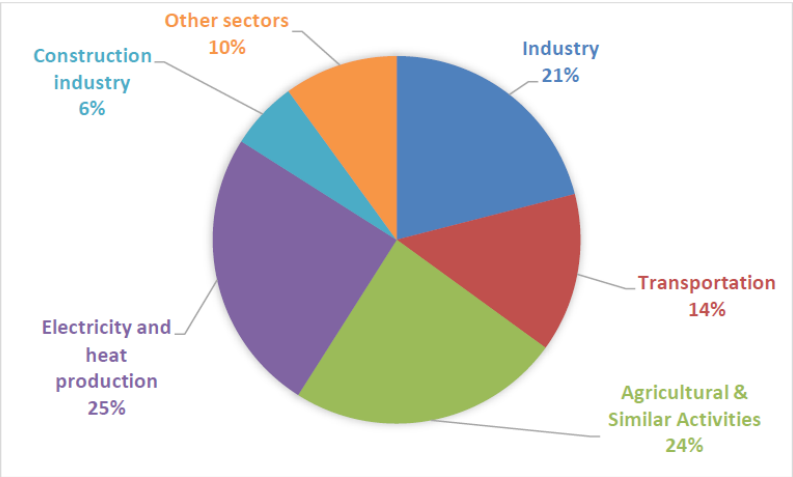
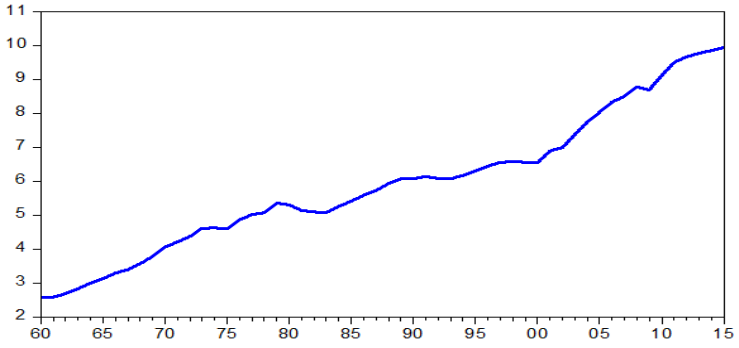


Figure 3 shows the economy sectors and the percentage they participate in the production of greenhouse gas emissions. The electricity generation sector (25%), the agriculture sector and other agricultural activities (24%), and the industry sector (21%) are the most important sectors in terms of greenhouse gas production, representing 70% of total pollutants. The year 2015 was marked by a historic event, the signing of a landmark agreement regarding climate change in Paris at the 21st COP21 forum [19] by 194 countries and the EU.

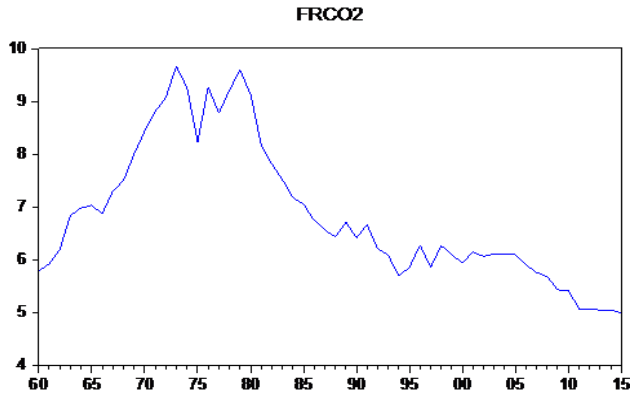
Carbon dioxide is a colorless and odorless gas substantially contributing to the greenhouse effect and global warming. It is not a typical major pollutant, as, at ordinary concentrations, it has no impact on health and does not react chemically to generate other air pollutants. However, carbon dioxide is the main greenhouse gas for which emissions limits have been applied. The following Figure 4 shows the increase of carbon dioxide emissions worldwide for the period from 1960 to 2015.

Figure 4 Increase in global carbon dioxide emissions, 1960-2015 (metric tons per capita) [20]



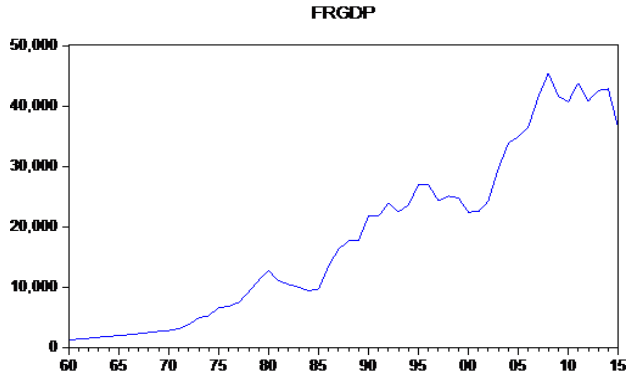
In this section there is a discussionbased on Figures, of the sample variables concerning Sweden and France from 1960 to 2015.
The Figure 5, which analyzes carbon dioxide emissions data in France from 1960 to 2015, demonstrates that there was a significant increase in carbon dioxide emissions until 1980 followed by a continuous downward trend. In 2015, France managed to reduce carbon dioxide emissions to a record low.

Figure 5 Carbon dioxide (CO2) emissions in France from 1960 to 2015 (metric tons per capita)



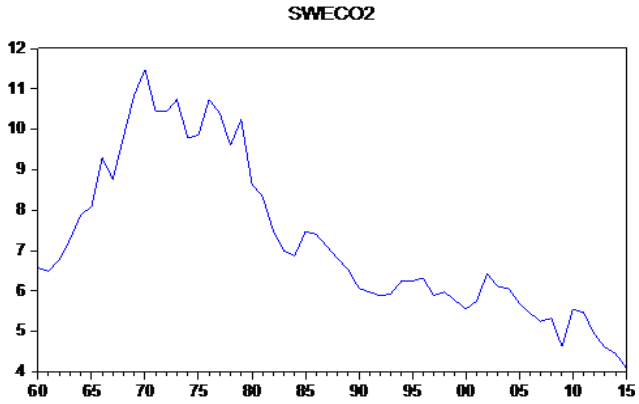
In addition, the following chart, which displays information about the Gross Domestic Product (GDP), demonstrates that in France GDP per capita during that period followed a continuous upward trend until 2009 during the global financial crisis, which had a considerable effect on it. The negative impact of the crisis is reflected in the downward trend of GDP, which starts in 2010 and continues until 2015.

Figure 6 GDP per capita in France, 1960-2015 (dollars) [21]



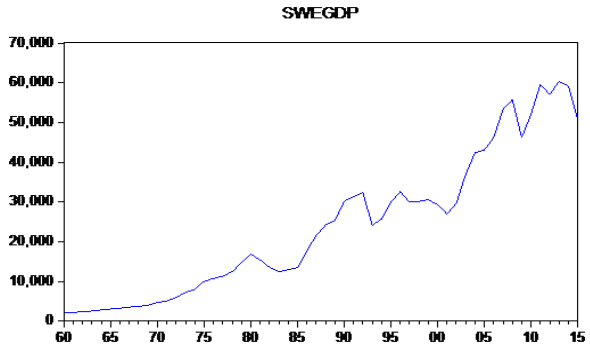
Sweden is known as one of the most organized developed countries in terms of its socio-political and anthropocentric system worldwide. Similar to France, carbon dioxide emissions in Sweden increased significantly until 1980 and then continuously declined. Remarkably, by 2015, Sweden's environmental policy enabled almost the complete elimination of carbon dioxide emissions, as shown in Figure 7 below.

Figure 7 Carbon dioxide (CO2) emissions in Sweden from 1960 to 2015 (metric tons per capita)



Sweden's GDP per capita, one of the highest in the world displaying a continuous upward trend until 2009, was definitely affected by the global crisis, but not as much as other countries, and recovered very quickly.

Figure 8 Sweden's GDP per capita in 1960-2015 (Dollars) [21]

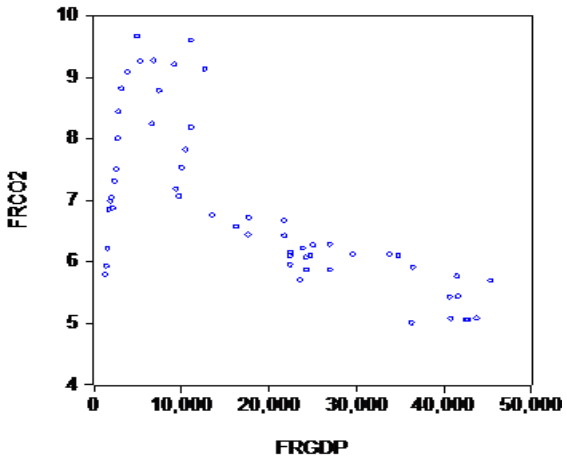


III. Result

This section discusses the diagrams displaying the existence of EKC in Sweden and France from 1960 to 2015. The vertical axis measures environmental degradation in terms of carbon dioxide emissions in metric tons per capita, whereas the horizontal axis measures GDP per capita.

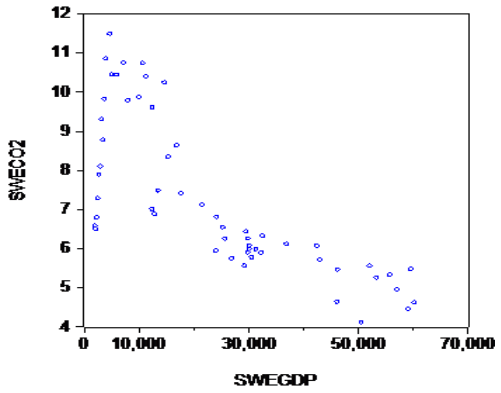
Figure 3.1 shows the existence of Kuznets curve in France. The lower part of the diagram includes low incomes; as per capita income increases, there is a huge increase in carbon dioxide emissions and, consequently, in environmental degradation. The parallel increase in income and environmental degradation lasted 20 years in France, and in 1980 the turning point occurred. After the turning point, there was a steady decline in carbon dioxide emissions, sharp at first and then lower, whereas there was also a steady increase in income per capita.

Figure 9 Environmental Kuznets curve in France



Similarly, in Sweden (Fig. 10), the existence of the EKC is also established. The lower part of the diagram shows low incomes; as income per capita increases, there is a huge increase in both carbon dioxide emissions and, consequently, in environmental degradation. This parallel increase in income and environmental degradation in Sweden lasted 13 years, and the turning point was observed in 1973. After the turning point, there was a steady decline in carbon dioxide emissions, sharp at first and then lower, whereas there was also a steady increase in income per capita.

Figure 10 Environmental Kuznets curve in Sweden



Figures 9 and 10 demonstrate a similar trend and enhance the environmental Kuznets curve hypothesis. Reaction times, turning points and carbon dioxide emissions reduction measures are almost identical. The main difference between the two countries involves income per capita, which in Sweden is higher than in France.

IV. Discussion

In this paper we estimate the Environmental Kuznet curve for the case of France and Sweden by taking into account GDP and CO2 emissions. The results confirmed the existence of the EKC in Sweden and France with a data spanning from 1960 to 2015 and show a schematic of the inverted U-Shaped hypothesis.

Our study provides that the increase in income causes environmental pollution in earlier stages of economic growth and both environmental pollution by CO2 and GDP are ameliorated at later stages after a certain income level. More specifically, both countries quickly left the first stage of the EKC, ie the ascending part of the EKC, and moved on to the more developed part, where a reduction in CO2 emissions with a simultaneous increase in GDP is observed. Between the two countries, Sweden shows a slightly faster transition, while at the same time it is observed that it had higher amounts of CO2 emissions and higher GDP, throughout the period under study.

This paper provides new evidence for the current policy of decision-making to enhance the understanding of the relationship between GDP and CO2 emissions. However, further research is required to investigate the role of financial development and environmental degradation. Nowadays most countries around the globe are on the left ascending part of Kuznets curve. As this includes developing and emerging economies, such as the Brics Union (Brazil, Russia, India, China, SouthAfrica), Turkey, Indonesia, Mexico and several other countries, there is an increase in the overall environmental degradation.

One possible solution to cope up with the potential consequences is to provide know-how to developing countries in order to enable a fast shift to the third stage of Kuznets curve and to rapidly reduce pollution and environmental impact. In addition, it is suggested that the countries at issue should cater for relevant education to their citizens, with a view to raising awareness about environmental issues and about the methods they can employ to reduce emissions and make proper use of energy.

V. Conclusion

While EKC has several weaknesses and has been strongly criticized by a significant part of the academic community, it remains a useful econometric method to assess and forecast statistical correlation of pollutant emissions and economic growth. Further research could be carried out in groups of countries with common weather and geographical features, such as the Mediterranean and Scandinavian countries and Central Europe. In addition, the application of various economic and econometric methods of analysis, such as Panel Data Analysis, would be most valuable.

References

[1]. Kuznets, S. (1955). Economic Growth and Income Inequality. The American Economic Review, 45(1), 1-28. Retrieved September 11, 2021, from http://www.jstor.org/stable/1811581

[2]. Grossman Gene M., Krueger Alan B., (1995) Economic Growth and the Environment, The Quarterly Journal of Economics, Volume 110, Issue 2, May Pages 353–377, https://doi.org/10.2307/2118443)

[3]. Holtz-Eakin, D. and Selten, T.M. (1995) Stoking the fires: CO2 emissions and Economic Growth, Journal of Public Economics, 57, 85-101),

[4]. Cole, m., Rayner, a., & Bates, j. (1997). The environmental Kuznets curve: An empirical analysis. Environment and Development Economics, 2(4), 401-416. Retrieved August 29, 2021, from http://www.jstor.org/stable/44379185

[5]. McKitrick and Strazicich (2006) McKitrick R, Strazicich MC. Reply to Holtsmark. Energy & Environment. 2006;17(2):221-221. doi:10.1260/095830506777070033 and Aldy 2006 (2006). Aldy, J.E. Per Capita Carbon Dioxide Emissions: Convergence or Divergence?. Environ Resource Econ 33, 533–555 (2006). https://doi.org/10.1007/s10640-005-6160-x

[6]. Mishra, Mukesh Kumar (2020) : The Kuznets Curve for the Sustainable Environment and Economic Growth, ZBW – Leibniz Information Centre for Economics, Kiel, Hamburg This Version is available at: http://hdl.handle.net/10419/21673

[7]. Aldy, E. ,J. ,(2004), "An Environmental Kuznets Curve Analysis of U.S. StateLevel Carbon Dioxide Emissions", Department of Economics Harvard University, pp.4-9.

[8]. Stern, I., D., (2003), "The Environmental Kuznets Curve", International Society for Ecological Economics, pp. 5-8

[9]. Eunho Choi, Almas Heshmati, Yongsung Cho, (2010). An Empirical Study of the Relationships Between CO2 Emissions, Economic Growth and Openness. Journal of Environmental Policy. 10. 10.17330/joep.10.4.201112.3.

[10]. Keho, Y.(2015), "An Econometric Study of the Long-Run Determinants of Co2 Emission in Cote d'Ivoire", Journal of Finance and Economics, Vol. 3, pp. 12- 16.

[11]. Katsuhisa Uchiyama (2016) "Environmental Kuznets Curve Hypothesis and Carbon Dioxide Emissions", Development Bank of Japan Research Series, pp.11-17

[12]. Arrow, K. J., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C. S., (1995), "Economic growth, carrying capacity and the environment", Ecological Economics, Vol. 268, pp. 520–521

[13]. Rosa Duarte, Vicente Pinilla, Ana Serrano, Is there an environmental Kuznets curve for water use? A panel smooth transition regression approach, Economic Modelling, Volume 31, 2013, Pages 518-527, ISSN 0264-9993, https://doi.org/10.1016/j.econmod.2012.12.010.

[14]. Miglietta, Pier Paolo & De Leo, Federica & Toma, Pierluigi. (2016). Environmental Kuznets curve and the water footprint: An empirical analysis. Water and Environment Journal. 31. 20-30. 10.1111/wej.12211.

[15]. Katz, David. (2015). "Water use and economic growth: reconsidering the Environmental Kuznets Curve (EKC) relationship". Journal of Cleaner Production. Journal of Cleaner Production. 88. 10.1016/j.jclepro.2014.08.017.

[16]. Selden, T. M., & Song, D., (1994). "Environmental quality and development: Is there a Kuznets curve for air pollution emissions?", Journal of Environmental Economics and Management, Vol. 27, pp. 147–162

[17]. Dijkgraaf, E., & Vollebergh, H. R. J., (2005), "A test for parameter homogeneity in CO2 panel EKC estimations". Environmental and Resource Economics, Vol. 32, pp. 229–239.

[18]. Intergovernmental panel on climate change (Climate Change 2014 Mitigation of Climate Change Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press)

[19]. Sustainable innovation forum (2015), Retrieved 25-09-2017 from http://www.cop21paris.org/

[20]. Carbon Dioxide Information Analysis Center (2017), Ανάκτηση 13-09-2017 από http://cdiac.ornl.gov/trends/emis/tre_glob_2014.html

[21]. The world bank Data (2017), Ανάκτηση 19-07-2017 από https://data.worldbank.org/indicator

Polytimi Farmaki, et. al. "Empirical Study On The Environmental Kuznets Curve On CO2 Emissions In France And Sweden."*IOSR Journal of Environmental Science, Toxicology and Food Technology* (IOSR-JESTFT), 15(9), (2021): pp 27-34.